2016

Private contracting with externalities: Divide and conquer?

Jeanine Miklos-Thal
Greg Shaffer, *University of Rochester*

ARTICLE IN PRESS
JID: INDOR [m1L;May 10, 2016;14:55]
International Journal of Industrial Organization 000 (2016) 1–13
Contents lists available at ScienceDirect
International Journal of Industrial Organization
www.elsevier.com/locate/INDOR

Private contracting with externalities: Divide and conquer?

Jeanine Miklós-Thal*, Greg Shaffer

Simon Business School, University of Rochester, Rochester, NY 14627, United States

ARTICLE INFO

Article history:
Available online xxx

JEL classification:
C72
D82
L13
K41

Keywords:
Principal-agent games
Divide and conquer strategies
Network effects
Two-sided markets
Union formation
Input licensing

ABSTRACT

This paper considers the efficacy of divide-and-conquer strategies in principal-agent games involving contracting with externalities. We find that whereas divide-and-conquer offers can arise in equilibrium under some conditions when the principal's offers are *publicly* observable, they cannot arise in equilibrium when the principal's offers are *privately* observable and the agents hold passive out-of-equilibrium beliefs. This insight applies to technology and platform adoption decisions with network effects, labor relations, settlement negotiations, and input licensing, among others.

1. Introduction

Many principal-agent settings involve contracting with externalities where the principal must pay the agents to obtain her preferred outcome. In this paper, we consider a class of such games in which (i) the externalities are such that the minimum payment

* Corresponding author. Tel.: +15852765166.
E-mail addresses: jeanine.miklos-thal@simon.rochester.edu (J. Miklós-Thal), shaffer@simon.rochester.edu (G. Shaffer).

http://dx.doi.org/10.1016/j.ijindorg.2016.03.002

needed to induce each agent to take the action that is preferred by the principal is decreasing in the number of other agents that are expected to take the same action, and (ii) the agents simultaneously and independently choose their actions.

Applications can be found in industrial organization, law and economics, and labor economics, among others. Examples include a firm that is seeking to induce buyers to adopt its technology/platform when there are network effects that make buyers more eager to adopt the technology/platform when others also do so; a defendant that is seeking to settle out-of-court with potential plaintiffs when there are economies of scale in litigation; a firm that is seeking to convince workers not to form a union when the benefits of joining are increasing in the number of workers that join; and a firm that is seeking to sell input licenses to downstream buyers when each buyer stands to lose more from a competing buyer's decision to license the input when it does not license the input than when it does.

In these and similar settings, it has often been suggested that the principal should adopt a "divide-and-conquer" strategy to exploit the contracting externalities that exist among the agents. In a divide-and-conquer strategy, the principal picks an agent and offers him a payment that induces him to take the principal's preferred action even if he expects the other agents not to, picks another agent and offers him a payment that induces him to take the principal's preferred action even if he expects only one other agent to do so, picks a third agent and offers him a payment that induces him to take the principal's preferred action even if he expects only two other agents to do so, and so on with each agent until her preferred outcome is implemented. In other words, the principal constructs an optimal divide-and-conquer path by ordering (identical) agents in an arbitrary fashion, and then offering each agent a payment that is just accepted if the agent believes that all agents who are lower in the order will take the principal's preferred action and all agents who are higher in the order will not. With "increasing externalities" (Segal, 2003), agents who are higher-ordered are more eager to take the principal's preferred action than are agents who are lower-ordered, and thus are offered smaller payments by the principal.

Previous analyses and discussions of divide-and-conquer strategies have focused (implicitly or explicitly) on the case of *publicly-observable* offers,[1] where each agent can observe the offers made to all agents prior to choosing his action. The present paper contributes to the literature by considering instead the case of *privately-observable* offers, where the offers the other agents have received are not known.

We find that divide-and-conquer strategies lose their efficacy (i.e., fail to work) when the offers are privately observable and the agents have passive out-of-equilibrium beliefs.[2] Not only will the principal not be able to "bribe" her way profitably to her preferred

[1] See, for example, Caillaud and Jullien (2003), Che and Spier (2008), Grossman and Hart (1988), Innes and Sexton (1994), Jullien (2011), Katz and Shapiro (1986a, 1986b); Segal and Whinston (2000), and Posner et al (2010), who consider such strategies in a specific context, and Segal (2003), who studies such strategies more generally, but who also restricts attention to the case of publicly-observable offers.

