Partnerships based on Joint Ownership

Matthias Blonski* Daniel Herbold† Giancarlo Spagnolo‡

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comments welcome

Abstract

Who should own what in a successful relationship to provide the best incentives? In this article we show that Joint Ownership rather than Private Ownership offers stronger incentives to cooperate if partners are sufficiently patient. This is especially the case if haggling costs matter once the relationship breaks down. Since all property rights must be renegotiated anew the termination of a partnership based on Joint Ownership is a painful procedure. We show all our results within a general relational contracting model with imperfect monitoring that can accommodate static ownership models like Hart and Moore (1990) together with relational ownership models as different as Baker, Gibbons and Murphy (2002) or Halonen (2002) as special cases. In contrast with this literature, we show that in general, Joint Ownership entails no trade off between short- and long-run incentives for cooperation.

JEL Classification: D23, L22

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*corresponding author, Department of Economics, Johann Wolfgang Goethe University, 60323 Frankfurt am Main, Germany. e-Mail: *blonski@wiwi.uni-frankfurt.de*

†Ernst and Young, Germany.

‡University of Rome 'Tor Vergata', SITE - Stockholm School of Economics, and CEPR.

1 Introduction

How should we set up a business partnership to provide the best incentives for success and longevity? How does the value of a partnership depend on its design? What is the tension between short run and long run incentives? What is the role of property rights in this context? In particular, who should own which assets and under which circumstances may joint ownership, i.e. a situation where the use of the asset requires the consent of all owners, be a better recipe for lasting success compared to private ownership where a single party can freely decide over the use of the asset?

To analyze these questions, it is not only important to understand parties' incentives and behavior during the relationship, but also in the state where a relationship has broken down. The critical role of the breakdown case for determining the fate of the relationship has been one of the key insights of the economic literature on ownership. We follow here the tradition of Hart and Moore (1990) by defining a *jointly owned* asset as an asset that can only be turned productive by consent of all owners. This implies that each jointly owning party has a veto right on its use. In other words, an asset stays in a useless and potentially costly limbo state as long as at least one of the joint owners disagrees on its use. Rational parties may anticipate that this hapless state of the world after a separation would not last forever. Instead, former partners after a separation want to change property rights for good and haggle over the further outcome. *Haggling costs, renegotiation costs, or transaction costs*, as they have been called in different strands of the literature thereby play a critical role for the costs parties would have to incur once their relationship breaks down and they prefer to separate.[1] In most legal systems lawyers' and judges' fees rise with the number and the size of issues haggled over. In this paper, therefore, we suppose that it is (weakly) less costly to haggle only over a subset of assets. We call this latter assumption *renegotiation asset monotonicity*. The existing literature mostly imposes fixed, exogenous renegotiation costs, rules renegotiation out entirely or transaction assumes that costs are zero. These assumptions are special cases of our present setup, which allows for general renegotiation costs that may depend on the number of assets subject to renegotiation. In section 2 we relate our analysis to the existing literature in more detail.

[1] The critical role for haggling after separation of a relationship is evident in *Brexit* where most observers and pundits agree that the immense number of issues that has to be haggled over imposes heavy renegotiation costs on both sides. Our present theory and results support the old and un-British idea of an ever closer union in the sense that this is the design to minimize the incentives to separate by maximizing the pain of haggling after a separation. Thereby the present EU provides stronger cooperation incentives compared to more flexible and looser settings where parties keep more private control rights and thereby provide much less base for haggling after a possible separation.

We focus on repeated social dilemma games, which are situations that entail an inherent tension between short- and long-run incentives to engage in cooperative behavior. Summarizing what is at stake if the relationship breaks down — the *relationship value* — reflects players' long-run incentives to cooperate. By contrast, in the short term, the strategic form of a social dilemma game implies that players are tempted to deviate from cooperation. We summarize these deviation incentives with the concept of *required liquidity* necessary to implement cooperation, introduced by Goldlücke and Kranz (2012). Intuitively, the required liquidity represents the maximum range of side payments necessary to implement cooperative behavior. Regarding off-equilibrium strategies, we follow the standard in the literature on relational incentive contracts (e.g. Levin (2003), Rayo (2007) and Halac (2012)) by assuming that, after a deviation from prescribed behavior, players separate and turn to alternative trading partners for good. This assumption, contrasts with most existing studies on property rights in dynamic settings which typically assume that parties employ *Nash reversion*, i.e. permanently play the spot market equilibrium following any deviation from prescribed behavior. While under this latter assumption a relationship turns less friendly after a defection it still remains intact on a lower level. We argue here that such a specification for off-equilibrium behavior has drawbacks beyond disconnecting oneself from the relational incentive contracts literature. First, from an applied perspective, the termination of the trading relationship following defective behavior is how most business parties in practice handle breakdowns in cooperation in a world with plenty of alternatives. Therefore, a realistic description of long-term trade relationships should give parties the option to turn to other trading partners. Second, Nash reversion is not an optimal punishment in the sense of Abreu, Pearce and Stacchetti (1990) not even among those strategies for which the relationship survives. From a theoretical point of view it is inconsistent to assume that players can optimize their relationship along the dimension of ownership but not with respect to their strategies. Conversely, when players have the option to separate, such a separation is always an optimal punishment.

We show that under asset monotonicity *Joint Ownership* stands out in the sense that the partnership with the most painful perspectives of separation is the one with the most jointly owned assets. In turn, these negative prospects of separation deter deviations from cooperative behavior within an ongoing relationship. As the future value of the partnership rises with partners' patience, Joint Ownership is always optimal when players are sufficiently patient. Conversely, when parties are impatient, optimal ownership depends on the specific strategic setting. However, we show that Joint Ownership does not always entail an inherent trade off between short- and long-term incentives to engage in cooperation. In particular, we consider several concrete settings, known from the existing literature to characterize optimal ownership, showing that even if players are impatient, Joint Ownership may be optimal as well.

Our Results. Our main insights can be summarized as follows: First, Joint Ownership is always optimal for partnerships between patient players. Parties can strengthen incentives to cooperate by designing their partnership in such a way that life outside it is as unpleasant as possible. One way to do this is to minimize the usefulness of assets outside the partnership. We show that Joint Ownership stands out in this respect and achieves this criterion among all ownership structures because a jointly owned asset's further use can be blocked by each of its joint owners. Further, Joint Ownership maximizes the haggling that is necessary to sort out more useful ownership rights after separation. Therefore, Joint Ownership is generally more valuable in environments with high renegotiation costs. To derive more concrete results for intermediate patience, we examine more specific trading environments. E.g., contrary to classical wisdom private ownership may be inefficient even for impatient players, e.g. when rent-seeking actions are available that affect productivity within and outside the relationship in different ways. In section 7 we reconsider a famous hidden action problem with a principal and an agent as in Baker, Gibbons and Murphy (2002) where we add Joint Ownership and compare our findings with original results. We expand Baker, Gibbons and Murphy's observations both by adding a third option (Joint Ownership) to the ownership design problem and by analyzing the classic "make-or-buy" decision in an environment with optimal punishment and costly renegotiation. We show that Joint Ownership always dominates Integration, because it stipulates both a more severe punishment as well as stronger short-term incentives to cooperate, as the principal cannot "take the output and run", as she can under Integration. From the results, it follows that optimizing ownership implies a "collaborate-or-buy" rather than a "make-or-buy" decision.