[2] Passive beliefs are the most commonly assumed out-of-equilibrium beliefs in the vertical-contracting literature with private offers (see Hart and Tirole, 1990, and McAfee and Schwartz, 1994, for details).

outcome in this case, but the lack of observability may re-establish equilibria in which all agents will refuse the principal's offer, leading to the worst possible outcome for the principal. Among other things, this suggests that in the settings described above, where the principal is seeking to induce the adoption of certain technologies/platforms, engage in settlement negotiations, discourage union formation, and sell input licenses, it will be optimal for the principal to commit wherever possible to making her offers public. Our findings also offer guidance to policymakers who may want to affect the outcome of the game by either encouraging or discouraging the principal's efforts (e.g., by making a commitment to public offers either easier or harder, respectively, for the principal).

To our knowledge, only two other papers consider, as we do, the case of publicly-observable offers: Segal (1999, Section 4), and Miklós-Thal and Shaffer (2015). We differ from the former in that Segal (1999) focuses on efficiency properties rather than the principal's ability to use a divide-and-conquer strategy to break coordination on a focal (and undesirable from the principal's perspective) equilibrium, which is our main focus. Miklós-Thal and Shaffer (2015), who analyze the role of contract observability in the naked-exclusion model introduced by Rasmusen et al (1991) and further refined by Segal and Whinston (2000), is more closely related. In the naked-exclusion setting, when the incumbent uses a divide-and-conquer strategy on the equilibrium path, acceptance is a dominant strategy for each of the agents that accepts exclusivity; the other agents are offered zero and do *not* agree to exclusivity.[3] In contrast, in this paper, we assume the principal loses money if each agent that accepts is paid a bribe high enough such that the agent plays a dominant strategy. It follows that a divide-and-conquer strategy in our setting, if it is to be profitable, must involve discriminatory payments (not just offers) on the equilibrium path – some agents accept bribes that they would prefer to refuse if other agents refused theirs.

Both in Miklós-Thal and Shaffer (2015) and in the present paper, a divide-and-conquer strategy cannot arise in equilibrium when offers are private and the agents hold passive out-of-equilibrium beliefs. Unlike in the naked-exclusion setting considered in Miklós-Thal and Shaffer (2015), however, we find that private observability can re-establish the existence of equilibria in which all agents refuse the principal's offer. This happens in the range of parameters where a divide-and-conquer strategy equilibrium exists with public offers.[4] The intuition for this difference in results is as follows. In Miklós-Thal and Shaffer (2015), the effectiveness of a divide-and-conquer strategy in deviations does not depend on the observability of offers (because acceptance is a dominant strategy for each agent that is needed to deter entry). In the present paper, on the other hand, private offers undermine the principal's ability to break up an equilibrium in which no one accepts the bribe. The agent that accepts a low offer in the divide-and-conquer strategy only accepts

[3] There are also equilibria in which more than the critical number of agents accept exclusivity, but these rely on coordination failure among the buyers. Such equilibria are excluded from the analysis here.

[4] In the naked-exclusion setting, on the other hand, the only equilibria that exist in this parameter range when the offers are private and the agents have passive beliefs are those that rely on a coordination failure among agents.

the offer if he believes that the other agent will accept as well – with passive out-of-equilibrium beliefs, he will thus reject an unexpected offer from the principal if the offer is not high enough to make acceptance optimal even when the other agent rejects.

2. The model

The model has three players: a principal and two agents.[5] The agents are symmetric and indexed by $i = 1, 2$. There are two periods in the game. In period 1, the principal makes simultaneous offers to agents 1 and 2. The offer to agent i consists of a promise to pay agent i an amount $t_i \geq 0$ if agent i chooses action B in period 2 and zero otherwise. In period 2, the agents simultaneously choose action A or action B, where $x_i \in \{A, B\}$ denotes i's choice. The principal then pays agent i t_i if and only if $x_i = B$. Thus, one can think of the payment t_i as a "bribe" that "rewards" agent i for choosing action B.[6]

Denoting agent i's utility by $u(x_i, x_{-i})$, where $-i$ denotes the other agent and x_{-i} is the action the other agent takes, the agents' payoff matrix looks as follows:

	A	B
A	$u(A, A),\ u(A, A)$	$u(A, B),\ u(B, A) + t_2$
B	$u(B, A) + t_1,\ u(A, B)$	$u(B, B) + t_1,\ u(B, B) + t_2$

To capture the essence of the problem that we want to focus on, we assume that $u(A, A) > u(B, A)$, and that there are externalities in the agents' utilities in the sense that each agent's utility depends not only on its own action, but also on the other agent's action. The former assumption ensures that (A, A) is a pure-strategy equilibrium in the benchmark game in which the principal cannot offer bribes.[7] The latter assumption implies that either $u(A, A) \neq u(A, B)$ or $u(B, A) \neq u(B, B)$, or both $u(A, A) \neq u(A, B)$ and $u(B, A) \neq u(B, B)$. It is needed to highlight the power of divide-and-conquer strategies that allow the principal to gain by treating otherwise identical agents asymmetrically.

We also assume that the externalities in the agents' utilities are strictly increasing, which, as shown by Segal (2003), is necessary in the case of publicly-observable offers for the existence of equilibria in which the principal relies on a divide-and-conquer strategy.

Assumption 1. Externalities are strictly increasing:

$$u(A, A) - u(B, A) > u(A, B) - u(B, B).$$

Assumption 1 can be interpreted in two ways. One interpretation is that an agent is more eager to choose action A when the other agent chooses A than when the other

[5] It is straightforward to extend the model to $n > 2$ agents with no change in the qualitative results.
[6] Alternatively, one can think of the principal as punishing agent i for choosing action A.
[7] Throughout, we will focus on equilibria in pure strategies.

agent chooses B, and vice-versa. Thus, Assumption 1 implies that $u(x, x) - u(-x, x) > u(x, -x) - u(-x, -x)$. The other interpretation is that the externality of choosing action x is higher on an agent that also chooses x than on an agent that chooses $-x$. Thus, for example, it follows that $u(x_i, B) - u(x_i, A)$, is greater for $x_i = B$ than for $x_i = A$.

As for the principal, we assume that the principal has a direct interest in the agents' actions. Its payoff is $\Pi_{BB} - t_1 - t_2$ if both agents choose action B, $\Pi_{AB} - t_i$ if only agent i chooses action B, and 0 if both agents choose action A. We further assume that the principal's gross payoff is increasing in the number of agents that choose action B. Thus, we assume that $\Pi_{BB} \geq \Pi_{AB} \geq 0$, with at least one of the inequalities being strict.

Note that the principal can make choosing action B a (weakly) dominant strategy for agent i by offering a payment of $t_i \geq u(A, A) - u(B, A)$. In order to focus on the profitability of divide-and-conquer strategies that exploit the externalities between agents, we assume that inducing the outcome (B, B) by offering bribes that are high enough to make action B a dominant strategy for *each* of the agents is unprofitable for the principal:

$$\Pi_{BB} < 2(u(A, A) - u(B, A)). \tag{1}$$

Similarly, we assume that

$$\Pi_{AB} < u(A, A) - u(B, A), \tag{2}$$

so that it is never profitable for the principal to induce only one agent to choose B.[8]

Our main question is whether the principal will be able to profitably induce the agents to play B, and how this ability depends on the observability of its offers. Since the period 2 subgame can have multiple equilibria, the principal's ability to induce (B, B) may depend on equilibrium selection in period 2. To focus on situations in which the principal's success does not rely on the agents' coordinating on (B, B), we assume that action A is focal. Denoting the equilibrium outcome by $\left(\widehat{t}_1, \widehat{t}_2, \widehat{x}_1, \widehat{x}_2\right)$, the formal definition is as follows:

Assumption 2. Action A is focal: if $\widehat{t}_i < u(A, A) - u(B, A)$ for all i, then $\widehat{x}_1 = \widehat{x}_2 = A$.

Assumption 2 states that (on the equilibrium path) the agents coordinate on the equilibrium in which both play A if it exists and does not involve weakly-dominated strategies.[9] Along with conditions (1) and (2), it ensures that the outcome of the game will either involve both agents choosing action A or both choosing action B, with a bias toward outcome (A,A) unless the principal can exploit the externalities between agents.

[8] Condition (1) implies condition (2) if the principal's gross payoff is convex in the number of agents that choose B. Thus, condition (1) implies condition (2) if $\Pi_{AB} \leq \Pi_{BB}/2$.

[9] In the case of publicly-observable offers, where each agent i observes both t_1 and t_2, we will see that all subgame-perfect equilibria satisfy the condition in Assumption 2 off the equilibrium path as well.

Please cite this article as: J. Miklós-Thal, G. Shaffer, Private contracting with externalities: Divide and conquer? International Journal of Industrial Organization (2016), http://dx.doi.org/10.1016/j.ijindorg.2016.03.002

3. Analysis

3.1. Public offers

We first consider the case in which the offers in period 1 are publicly observable, the case considered in most of the previous literature. With public offers, each agent observes his own and the other agent's offer prior to deciding whether to choose A or B.