The paper's strong case for Joint Ownership when partners are sufficiently patient and haggling costs are substantive may raise the question of why Joint Ownership is not much more prominent in practice. In fact, as argued by Hansmann (1996) and Cai (2003), in business transactions Joint Ownership is much more common than generally perceived. Moreover, future work may use this result as a benchmark to extend the literature and find other effects that may balance or pull in different directions in specific institutional environments, much like Elinor Ostrom (1990) suggested to do.

The remainder of the paper is organized as follows. In the next section, we relate our study to the existing literature. Section 3 motivates the logic of the results with a simple numerical example. Section 4 introduces the static framework that underlies the repeated game. Section 5 describes the repeated game and introduces voluntary side payments. Section 6 defines optimal ownership and characterizes optimal ownership structures. Section 7 relates our findings to established results in the existing literature. Section 8 concludes.

2 Related Literature

In this section, we review the most relevant parts of the immense literature on the role of property rights in the context of designing successful relationships and explain in more detail the deviations of our present theory from the existing literature.

Grossman and Hart (1986) and Hart and Moore (1990) were the first to analyze how the allocation of property rights can improve trade under incomplete contracting in a static context. Segal and Whinston (2013) survey this literature and its ramifications.

Garvey (1995), Baker, Gibbons and Murphy (2001, 2002) and Halonen (2002) were among the first to analyze the role of property rights in ongoing relationships. Baker, Gibbons and Murphy (2001, 2002) compare *Integration* where a principal owns all assets with *Outsourcing* under which the agent owns some asset in a repeated principal-agent model, where incentives are provided by relational contracts. They find that ownership matters as it affects players' incentives to honor the relational contract. Our analysis extends their work on several grounds, overturning some of their results and confirming others. We relax the assumption of costless renegotiation of ownership, which simplifies their analysis but precludes ownership from affecting the relationship value. By contrast, our notion of renegotiation asset monotonicity implies that the optimal choice of the ownership structure must also account for long-term effects. Further, we allow for optimal punishment considering strategies other than Nash reversion, as these imply that parties would not optimize with respect to the dynamic incentive structure that supports cooperation. Finally, we extend Baker et al.'s comparison between Outsourcing and Integration by adding the option of Joint Ownership. We find that Joint Ownership dominates Integration for any level of patience. By contrast, whether Joint Ownership of Outsourcing is optimal depends on the specific of the strategic setting.

Halonen (2002) is one of the first and the most influential contributions that studies Joint Ownership in a dynamic context. She considers a one-shot game as in Hart and Moore (1990) that is played repeatedly with deviations being punished by Nash reversion. She shows that in the static framework Joint Ownership is always inefficient. However, this downside turns out to be an upside in the repeated setting with side payments since under Nash reversion, the most inefficient ownership structure constitutes the most severe punishment, thereby creating the strongest incentives to cooperate. In her framework this trade off is solved in favor of one or the other ownership structure depending on the elasticity of the cost of investment. Our present article identifies several restrictions with this line of reasoning. First, the stage game studied by Hart and Moore and Halonen is rather special as it specifies an action space with a one-dimensional effort variable. With a numerical example in section 3 we show that a slightly more general action space obtained by adding a rent seeking action that raises the payoff of a private owner outside the relationship but not within, may lead to Joint Ownership being more efficient than private ownership even in the static setting. In this setting, private ownership is the more efficient punishment and thereby provides better cooperation incentives in long-term relationships under Nash reversion, while Joint Ownership may be optimal in the static game, turning Halonen's result on its head.[2] In this paper, we assume that off the equilibrium path, players do not revert to the Nash equilibrium which is no optimal penal code but instead terminate the relationship which is an optimal punishment. More precisely, our analysis shows that with a more general action space and optimal punishment, Joint Ownership may indeed be the second best efficient static ownership structure as well as the one that creates the strongest cooperation incentives for patient players compared to all other cases. The tradeoff identified in Halonen is therefore entirely dependent on the restrictive action set and suboptimal strategies adopted in her model. By contrast, we show that Joint Ownership need not entail a tradeoff between short- and long-run incentives to cooperate.

Garvey (1995) also analyzes the role of ownership in a repeated trade model with perfect monitoring and a specific cost function and production technology. However, his model imposes an exogenous, non-optimal transfer, while we allow players to choose the contingent side-payment optimally. For this reason, Garvey's conclusion that optimal ownership rights should be symmetric across firms is not valid in our framework.

While focusing on optimal ownership in relational contracts, our model borrows heavily from various methods developed for analyzing general models of relational incentive contracts. Malcomson (2013) provides a comprehensive survey of the literature on relational incentive contracts. We use techniques developed by Levin (2003) and Goldlücke and Kranz (2012) for repeated imperfect monitoring settings. We also contribute to the literature that studies how certain aspects of relationships should be designed so as to improve and facilitate relational incentive contracts. Within this strand, Rayo (2007) examines a repeated moral-hazard-in-teams model and studies to what extent different profit-sharing rules can improve the effectiveness of relational incentives. Che and Yoo (2001) analyze what form of performance evaluation best supports the implicit contract among members of a production unit. Baker, Gibbons and Murphy (1994), Bernheim and

[2] An analogous full reversal of Halonens results would obtain if the stage game allowed parties to endogenously choose the degree of specificity of their investments, as in Cai (2003).

Whinston (1998), Kvaloy and Olsen (2009), Pearce and Stacchetti (1998) and Schmidt and Schnitzer (1995) look at how explicit contracts and formal incentives should be designed so as to optimally support and complement existing implicit contracts. Li and Matoushek (2013) study how periodically arising conflicts in repeated principal-agent relationships should be managed. Furthermore, Halac (2015) analyzes how an ex-ante unilateral and irreversible investment by one party affects that party's ability to sustain a relational contract under different informational assumptions.

Finally, in a related paper, Miller and Watson (2013) study behavior in repeated games when players can bargain over the choice of the continuation equilibrium.[3] They find that the distribution of bargaining power has important implications for the choice of continuation play and hence for the set of allocations that can be sustained by relational contracts. Our model is more specific as different ownership structures establish different allocations of bargaining power and by allowing for nonzero haggling costs.

3 A Numerical Example

Consider players 1 and 2 and an *asset*. Ex ante, player 1 has three possible actions of *high*, *medium* and *low* investment into specific human capital with investment costs of 8, 5 and 0, respectively. Suppose, player 2 is not strategic, but important as a trading partner. In a relationship with player 2, player 1's investment generates output of 26, 22 and 14, respectively. Our interpretation of medium investment is that player 1 gets more productive using the asset. High investment means that on top of being more productive with the asset, player 1 can produce especially well for player 2, but not for other trading partners. In particular, outside the relationship, i.e. with an alternative trading partner, player 1 can realize outside payoffs of 6, 6 and 0 for high, medium and low investment, respectively.

For this specification the *high* specific human capital investment is efficient and the corresponding joint surplus is $18 = 26 - 8$. Player 1's investment has value 0, unless she has access to the asset. In the language of Hart and Moore (1990) player 1 is indispensable for the asset since without player 1 player 2 is not productive with the asset. We now compare just the two ownership structures, *Joint Ownership* and *Private Ownership*, the latter here in the form of player 1 control. Ex post, players split the output according to Nash bargaining with symmetric bargaining power.

Under Joint Ownership, the players have to reach a consensus to be productive. Player 1 cannot put his investment to an alternative use without player 2's agreement.

[3] See also Goldlücke and Kranz (2013), who study how different concepts of renegotiation-proofness apply to relational contracts.

Hence, under Joint Ownership, players split the output in half. Accordingly, under Joint Ownership, player 1 will choose *low* investment which yields him payoff $7 = \frac{1}{2} \cdot 14 - 0$ and generates a total surplus of 14.

As private owner player 1 can put the asset to alternative use. Outside the relationship with player 2 there is no incentive to invest more than the medium investment since the high investment was specific to player 2. Hence, player 1 will choose medium investment with payoff equal to the Nash bargaining outcome minus investment cost, i.e. $9 = 6 + \frac{1}{2}[22 - 6] - 5$.

This numerical example so far formulates the well known mechanism from the Grossman-Hart-Moore literature under which Private Ownership raises a player's investment incentive by improving her bargaining position. Next, we show that this logic may break down once player 1 may, as a fourth alternative, choose an *investment in general human capital* which is comparably more productive in improving player 1's outside payoff than his investment in specific human capital. Investing in general human capital action generates low output 14 within the relationship but yields the better outside payoff 12 while generating private cost 3. Hence, general human capital investment is a *rent seeking action.*

Under Private Ownership player 1 as the owner of the asset will now prefer the *rent seeking action* yielding her a payoff of $10 = 12 + \frac{1}{2}[14 - 12] - 3$. Now, the surplus is only $11 = 14 - 3$. As before, under *Joint Ownership* player 1's outside payoff is always 0, since she cannot use the asset without player 2's consent. Hence, there is no point in investing. Therefore, under Joint Ownership player 1 picks *low* investment as mentioned before yielding the better second best surplus 14.

In the repeated version of the game with discount factor δ the value of the relationship is the difference between the surplus stream within the relationship and the surplus stream that can be reached once the relationship has broken down. In Halonen's (2002) framework Private Ownership would generate a larger relationship value compared to Joint Ownership as $\frac{1}{1-\delta}((26-8)-(14-3)) = \frac{7}{1-\delta}$ under Private Ownership and $\frac{1}{1-\delta}((26-8)-(14-0)) = \frac{4}{1-\delta}$ under Joint Ownership. In turn, in her model Private Ownership is the more valuable relationship and thereby the first best cooperative outcome could be supported as an equilibrium for a larger range of discount factors compared to Joint Ownership which is Halonen's optimality criterion for the dynamic case.

In our formulation, by contrast, a relationship terminates and former partners turn to alternative trading partners once cooperation breaks down. Since the jointly owned asset has no value outside the relationship former partners anticipate that ownership rights of the jointly owned asset have to be haggled over. Suppose that it costs $\gamma > 0$ to haggle and alter ownership to the next best alternative which would be Private

Ownership. This implies that in our model the relationship value of Joint Ownership is $\frac{1}{1-\delta}(26-8)-\left(\frac{1}{1-\delta}(6-5)-\gamma\right)=\frac{17}{1-\delta}+\gamma$ which outperforms the relationship value for private ownership given by $\frac{1}{1-\delta}(26-8)-\left(\frac{1}{1-\delta}(6-5)\right)=\frac{17}{1-\delta}$. This further shows that the relationship value of an ownership structure increases with haggling cost γ that becomes relevant once the partnership breaks down.

The above example illustrates a case, where, under a repeated game with rent-seeking, the asset should not be privately owned by the player who is indispensable to its use.[4] In the corresponding repeated version of any such stage game, for sufficiently patient players, Private Ownership would be the more effective punishment if players cannot terminate the relationship. In turn, this shows that in Halonen's model Joint Ownership may fail to provide optimal incentives since this prediction depends on her specification of the stage game. We show in the remainder of this article that in our more general framework, where off-equilibrium payoffs are optimal penal codes in the form of relationship termination, Joint Ownership maximizes the value of the relationship and thereby always creates the strongest incentives for cooperation for sufficiently patient players.

4 Framework

We begin by describing the stage game environment and in the next section, turn to the repeated game which is our main focus. Consider two risk-neutral players $i=1,2$ who decide simultaneously on costly actions $e_i \in E_i$ in a compact action space E_i. Let

$$e=(e_1,e_2)\in E=E_1\times E_2$$

be an action profile. Our specification includes both cases of observable actions (perfect monitoring) and of non-observable actions (imperfect monitoring). An action e_i might e.g. be a complex high-dimensional plan for conducting business for all contingencies that might be relevant during the stage game[5]. Let (Ω,σ) be a probability space with Ω denoting the set of all possible states of nature with typical element ω and with sigma algebra σ. Actions generate a stochastic joint project payoff $Q(e,\omega)\geq 0$ as well as (potentially stochastic) private costs $C_i(e_i,\omega)$ to player i. The expected joint surplus of the stage game is given by

$$S(e)=\mathbb{E}\left[Q(e,\omega)-C_1(e_1,\omega)-C_2(e_2,\omega)\right]$$

[4] Cai (2003) found already that Joint Ownership may be efficient even in the static game when specific and general investments are substitutes rather than complements.

[5] We also allow action spaces to consist of only one element. As in our numerical example in section 3 or in the principal agent setting in section 7 our theory includes cases where one player is not strategic.

where $\mathbb{E}$ denotes the expectation operator with respect to (Ω, σ). Suppose there exists a unique action profile $e^c = (e_1^c, e_2^c) \in E$ – the *cooperative action profile* – that maximizes the size of the expected joint surplus given by $S^c = S(e^c)$.

Asset Ownership. Consider a set A of non-human assets. We call a partition $\alpha = (A_1, A_2, A_{12})$ of A *ownership structure* or just *ownership.* The subset A_i are privately owned assets of party i, and A_{12} are jointly owned assets.

Our interpretation of ownership follows the tradition of Hart and Moore. Ownership of an asset confers control rights and ultimately veto power over the use of the asset. Joint Ownership means that every owner has veto power, i.e. a jointly owned asset can only be used with the consent of all owners. The ownership structure α is observable and verifiable in court.

The salient cases of ownership are (i) *Joint Ownership* $\alpha^J = (\emptyset, \emptyset, A_{12})$ where $A_{12} \neq \emptyset$, (ii) *Integration* α^I, where one party, say $i = 1$ owns all assets, so that $A_1 \neq \emptyset = A_2 = A_{12}$, (iii) *Outsourcing* α^O where both parties own assets, but there are no jointly owned assets so that $A_1 \neq \emptyset$, $A_2 \neq \emptyset = A_{12}$ and (iv) *Mixed Ownership* α^M where there are both jointly and privately owned assets.