Proposition 1. *Suppose offers are publicly observable. Then there exist subgame-perfect equilibria, and in all such equilibria, play takes the following form:*[10]

(i) *If* $\Pi_{BB} > u(A,A) - u(B,A) + \max\{0, u(A,B) - u(B,B)\}$, *then* $t_i = u(A,A) - u(B,A)$, $t_{-i} = \max\{0, u(A,B) - u(B,B)\}$, *and* $x_i = x_{-i} = B$ *for* $i \in \{1, 2\}$.
(ii) *If* $\Pi_{BB} < u(A,A) - u(B,A) + \max\{0, u(A,B) - u(B,B)\}$, *then* $t_i \leq u(A,A) - u(B,A)$ *and* $x_i = A$ *for all* i.

Proof. Denote the equilibrium outcome by $(\widehat{t}_1, \widehat{t}_2, \widehat{x}_1, \widehat{x}_2)$. The proof proceeds in three steps. First, suppose (in negation) that $\widehat{x}_i = B$ and $\widehat{x}_{-i} = A$ for $i \in \{1,2\}$. Then, it must be that $\widehat{t}_i \geq u(A,A) - u(B,A)$. By condition (2), the principal's payoff is strictly negative in this case; hence, the principal has a profitable deviation to $t_1 = t_2 = 0$.

Second, suppose that $\widehat{x}_1 = \widehat{x}_2 = B$. Then, given that action A is focal, it must be that $\widehat{t}_i \geq u(A,A) - u(B,A)$ and $\widehat{t}_{-i} \geq u(A,B) - u(B,B)$ for $i \in \{1,2\}$.[11] Since $\widehat{t}_i \geq 0$ for all i, these conditions imply a strictly negative payoff for the principal if $\Pi_{BB} < u(A,A) - u(B,A) + \max\{0, u(A,B) - u(B,B)\}$, which means that the principal has a profitable deviation to $t_1 = t_2 = 0$ in this case. If $\Pi_{BB} \geq u(A,A) - u(B,A) + \max\{0, u(A,B) - u(B,B)\}$, on the other hand, the game has an equilibrium with offers $\widehat{t}_i = u(A,A) - u(B,A)$ and $\widehat{t}_{-i} = \max\{0, u(A,B) - u(B,B)\}$ for $i \in \{1,2\}$ and $\widehat{x}_1 = \widehat{x}_2 = B$. First, following the offer $(\widehat{t}_1, \widehat{t}_2)$, the period 2 subgame has an equilibrium in which both agents play B. (It also has an equilibrium in which both play A, but that equilibrium involves a weakly dominated strategy for the agent who is offered $u(A,A) - u(B,A)$.) Second, after any deviant offers $t_i \leq \widehat{t}_i$ for all i, with a strict inequality for at least one of the agents, the period 2 subgame has an equilibrium in which both agents play A; if this equilibrium is selected, the principal cannot profitably deviate to lower offers. Moreover, given (2), the principal cannot profitably deviate to offers that induce $x_i = B$ but $x_{-i} = A$. Finally, there are no equilibria in which $\widehat{t}_i > u(A,A) - u(B,A)$ and/or $\widehat{t}_{-i} > \max\{0, u(A,B) - u(B,B)\}$ for $i \in \{1,2\}$, otherwise the principal could profitably deviate to offers that induce both agents to play B at a lower total cost for the principal.

[10] *If* $\Pi_{BB} = u(A,A) - u(B,A) + \max\{0, u(A,B) - u(B,B)\}$, equilibria of the form described in (i) coexist with equilibria of the form described in (ii).
[11] Recall that externalities are increasing, so $\widehat{t}_i \geq u(A,A) - u(B,A)$ implies that $\widehat{t}_i > u(A,B) - u(B,B)$.

Third, suppose that $\widehat{x}_1 = \widehat{x}_2 = A$. Then, it must be that $\widehat{t}_i \le u(A, A) - u(B, A)$ for all i. The principal earns zero payoff in this case. Given (2), the principal cannot profitably deviate to offers that induce $x_i = B$ but $x_{-i} = A$. Now consider deviations aimed at inducing (B,B). The principal can ensure that (B,B) is the unique equilibrium of the period 2 subgame by making offers of the form $t_1 = u(A, A) - u(B, A) + \varepsilon$ and $t_2 = \max\{0, u(A, B) - u(B, B)\} + \varepsilon$ to the agents, where $\varepsilon > 0$ can be arbitrarily small. It follows that the principal has a profitable deviation if $\Pi_{BB} > u(A, A) - u(B, A) + \max\{0, u(A, B) - u(B, B)\}$. If $\Pi_{BB} \le u(A, A) - u(B, A) + \max\{0, u(A, B) - u(B, B)\}$, on the other hand, an equilibrium in which $\widehat{x}_1 = \widehat{x}_2 = A$ exists, because after any offers such that $t_i < u(A, A) - u(B, A)$ and/or $t_{-i} < \max\{0, u(A, B) - u(B, B)\}$ for $i \in \{1, 2\}$, the period 2 subgame has an equilibrium in which both agents play A. □