E.g., a business partnership, such as one among consultants, lawyers or architects will typically feature mostly jointly owned assets such as the brand or firm name, client lists as well as decision rights and claims to the firm's returns. Joint ventures for example will feature both jointly (decision rights, claims to R&D results) as well as individually owned assets such as buildings and machines.

Disagreement Payoffs. Action e together with ownership structure α generates stochastic *disagreement payoffs*

$$\left(P_1\left(e_1, A_1, \omega\right), P_2\left(e_2, A_2, \omega\right)\right) \in \mathbb{R}^2,$$

representing players' individual payoffs P_1, P_2 if they decide not to trade with each other. Player i's disagreement payoff $P_i\left(e_i, A_i, \omega\right)$ depends only on his privately owned assets A_i. E.g., if negotiations over a business partnership or a joint venture break down, P_1 and P_2 reflect what each party can get employing its assets in the next-best alternative. Clearly, generally e_i^c is not the optimal action that maximizes P_i outside of the relationship.

Inside Ownership Payoffs. Action profile and ownership together with the state of the world determine the division of the joint payoff inside the relationship, i.e. who owns how much of the joint payoff Q once it is produced. We introduce the notation

$$q(e, \alpha, \omega) = (q_1(e, \alpha, \omega), q_2(e, \alpha, \omega)) \in \left\{(q_1, q_2) \in \mathbb{R}_+^2 \,|\, q_1 + q_2 = 1\right\}.$$

The vector $q = (q_1, q_2)$ represents the default division of the joint payoff if the two parties cannot agree on any other division of the joint payoff. The specification of q comprises a broad range of different division rules. E.g. if some parts of (e, α, ω) are contractible, q could reflect the contractible division of the joint surplus, such as fixed wages, bonuses based on verifiable outcomes or party's equity shares, reflecting their claims to the relationship's returns. If all components of (e, α, ω) are non-verifiable, q could reflect the outcome of the ex-post Nash-bargaining process of the static game. The specification of q allows us to compare various salient contributions in the literature as special cases within our theory.[6] E.g. in the Grossman-Hart-Moore (GHM) framework, an investing player is essential to realizing the ex-post gains from his investment, implying that both the set of assets and the identities of the players who cooperate determine the resulting surplus (see Hart and Moore, 1990). In that context players can be interpreted as investing in human capital. Since then players can always withhold their contribution to the joint surplus, it is natural to assume that it is split according to the Nash bargaining solution. By contrast, if players invest into physical capital, only the allocation of ownership matters for the size of the surplus. In Baker, Gibbons and Murphy (2002), under Integration, the principal can realize the gains from the agent's investment without having to ask him for permission. This allocation is different from a Nash-bargaining solution in which the agent's outside option is zero, as in that case, the resulting surplus would still be split half-half. Our specification of how the surplus is shared nests both interpretations. For $q_i(e, \alpha) = \frac{1}{2} + \frac{P_i(e_i,\alpha) - P_{-i}(e_{-i},\alpha)}{2Q(e)}$, we get the human capital interpretation. If $q_i(\alpha)$ is independent of e, we get the physical-capital interpretation. Indeed, as we allow the joint payoff Q itself to be part of the set of assets, we additionally allow asset ownership to determine what Segal and Whinston (2012) have termed "pure cash rights".

In the dynamic model we allow for voluntary side payments which will generally lead to a surplus division that differs from q. Consistent with the literature we assume that voluntary side payments need to be self-enforcing and can be contingent on any observable (but potentially non-verifiable) information.

Under ownership structure $\alpha = (A_1, A_2, A_{12})$, the stage-game payoff for player i is given by

$$q_i(e, \alpha, \omega) Q(e, \omega) - C_i(e_i, \omega).$$

For any ownership structure α the *expected payoff* for player i is given by

$$u_i^{sg}(e, \alpha) := \mathbb{E}\left[q_i(e, \alpha, \omega) Q(e, \omega) - C_i(e_i, \omega)\right].$$

[6]E.g., it would be simpler and more elegant to define individual payoffs $Q_1 + Q_2 = Q$ within the partnership implicitly defining the default split. The downside would be that it gets hard to identify the role of the division rule for the nature of the results in the different models.

Figure 1 summarizes the sequence of events in the stage game.

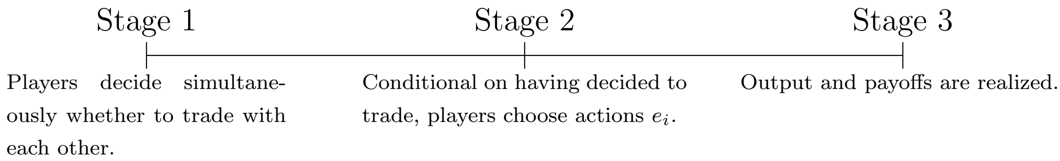

Figure 1: Sequence of events in the stage game.

Relationship Design Problem. Any ownership structure α defines a stage game $\Gamma(\alpha)$ in which, at a first stage, players decide whether or not to trade with each other, and then at a second stage they play a simultaneous-move game with payoffs $u_i^{sg}(e, \alpha)$. Let $e^* = (e_1^*, e_2^*)$ denote the Nash equilibrium of $\Gamma(\alpha)$. In general, players that maximize $u_i^{sg}(e, \alpha)$ do not maximize the joint surplus $S(e)$. We focus on static games $\Gamma(\alpha)$ that are characterized by (i) a unique action e^c that maximizes $S(e)$ for any ownership structure $\alpha \in A$ and (ii) a unique (pure strategy) Nash equilibrium, called *holdup equilbrium* $e^d(\alpha) = \left(e_1^d(\alpha), e_2^d(\alpha)\right)$ with $e_i^d(\alpha) \neq e_i^c$ for $i = 1, 2$ and any $\alpha \in A$.

We define ownership structure $\hat{\alpha} \in A$ as *short-term efficient* if it maximizes the joint holdup equilibrium surplus. The corresponding set of short-term efficient ownership structures is denoted by $\hat{A}$.

Outside Payoffs. Instead of playing the simultaneous-move game described above, at the beginning of the stage game, players can also opt not to trade with each other at all. In that case, each player i can guarantee himself an *outside payoff.* In particular, in that case, players will choose e_i as to maximize their disagreement payoffs. Thus, we define the outside payoffs $u_i^0(A_i)$ by:

$$u_i^0(A_i) = \mathbb{E}\left[P_i\left(e_i^0(A_i), A_i, \omega\right) - C_i(e_i^0(A_i), \omega)\right],$$

where

$$e_i^0(A_i) \in \underset{e_i}{\operatorname{argmax}}\, \mathbb{E}\left[P_i\left(e_i, A_i, \omega\right) - C_i(e_i, \omega)\right].$$

Clearly, as $P_i(e_i, A_i, \omega)$ depends only on privately owned assets A_i of ownership structure $\alpha = (A_1, A_2, A_{12})$, so does $u_i^0(A_i)$. Define $U^0(\alpha) = u_1^0(A_1) + u_2^0(A_2)$. These payoffs will play the role of optimal punishment payoffs in the repeated game.

Outside Payoff Asset Monotonicity. Our interpretation of a relationship that has broken down is that parties become unable to trade with each other and cannot use jointly owned assets for productive purposes. This is reflected by the fact that joint assets are only productive in the stage game $\Gamma(\alpha)$, but not if players choose their outside payoffs. Therefore, a natural assumption is that for ownership structure $\alpha = (A_1, A_2, A_{12})$, disagreement payoffs P_i satisfy *outside payoff asset monotonicity* defined by

$$u_i^0(A_i) \leq u_i^0(A_i') \text{ for } A_i \subseteq A_i'. \tag{1}$$

Hence, privately owning more assets never reduces the outside payoff since there is always the option not to use them[7]. Clearly, players will have an incentive to renegotiate asset ownership.

5 The Repeated Game

Suppose now that the stage game $\Gamma(\alpha)$ is repeated in each of infinitely many periods indexed by $t = 1, 2, ...$ Thus, in this section, we add t-indices to all variables except for the ownership structure α which remains constant over the course of the relationship. The repeated interaction may allow players to sustain cooperative behavior in a given period t by threatening to sanction any deviation from specified behavior in future periods.

Side Payments. We add to the stage game $\Gamma(\alpha)$ the possibility for players to exchange side payments at the end of each period. In particular, denote the net payments made at the end of period t by $\beta_t = (\beta_{t1}, \beta_{t2})$. These can be conditioned on all variables that are jointly observed by both players up to t. However, in contrast to the payments specified by $q(.)$, the payments in β_t are voluntary. Please note that without loss of generality, we can disregard money burning.[8] Additionally we allow players to exchange up-front side payments in the very first stage of the repeated game denoted by $\beta_0 = (\beta_{01}, \beta_{02})$. These can be interpreted as entry fees or buy-in-payments and turn out to be a useful tool in proving stationary strategy profiles[9].

In the repeated game, β_0 is used to shift (quasi-)rents between the two players, while β_t for $t \geq 1$ will be used to administer players' incentives to take particular actions within

[7]Once we discuss renegotiation there will be another property called *renegotiation asset monotonicity*.

[8]While it is known that the possibility of money burning may generally affect the payoff set of repeated games with side payments under imperfect monitoring Goldlücke and Kranz (2012) show that money burning does not enlarge the equilibrium payoff set of the repeated game if the stage game has a Nash equilibrium that gives each player her min-max payoff. Since mutual termination of the relationship establishes such a Nash equilibrium we do not have to worry about money burning from here and remove it from our notation without loss of generality.

[9]Goldlücke and Kranz (2012) assume that transfers can be performed at the beginning *and* at the end of each stage. To save on notation we omit the transfer payments at the beginning of each stage. We show in our proofs that all our critical results hold as long as we allow for an up-front payment before the first stage.

period t. Therefore, the up-front side payments β_0 do not depend on the history of play while side payments β_t for $t \geq 1$ will be functions of all jointly observed variables up to the point when they are made. Figure 2 illustrates the timing of events in the stage game with side payments.

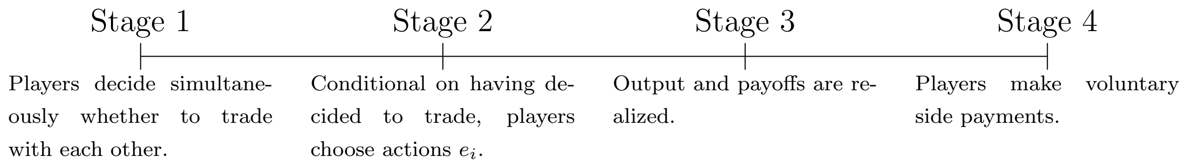

Figure 2: Sequence of events in a representative period t.

The expected joint surplus in period t is given by

$$S_t(e_t; \alpha) = \mathbb{E}\left[Q\left(e_t, \omega\right) - C_1\left(e_{t1}, \omega\right) - C_2\left(e_{t2}, \omega\right)\right]. \tag{2}$$

Since the side payments are voluntary they have to be made self-enforcing by an appropriate choice of continuation play. We assume that if a player fails to make an appointed payment, both players revert to playing the optimal punishment profile under which mutual trade ceases and both players turn to their optimal out-of-relationship actions $e_i^0(A_i)$ forever thereafter.[10]

Renegotiation of Ownership. In our setting, if renegotiation is not feasible then, by renegotiation asset monotonicity, Joint Ownership minimizes the sum of outside payoffs $U^0(\alpha)$. By contrast, if players are allowed to renegotiate ownership, they will choose an ownership structure that maximizes the continuation payoff after the breakup, $U^0(\alpha)$.[11] In this paper, we take the view that total renegotiation costs depend on the difference between the ownership structure *from* and the ownership structure *to* which players will negotiate. Intuitively, a renegotiation of ownership that involves reassigning the control rights over only a few assets should generally entail smaller costs than a more complex renegotiation which requires the reallocation of many assets.

Let $z^0(A)$ denote the (administrative, psychological, and haggling) costs of renegotiating ownership for all assets in the set A after a relationship has broken down. Similar to the idea of *outside payoff asset monotonicity* defined in (1), we say that renegotiation costs $z^0(A)$ satisfy *renegotiation asset monotonicity* if

$$z^0(A) \leq z^0(A') \text{ for } A \subseteq A'. \tag{3}$$

[10]As emphasized in the previous section, such behavior constitutes an optimal punishment profile as it minmaxes the respective deviator.

[11]Recall that ownership is contractible. Hence, players can always realize the gains from renegotiation by an appropriate contractual agreement.

If a relationship breaks down, players will want to renegotiate to an ownership structure that yields the highest joint continuation payoff. Hence, by (3), if a relationship with ownership structure α breaks down, players will renegotiate to an ownership structure $\alpha^R(\alpha) \in \text{argmax}_{\widetilde{\alpha}}\ U^0(\widetilde{\alpha}) - z^0(\alpha, \widetilde{\alpha})$. Let $\bar{U}^0(\alpha) := U^0(\alpha^R(\alpha)) - z^0(\alpha, \alpha^R(\alpha))$ denote the maximum joint continuation payoff of a relationship with ownership structure α that breaks down. Thus, even though players are free to reassign asset ownership after a relationship breaks down, the current ownership structure does affect the costs of renegotiation and therefore also the optimal reallocation of assets. Asset monotonicity implies that Joint Ownership minimizes players' joint continuation payoff after breakdown for any action e.

Lemma 1 *For any action profile e, $\bar{U}^0(\alpha)$ is minimized by Joint Ownership α^J.* □

Lemma 1 holds irrespective of the size of the renegotiation costs including the case of infinite renegotiation costs considered by Halonen (2002). Because outside of the relationship jointly owned assets become useless, Joint Ownership always minimizes the continuation payoff as it entails the highest renegotiation costs among all initial ownership structures.