Proposition 1 establishes that the principal can induce (A,A) by offering a payment of $u(A, A) - u(B, A)$ to one agent (to make it a weakly-dominant strategy for this agent to choose B even if she expects the other agent to choose A), and a strictly lower payment of $\max\{0, u(A, B) - u(B, B)\}$ to the other agent (to induce this agent to choose B given that he expects the first agent will also be choosing B). The principal employs a divide-and-conquer strategy to make inducing her preferred outcome cheaper than if she had to treat both agents identically. Under this strategy, the principal loses on the first transfer but gains on the second transfer. As long as the overall gain to the principal in going from outcome (A,A) to outcome (B,B) exceeds the sum of the payments that she must give to the agents to induce (B,B),Proposition 1 implies that (B,B) will arise in equilibrium. Otherwise, (A,A) will arise. Given conditions (1) and (2), one can see that inducing (B,B) is only possible when the externalities between agents are increasing. If the externalities were decreasing (i.e., if the inequality in Assumption 1 were reversed), it would not be possible for the principal to induce (B,B) in equilibrium.

3.2. Private offers

We now consider the case in which the period 1 offers are privately observable. With private offers, each agent observes his own offer, but not the other agent's offer, prior to making his decision.

Although each agent's inference about what the other agent has received will be correct in equilibrium, analyzing the equilibria of the game in this case requires an assumption about each agent's beliefs about the offer received by the other agent when the agent receives an unexpected (i.e, out-of-equilibrium) offer from the principal. To this end, we assume in what follows that agents have passive beliefs. With passive beliefs, even after observing an unexpected offer from the principal, an agent believes that the other agent has received his equilibrium offer (Hart and Tirole., 1990; McAfee and Schwartz, 1994).[12]

[12] Passive beliefs are sometimes justified by assuming that unexpected offers are interpreted as mistakes.

Proposition 2. *Suppose offers are only privately observable. Then there exist perfect Bayesian equilibria with passive beliefs, and in all such equilibria, play takes the following form:* $t_i \leq u(A, A) - u(B, A)$ *and* $x_i = A$ *for all* i.[13]

Proof. Denote the equilibrium outcome by $\left(\widehat{t}_1, \widehat{t}_2, \widehat{x}_1, \widehat{x}_2\right)$. We first show that $\widehat{x}_i \neq B$ for all i. Suppose (in negation) that $\widehat{x}_1 = \widehat{x}_2 = B$. Then, given that action A is focal, it must be that $\widehat{t}_i \geq u(A, A) - u(B, A)$ for at least one i, otherwise $\widehat{x}_1 = \widehat{x}_2 = A$. Suppose the principal deviates by offering $t_i \in \left(u(A, B) - u(B, B), \widehat{t}_i\right)$ to an i for whom $\widehat{t}_i \geq u(A, A) - u(B, A)$, while making the equilibrium offer to agent $-i$. With passive beliefs, i will believe that $-i$ received his equilibrium offer and thus that $-i$ will play his equilibrium action B. Given this belief, agent i plays B for any $t_i > u(A, B) - u(B, B)$. Agent $-i$, who received its equilibrium offer, plays B as well. With this deviation, the principal thus earns strictly more than his candidate equilibrium payoff $\Pi_{BB} - \widehat{t}_1 - \widehat{t}_2$.

Next, suppose that $\widehat{x}_i = B$ and $\widehat{x}_{-i} = A$ for $i \in \{1, 2\}$, which requires that $\widehat{t}_i \geq u(A, A) - u(B, A)$. Given condition (2), this implies that the principal's payoff is strictly negative in this case; hence, the principal has a profitable deviation to $t_1 = t_2 = 0$.

Finally, we show that equilibria in which both agents play A exist. Suppose that $\widehat{t}_i \leq u(A, A) - u(B, A)$ for all i,[14] and that each agent's equilibrium strategy is to play A if he receives an offer in $[0, u(A, A) - u(B, A)]$ and B if he receives an offer in $(u(A, A) - u(B, A), \infty)$. With passive beliefs, after any offer, agent i believes that agent $-i$ was offered $\widehat{t}_{-i} \leq u(A, A) - u(B, A)$ and thus, given his strategy, will play A. For any offer $t_i \leq u(A, A) - u(B, A)$, agent i's best-response to A is to play A as well. For any offer $t_i > u(A, A) - u(B, A)$, on the other hand, playing B strictly dominates playing A. Thus, agent i's strategy is optimal given his beliefs and the equilibrium strategies of the other players. Given the agents' strategies, conditions (1) and (2) imply that the principal cannot profitably deviate to an offer that would induce one or both agents to play B. □

The impact of private observability is twofold. First, Proposition 2 establishes that equilibria in which both agents play A now exist even if Π_{BB} exceeds the total payment that the principal would make with a divide-and-conquer strategy. Second, Proposition 2 establishes that there are no equilibria in which both agents play B anymore. Both differences in results between the public-offer case and the private-offer case arise because of the principal's inability to rely on a divide-and-conquer strategy when offers are private.