6 Optimal Ownership

In this section, we study the optimal design of a relationship. We look for a an optimal ownership structure which maximizes the joint surplus.

Equilibrium Concept. We study perfect public equilibria (PPE) of the repeated game. In a PPE, players condition their strategies only on public histories as we defined them in the previous section, and, after any public history, their strategies must constitute a Nash equilibrium.[12] We defer the formal definition of public histories to the appendix.

The Value of the Relationship. Let $V(e_t; \alpha) = S_t(e_t; \alpha) - \bar{U}^0(\alpha)$ denote the *value of a relationship* for action profile e_t. The relationship value reflects the per-period productivity of the relationship relative to what the players could achieve by breaking up the relationship and turning to the best alternative outside the relationship.

[12]Restricting attention to public strategies is without loss of generality. The agent has private information about the effort profile, but since this private information is one-sided, the outcome of a sequential equilibrium in which players use private strategies is also the outcome of a PPE. See p. 330 in Mailath and Samuelson (2006)

Stationary Strategy Profiles. In this paragraph, we apply a well known result from the literature on relational incentive contracts that without loss of generality, we can restrict attention to stationary strategies (see Levin (2003) and Goldlücke and Kranz (2012)). Under a stationary strategy profile the same action profile is played forever on the equilibrium path. An equilibrium with a stationary strategy profile is called an *optimal stationary equilibrium* if there is no other stationary equilibrium that implements a higher relationship value. Accordingly, an ownership α is *optimal* if it is part ofan optimal stationary equilibrium. The structure of the repeated games we analyze is a specification of those formulated and analyzed by Goldlücke and Kranz (2012). They have shown that all public perfect equilibrium payoffs can be implemented by optimal stationary equilibria that only differ in their up-front payments[13]. This result allows us to focus on ownership structures keeping in mind that many payoff equivalent side payment paths may support the relationship design, among which the stationary equilibrium. Further, by this result we can simplify, dropping the t-indices in the remainder of the analysis to save on notation. More specifically, if we talk about a side payment profile β we mean $\beta = ((\beta_{01}, \beta_{02}), (\beta_{11}, \beta_{12}), \ldots)$ with up-front payments (β_{01}, β_{02}) in stage 1 and stationary side payments (β_{11}, β_{12}) from stage 1 on. If we talk about a stage side payment without a time index we mean stationary side payments (β_{21}, β_{22}). We now turn to the action profiles that players can implement using such strategies.

Incentive Compatibility. We start with players' incentives to pick a particular action, given some side payment profile β. Levin (2003) has shown that variations in continuation play — the standard tool in the theory of repeated games to provide incentives — can be substituted by appropriate side payments within appropriate boundaries. In particular, a side payment profile β that implements action $e = (e_1, e_2) \in E$ as a perfect public equilibrium must satisfy

$$u_i^{sg}(e, \alpha) - \mathbb{E}(\beta_i|e) \geq u_i^{sg}(e_i', e_{-i}, \alpha) - \mathbb{E}(\beta_i|e_i', e_{-i}), \text{ for } i \in \{1, 2\} \text{ and } \forall e_i' \in E_i \tag{4}$$

Self-Enforcing Side Payments. Players are only willing to make a given side payment if it does not exceed the difference between the expected discounted payoff from continuing the relationship and the expected discounted payoff from breaking it up. Let $\bar{\beta}_i(e, \alpha)$ denote the maximal side payment that player i may have to pay for any possible

[13]Levin (2003) needs court enforced fixed transfers to show that public perfect equilibrium payoffs can be implemented by stationary equilibria. In the proof of Goldlücke and Kranz (2012) the up-front payments take this role to distribute surplus among players. It is noteworthy that the Goldlücke-Kranz result generalizes Levin in various respects, in particular, court enforcement is not necessary since the Goldlücke-Kranz up-front payments are self enforcing.

outcome of the history of play. Then, action e can be implemented as a perfect public equilibrium of the repeated game if and only if (4) holds together with

$$\bar{\beta}_i\left(e,\alpha\right) \leq \frac{\delta}{1-\delta}\left[u_i^{sg}\left(e,\alpha\right) - \mathbb{E}\left[\beta_i(e,\alpha)\right] - \bar{u}_i^0(\alpha)\right], \text{ for } i \in \{1,2\}. \tag{5}$$

Condition (5) reflects perfection of the side payments. Players must be willing to make any payment on and off the equilibrium path. Define

$$\Delta(e;\alpha) := \bar{\beta}_1\left(e,\alpha\right) + \bar{\beta}_2\left(e,\alpha\right)$$

as the sum of both players' maximum side payments for action profile e. Following Goldlücke and Kranz (2012), we call $\Delta(e;\alpha)$ the *required liquidity* necessary to implement e under ownership structure α. The required liquidity measures how much short-term transfer payment is necessary to implement a certain action profile e under ownership α. For example, players' short-term incentives to deviate from the cooperative profile e^c under ownership α are quantified by the required liquidity $\Delta(e^c;\alpha)$. In particular, the required liquidity of an action profile e is 0 if and only if it is a Nash equilibrium of the stage game.

Aggregated Incentives. For cooperation to be sustainable, the required liquidity, must be no larger than the discounted expected value of the deviation, which is the maximum loss from the ensuing punishment.

Lemma 2 *Action profile $e \in E$ can be implemented under ownership structure α if and only if*

$$\delta V(e;\alpha) - (1-\delta)\Delta(e;\alpha) \geq 0. \tag{6}$$

□

Following Levin (2003), we call condition (6) the *dynamic enforcement constraint.* It states that under some ownership structure α, an action profile e can be implemented as long as there exists some payment scheme β under which the required liquidity is no greater than the remaining value of the relationship.

Optimal Ownership. For given discount factor δ and ownership structure α, let $\mathcal{S}(\alpha,\delta) = \{S(e;\alpha) | \delta V(e;\alpha) - (1-\delta)\Delta(e;\alpha) \geq 0\}$ be the set of implementable surpluses. Then,

$$S(\alpha,\delta) := \sup \mathcal{S}(\alpha,\delta) \tag{7}$$

defines the maximum surplus implementable under ownership structure α, given discount factor δ. $S(\alpha,\delta)$ is well-defined, since $\mathcal{S}(\alpha,\delta)$ contains at least the surplus of the short-run equilibrium.

Definition 1 Given discount factor δ, ownership $\alpha^*(\delta)$ is *optimal* if and only if $\alpha^*(\delta) \in \operatorname{argmax}_\alpha S(\alpha,\delta)$.

□

Characterizing Optimal Ownership. The optimal ownership $\alpha^*(\delta)$ generally differs across different strategic environments. Before we look at more specific cases, we provide a general characterization.

Proposition 1 *For sufficiently low discount factor δ and for any relationship design problem $\left\{\hat{\Gamma}_\alpha\right\}_{\alpha\in A}$, any short-term efficient ownership structure $\widehat{\alpha}\in\widehat{A}$ is optimal.* $\square$

The intuition behind this result is straightforward. If δ is small enough, the dynamic enforcement constraint is satisfied only for equilibria of the stage game. Recall from our numerical example in 3 that the optimal ownership for small δ may be Joint Ownership.