When externalities are increasing and offers are *publicly* observed, the principal can use a divide-and-conquer strategy to break up a continuation equilibrium in which both agents play the focal action A. By offering $x_i > u(A, A) - u(B, A)$ to agent i, the principal makes playing B a strictly dominant strategy for i. Agent $-i$, who observes i's offer and hence anticipates that i will play B, is then willing to play B as well even if he is offered

[13] Note that although equilibria exist in which the principal offers to pay agent i some positive amount up to $u(A, A) - u(B, A)$, there will be no transfers on the equilibrium path given that $x_i = A$.
[14] Because $\widehat{x}_1 = \widehat{x}_2 = A$ implies $\widehat{t}_i \leq u(A, A) - u(B, A)$ for all i, we need not consider other offers.

only a small inducement, equal to $\max\{0, u(A, B) - u(B, B)\}$ in our setting. Using such a divide-and-conquer strategy to induce both agents to play B instead of playing the focal action A is profitable for the principal if Π_{BB} exceeds the total payment to the agents.

However, when each agent can only observe his own offer and the agents have passive beliefs, the principal can no longer use a divide-and-conquer strategy to break up coordination on A. The difficulty stems from the fact that the agent who receives a low offer in the divide-and-conquer strategy does not observe the offer made to the other agent. If the agent who receives the low offer believes that the other agent received his equilibrium offer, as with passive beliefs, he will play A. To induce both agents to switch from A to B would hence require offers high enough to make playing B a dominant strategy for *each* of the agents. With such offers being prohibitively costly, the principal can no longer profitably break up an (A, A) equilibrium.

A divide-and-conquer strategy also cannot arise on the equilibrium path when each agent can only observe his own offer and the agents have passive beliefs. This is because when the principal's offers are only privately observed, the principal can profitably deviate by offering less to the agent who expects a high offer in the divide-and-conquer strategy. With passive beliefs, after receiving an unexpectedly low offer from the principal, the agent continues to believe that the other agent has received his equilibrium offer (as is indeed the case in the optimal deviation). The agent therefore believes that the other agent, who did not observe the deviation, will continue to play B. Because the high offer in a divide-and-conquer strategy exceeds the minimum amount needed to make choosing B a best-response to B, the principal can thus induce both agents to play B at a lower cost. Hence, the principal has a profitable deviation from the divide-and-conquer strategy.

4. Applications

There are many examples of contracting with externalities that comport with our setting. Applications arise, for example, in industrial organization, law and economics, and labor economics. We give a few examples below and discuss the implications of our results.

Technology/platform adoption with network effects (Caillaud and Jullien, 2003; Jullien, 2011; Katz and Shapiro, 1986b). Our first example is one of technology or platform adoption with network effects. In this example, each agent (or group of agents) is a buyer who chooses between two available technologies, and the principal is the seller of technology B (alternatively, the principal may be a policymaker who seeks to promote the adoption of technology B). In contrast, technology A is "unsponsored."[15]

[15] For example, one can think of technology A as being supplied by a competitive market.

Please cite this article as: J. Miklós-Thal, G. Shaffer, Private contracting with externalities: Divide and conquer? International Journal of Industrial Organization (2016), http://dx.doi.org/10.1016/j.ijindorg.2016.03.002

Externalities arise because there are positive (direct or indirect) network effects implying that an agent's payoff from adopting a given technology is higher if the other agent adopts the same technology (i.e., $u(x,x) > u(x,-x)$ for all $x \neq -x \in \{A,B\}$). Moreover, these externalities are increasing because choosing B imposes a negative externality on an agent who chooses A, but a positive externality on an agent who also chooses B.

One can think of t_1 and t_2 as individual discounts off some previously established list price if the principal is a seller, or as positive inducements that are offered by a policymaker.[16] And one can think of action A as being focal because A might be an existing technology while B might be a new technology that requires consumers to switch, with network effects that are strong enough so that $u(A,A) > u(B,A)$.[17]

Given this setting, our results from Propositions 1 and 2 suggest that the seller or policymaker who wants to promote technology B should endeavor to commit publicly to individualized discounts or inducements whenever possible. However, the latter may be especially difficult for policymakers who may wish to avoid the perception of being unfair.

Settlement negotiations (Che and Spier, 2008). Contracting externalities can also arise in settlement negotiations. The principal is a single defendant and the agents are plaintiffs. In period 1, the defendant makes settlement offers t_i to the plaintiffs. In period 2, each plaintiff independently decides whether to litigate (action A) or not (action B).

Externalities in the agents' payoffs arise because there are economies of scale in litigation in the sense that some of the fixed costs of litigation are spread among the plaintiffs that go to trial. Because the cost of trial per plaintiff is therefore decreasing in the number of plaintiffs that go to trial, each plaintiff is more eager to settle when the other plaintiff also settles than when he goes to trial, and thus the game exhibits increasing externalities.

Typically, when a case is settled out of court, the parties are in complete control of what remains private and what remains public, including the settlement amount. Our results suggest that the defendant should consider making the settlement offers public.

Labor relations (Neeman, 1999; Posner et al., 2010). Our third example is concerned with labor relations and the formation of unions. In this example, each agent represents a worker (or group of workers) who must decide whether to join a union (action A) or not (action B), and the principal is an employer who benefits from keeping union membership as small as possible, or even better, preventing unionization altogether.

In the absence of payments from the employer not to organize, each worker earns a higher payoff if both join the union than if neither joins the union, i.e., $u(A,A) > u(B,B)$.

[16] In the seller interpretation, suppose the list price is $\overline{p} \geq u(B,B)$. The actual price paid by i then becomes $\overline{p} - t_i$ and the agent's payoffs gross of bribes are $\widetilde{u}(B,x_{-i}) = u(B,x_{-i}) - \overline{p}$ and $\widetilde{u}(A,x_{-i}) = u(A,x_{-i})$. The principal's gross revenue is $2\overline{p}$ if both agents play B and $\overline{p}$ if a single agent plays B.

[17] See Jullien (2011) for an analysis of divide-and-conquer strategies in two-sided markets where one platform is focal because of favorable consumer expectations.

Externalities arise because a worker who attempts to organize while the other worker does not receives the lowest payoff, i.e, $u(A,B) < u(B,B)(< u(A,A))$. The payoff of a worker who does not organize, on the other hand, is independent of the other worker's action, i.e., $u(B, A) = u(B, B)$. Thus, the externalities are increasing because organizing has a positive externality on a worker who also chooses to organize, but no externality on a worker who does not organize.[18] Moreover, it is natural to expect coordination on A to be focal in this game, because (if it exists) it is the preferred equilibrium of the agents.

Given this setting, our results suggest that the employer should attempt (if possible) to make its payments public. Interestingly, although the National Labor Relations Act in the United States prohibits the use of bribes and penalties to prevent unionization, there is evidence that such tactics are used nonetheless (see Posner et al., 2010). Making bribes illegal, however, presumably makes it harder to commit publicly to rewarding workers to resist unionization, and therefore, per our results, harder for the employer to succeed.

Licensing (Katz and Shapiro, 1986a). Our last example concerns the licensing of an input. In this example, the agents are competing downstream firms that can either use a freely available inferior technology A, or a more advanced technology B, which requires the licensing of an input (e.g., a patent or access to a central facility) from the principal.

Externalities arise because a downstream firm is worse off when its competitor obtains a license than when it does not, i.e., $u(x,A) > u(x,B)$ for all $x \in \{A,B\}$. Moreover, these externalities are increasing if, as seems plausible, a downstream firm stands more to lose from its competitor's decision to license when it does not license than when it does.

As in the technology/platform adoption example with network effects, t_1 and t_2 can again be interpreted as individual discounts off some list price that is already incorporated into the gross payoffs. And one can think of action A as being focal because A might be an existing technology, and B might be a new technology that involves switching costs.

Given this setting, our results suggest that the licensor should try to make its individualized discounts, and thus discriminatory terms, public. Of course, this may not be possible or easy to do if, for example, the licensor is obligated by a standards organization to offer FRAND (fair, reasonable, and non-discriminatory) licensing terms to its members.

5. Conclusion

Previous literature in industrial organization has shown that the private observability of contract offers can have potentially dramatic effects on competitive outcomes. For

[18] In some situations, unions have positive externalities on workers that choose not to organize (so that $u(B, A) > u(B, B)$ in our model) because outsiders can free-ride on some of the improvements bargained by the union. However, externalities would be still increasing in this case as long as a union member benefits more from the other worker's joining the union than a worker that does not join the union.

example, this is one of the main messages in Hart and Tirole (1990), McAfee and Schwartz (1994), O'Brien and Shaffer (1992) and others in the literature that consider a single upstream firm (principal) selling an input to two or more downstream firms (agents). In that literature, however, the principal's aim is to coordinate the agents' actions so as to maximize the overall profit in the industry, which in principle can benefit all players.