Theorem 1 *If the discount factor is large enough, Joint Ownership is optimal. Among all ownership structures that are optimal, Joint Ownership maximizes the relationship value $V(e;\alpha)$.* $\square$

Theorem 1 reflects the fundamental advantage of Joint Ownership over any other ownership structure. It always maximizes the relationship value by minimizing players' joint continuation payoff from breaking up the relationship. The economic force behind this result differs from the one formulated in Halonen (2002) as Joint Ownership maximizes the loss of surplus after a relationship has broken down by maximizing the corresponding renegotiation costs. Thus, we should expect Joint Ownership to be generally more beneficial the greater the renegotiation costs are. To this end, define the *unit-cost of renegotiating* an asset in A as $\frac{z^0(A)}{card(A)}$. The next result shows that the range of discount factors for which Joint Ownership is optimal depends on the costs of renegotiating ownership after breakdown.

Theorem 2 *Let δ^J be such that for any $\delta\geq\delta^J$, α^J is optimal. Then, δ^J decreases with the unit-cost of renegotiation.* $\square$

7 Relationship Design with Moral Hazard.

In this section, we study optimal ownership within a model specification in the spirit of Baker, Gibbons and Murphy (2002) (henceforth BGM). BGM study the optimal relationship design with respect to the "make-or-buy" decision, i.e. they compare Integration with Outsourcing. In particular, we examine a hidden-action problem involving a principal and an agent. Yet, as motivated in the introduction and in contrast to BGM, we allow both players to terminate the relationship and to trade with alternative partners if the other player defects, plus we assume costly renegotiation of the asset of the equilibrium path. Hence, our first contribution is to analyze how the choice between Integration and

Outsourcing is affected by the introduction of optimal punishment and costly renegotiation. Second, in light of our general results, we study what happens if Joint Ownership is also a feasible option and hence analyze a "make-or-buy-or-collaborate" decision. Our interpretation of *Integration* is that the principal owns all non-human assets and the agent is an employee.[14] We interpret *Outsourcing* as the case where the agent owns some critical assets that are potentially valuable outside the relationship. As before, by *Joint Ownership* we understand that all non-human assets can only be used with both parties' consent.

Specification. Now only one player, say player $i = 1$ called the *agent* faces an effort decision $e \in E$ with cost $C(e, \omega)$ that affects the stochastic output $Q(e, \omega)$, the default distribution of output $q(e, \alpha, \omega)$ and his disagreement payoff $P_1(e, A_1, \omega)$.[15] Denote the unique "no-effort-choice" of the agent by $e = 0$ with $C(0, \omega) = 0$. Player $i = 2$, called the *principal*, is inactive regarding production, i.e. $E_2 = \{0\}, C_2 = 0$. Still, her disagreement payoff outside the relationship $P_2(A_2, \omega)$ may be positive. This allows for the principal to be able to hire a new agent once the relationship with player 1 has broken down. The agent's action e is private information, only its stochastic consequences $(Q(e, \omega), q(e, \alpha, \omega), P_1(e, A_1, \omega))$ are observed by both parties. To provide incentives to the agent towards the efficient cooperative action $e^c = \text{argmax}_e\, S(e)$, the principal offers a contract $\beta(\cdot) = s + b(Q, q, P)$ with a *fixed salary* s and a *variable bonus payment* $b(Q(e, \omega), q(e, \alpha, \omega), P_1(e, A_1, \omega))$. The latter may be contingent on performance, i.e. on the outcome of the variables observed by both parties. Clearly, independent of the ownership structure, for $\delta = 0$ the principal has no incentive to pay any bonus. This is anticipated by the agent who in the short run picks the optimal outside effort $e^d(A_1) \in \text{argmax}_e\, \mathbb{E}\left[q_1(e, \alpha, \omega)Q(e, \omega) - C(e, \omega)\right]$, which corresponds to the holdup equilibrium in the general formulation. In what follows, we index the ownership structure under consideration by $\alpha \in \{\mathcal{I}, \mathcal{O}, \mathcal{J}\}$.

Static Game. As we study a principal-agent model, the default ownership of output under *Integration* is such that the agent is an employee and the principal owns everything including the output, i.e. $q_2(e, \alpha^{\mathcal{I}}, \omega) = 1$ and $q_1(e, \alpha^{\mathcal{I}}, \omega) = 0$. This implies that in the static game, $e^d(\mathcal{I}) = e^d(\emptyset) = 0$. By contrast, under *Outsourcing* and *Joint Ownership*, critical assets can only be used with the consent of the agent. Hence, $q_1(e, \alpha, \omega) > 0$ for $\alpha^{\mathcal{J}}$ and $\alpha^{\mathcal{O}}$. E.g. under Nash bargaining, we would have $q_1(e, \alpha^{\mathcal{O}}, \omega)Q(e, \omega) = \frac{1}{2}\left[Q(e, \omega) + P_1(e, A_1^{\mathcal{O}}, \omega)\right]$ and $q_1(e, \alpha^{\mathcal{J}}, \omega)Q(e, \omega) = \frac{1}{2}Q(e, \omega)$. Therefore, $e^d(\mathcal{O}) \neq 0$ and

[14] BGM call the agent *upstream party*, the principal *downstream party*, and this case *employment*.

[15] We impose no restrictions on the choice set. It may well be a multitasking problem as in BGM.

$e^d(\mathcal{J}) \neq 0$. Hence, *Integration* is not short-term efficient since output is minimal, which is consistent with BGM's results. Whether *Outsourcing* or *Joint Ownership* is short term efficient for impatient players depends on the production technology.

Separation Payoffs. The (joint) separation payoff of a relationship with ownership structure α that has broken down is given by

$$\bar{U}^0(\alpha) = P_1\left(e^0, \alpha^R, \omega\right) + P_2\left(\alpha^R, \omega\right) - C\left(e^0\right) - z\left(\alpha, \alpha^R\right),$$

where α^R denotes the *resulting* ownership structure after haggling over the assets. Lemma 1 implies that $\bar{U}^0(\alpha)$ is minimized under *Joint Ownership*. Further, without additional assumptions, both cases $\bar{U}^0(\mathcal{I}) \leq \bar{U}^0(\mathcal{O})$ and $\bar{U}^0(\mathcal{I}) > \bar{U}^0(\mathcal{O})$ are possible in principle. Which case occurs depends on whether outside of the relationship, critical assets are more valuable in the hands of the principal or the agent.

Required Liquidity. We study both cases $\Delta^{\mathcal{O}} \geq \Delta^{\mathcal{I}}$ and $\Delta^{\mathcal{O}} < \Delta^{\mathcal{I}}$ for some action e. The analysis of the static game implies $\Delta^{\mathcal{J}} \leq \Delta^{\mathcal{I}}$. Under Joint Ownership, the agent always gets a positive share of the output, because critical assets can only be used with his consent. Yet, he cannot raise his payoff by threatening to realize his disagreement payoff, because $P_1(e, \emptyset, \omega) = 0$. Further, since *Joint Ownership* simultaneously minimizes $\bar{U}^0(\alpha)$, we have $\delta V(e; \mathcal{J}) \geq \delta V(e; \mathcal{I})$ for any e. This implies that within the principal agent model, studied here, any action e that can be implemented under *Integration* can also be implemented under *Joint Ownership*.