In contrast, in this paper, we consider principal-agent games involving contracting with externalities in which the agents' focal outcome differs from the principal's preferred outcome in the absence of monetary payments from the principal to the agents. As shown in previous literature, with publicly-observable offers and increasing externalities, the principal can (under certain conditions) use divide-and-conquer offers to obtain her desired outcome in such cases. We have shown, however, that the case of privately-observable offers can potentially have a dramatic effect, as in the vertical-contracting literature.

Specifically, we considered a class of principal-agent games in which (i) the principal must pay the agents to obtain her preferred outcome, (ii) the externalities in the agents' payoffs are increasing, and (iii) the agents simultaneously and independently choose their actions. Within this class of games, we found that divide-and-conquer strategies invariably fail to work when the principal's offers are privately observable and the agents have passive out-of-equilibrium beliefs (as is commonly assumed in the vertical-contracting literature). We found that not only will the principal not be able to "bribe" her way to her preferred outcome, but the lack of observability may even re-establish equilibria in which all agents refuse the principal's offer, which leads to the worst possible outcome for the principal.

We then showed how our findings could be applied to settings that included the case of a seller seeking to induce potential buyers to adopt her technology/platform, a defendant seeking to induce potential plaintiffs to settle out of court, an employer seeking to dissuade her workers from forming a union, and a licensor seeking to license her input to competing downstream firms. In each instance, we suggested that the principal may need to make her offers public if her divide-and-conquer strategy is to have the best chance of succeeding.

References

Caillaud, B., Jullien., B., 2003. Chicken and egg: competition among intermediation service providers. RAND J. Econ. 34 (2), 309–328.

Che, Y., Spier., K.E., 2008. Exploiting plaintiffs through settlement: divide and conquer. J. Inst. Theor. Econ. 164, 4–23.

Grossman, S., Hart., O., 1988. One share–one vote and the market for corporate control. J. Financ. Econ. 20, 175–202.

Hart, O., Tirole., J., 1990. Vertical integration and market foreclosure. Brookings Papers Econ. Act. 1990, 205–276.

Innes, R., Sexton, R.J., 1994. Strategic buyers and exclusionary contracts. Am. Econ. Rev. 84, 566–584.

Jullien, B., 2011. Competition in multi-sided markets: divide and conquer. Am. Econ. J.: Microecon. 3 (4), 186–220.

Katz, M.L., Shapiro., C., 1986a. Technology adoption in the presence of network externalities. J. Polit. Econ. 96 (4), 822–841.

Katz, M.L., Shapiro., C., 1986b. How to license intangible property. Q. J. Econ. 101 (3), 567–590.

Please cite this article as: J. Miklós-Thal, G. Shaffer, Private contracting with externalities: Divide and conquer? International Journal of Industrial Organization (2016), http://dx.doi.org/10.1016/j.ijindorg.2016.03.002

McAfee, R.P., Schwartz., M., 1994. Opportunism in multilateral vertical contracting: nondiscrimination, exclusivity, and uniformity. Am. Econ. Rev. 84, 210–230. 1994

Miklós-Thal, J., Shaffer., G., 2015 Naked Exclusion with Private Offers. University of Rochester. Am. Econ. J. Microecon. forthcoming.

Neeman, Z., 1999. The freedom to contract and the free-rider problem. J. Law, Econ. Organ. 15 (3), 685–703.

O'Brien, D.P., Shaffer., G., 1992. Vertical control with bilateral contracts. Rand J. Econ. 23, 299–308.

Posner, E.A., Spier, K.E., Vermeulen., A., 2010. Divide and conquer,. J. Legal Anal. 2 (2), 417–471.

Rasmusen, E., Ramseyer, J.M., Wiley., J., 1991. Naked exclusion. Am. Econ. Rev. 81, 1137–1145.

Segal, I., 1999. Contracting with externalities. Q. J. Econ. 114, 337–388.

Segal, I., 2003. Coodination and discrimination in contracting with externalities: dvide and conquer? J. Econ. Theory 113 (2), 337–388.

Segal, I., Whinston., M., 2000. Naked exclusion: comment. Am. Econ. Rev. 90, 296–309.

Please cite this article as: J. Miklós-Thal, G. Shaffer, Private contracting with externalities: Divide and conquer? International Journal of Industrial Organization (2016), http://dx.doi.org/10.1016/j.ijindorg.2016.03.002