Characterization. The following characterization result refers to any pairwise comparison in $\{\mathcal{I}, \mathcal{O}, \mathcal{J}\}$. We characterize optimal ownership for $\delta = 0$ (short-term efficiency) and for sufficiently patient players such that first best cooperation e^c can be implemented.

Proposition 2 *Consider the relationship design problem given by any two ownership structures in $\{\mathcal{I}, \mathcal{O}, \mathcal{J}\}$.*

1. *For the relationship design problem $\{\mathcal{I}, \mathcal{J}\}$, Joint Ownership is optimal for any $\delta \in (0, 1)$.*

2. *For the relationship design problem $\{\mathcal{O}, \mathcal{J}\}$, Joint Ownership is always optimal if $\Delta^{\mathcal{J}} \leq \Delta^{\mathcal{O}}$. If $\Delta^{\mathcal{J}} > \Delta^{\mathcal{O}}$, outsourcing is optimal if and only if $\Delta^{\mathcal{J}} \frac{V^{\mathcal{O}}}{V^{\mathcal{J}}} \geq \Delta^{\mathcal{O}}$*

3. *In relationship design problem $\{\mathcal{I}, \mathcal{O}\}$, each of the two ownership structures can yield the higher relationship value. This implies that in principle all four potential cases can be relevant:*

(i) $V^{\mathcal{I}} \geq V^{\mathcal{O}}$ *and* $\Delta^{\mathcal{I}} \leq \frac{V^{\mathcal{I}}}{V^{\mathcal{O}}}\Delta^{\mathcal{O}}$*:* $\mathcal{O}$ *is optimal for* $\delta = 0$ *and* $\mathcal{I}$ *is optimal if* e^c *can be implemented,*

(ii) $V^{\mathcal{I}} \geq V^{\mathcal{O}}$ *and* $\Delta^{\mathcal{I}} > \frac{V^{\mathcal{I}}}{V^{\mathcal{O}}}\Delta^{\mathcal{O}}$*:* $\mathcal{O}$ *is optimal for* $\delta = 0$ *as well as in the lower range of discount factors* $\delta \in \left[0, \frac{\Delta^{\mathcal{I}}-\Delta^{\mathcal{O}}}{\Delta^{\mathcal{I}}-\Delta^{\mathcal{O}}+V^{\mathcal{I}}-V^{\mathcal{O}}}\right]$ *where* e^c *can be implemented and* $\mathcal{I}$ *is optimal in the upper range* $\delta \in \left[\frac{\Delta^{\mathcal{I}}-\Delta^{\mathcal{O}}}{\Delta^{\mathcal{I}}-\Delta^{\mathcal{O}}+V^{\mathcal{I}}-V^{\mathcal{O}}}, 1\right]$*,*

(iii) $V^{\mathcal{I}} < V^{\mathcal{O}}$ *and* $\Delta^{\mathcal{I}} \leq \frac{V^{\mathcal{I}}}{V^{\mathcal{O}}}\Delta^{\mathcal{O}}$*: Here* $\mathcal{I}$ *is optimal for* $\delta = 0$ *and* $\mathcal{O}$ *is optimal if* e^c *can be implemented,*

(iv) $V^{\mathcal{I}} < V^{\mathcal{O}}$ *and* $\Delta^{\mathcal{I}} > \frac{V^{\mathcal{I}}}{V^{\mathcal{O}}}\Delta^{\mathcal{O}}$*:* $\mathcal{I}$ *is optimal for* $\delta = 0$ *as well as in the lower range of discount factors* $\delta \in \left[\underline{\delta}, \frac{\Delta^{\mathcal{O}}-\Delta^{\mathcal{I}}}{\Delta^{\mathcal{O}}-\Delta^{\mathcal{I}}+V^{\mathcal{O}}-V^{\mathcal{I}}}\right]$ *where* e^c *can be implemented and now* $\mathcal{O}$ *is optimal in the upper range* $\delta \in \left[\frac{\Delta^{\mathcal{O}}-\Delta^{\mathcal{I}}}{\Delta^{\mathcal{O}}-\Delta^{\mathcal{I}}+V^{\mathcal{O}}-V^{\mathcal{I}}}, 1\right]$*.* □

The first two statements relate Joint Ownership to any of the two other ownership structures and are novel since BGM did not include this comparison in their analysis. We knew already from the general results that Joint Ownership is optimal once agents are sufficiently patient. Here we see that Joint Ownership always dominates integration for the very reasons discussed above. Applying an elimination-argument, this result implies that in order to find the optimal ownership structure, one only needs to compare Joint Ownership and Outsourcing. Compared with Outsourcing, Joint Ownership is not optimal only if players are not too patient and the required liquidity under Outsourcing is lower than under Joint Ownership. This is in particular the case when the agent's action has a strong positive impact on his outside payoff which cannot be realized under Joint Ownership. Conversely if the agent can engage in rent-seeking as in our numerical example, Joint Ownership will be optimal. The third statement performs BGM's comparison between Outsourcing and Integration, albeit within our strategic setting with optimal punishment. The result confirms BGM who also find that both possibilities can occur depending on further specification.

8 Conclusion

In this paper, we provided a general framework for comparing arbitrary ownership forms with respect to improving incentives for cooperation in ongoing business relationships. We contributed to the existing literature on ownership in relational settings in two major ways. First, we assumed that any observed deviation from prescribed behavior triggers severance of the relationship. This assumption ensured that punishments were optimal. Second, our concept of *asset monotonicity* posits that the costs of renegotiating ownership are non-decreasing in the number of assets subject to renegotiation. In this framework, Joint Ownership has a fundamental advantage over any other ownership structure as it minimizes players' joint continuation payoff following a separation. Consequently, Joint Ownership is optimal if players are sufficiently patient and the range of discount factors for which incentives are optimal increases in the (unit-) costs of renegotiation. Further, we showed for a principal agent environment with moral hazard that at intermediate and lower levels of the discount factor the optimal ownership depends on the specification of the technological environment. In particular, we applied our approach to the principal-agent relationship studied by Baker, Gibbons and Murphy (2002). We generalized this framework and studied the performance of Joint Ownership within this context, showing that Joint Ownership always dominates Integration, which can hence be eliminated from the set of ownerships structures that potentially maximize the joint surplus.

There are other features that we could not consider and that may be important to fully understand the role of ownership in dynamic environments. For example, it seems important that future work considers robustness issues, like the amount of strategic risk cooperative relationships imply under different ownership structures (see Blonski and Spagnolo 2015) and their resilience to exogenous shocks and ability to adapt to changing environments (see Baker, Gibbons and Murphy 2011). Indeed, incorporating these additional issues appears to be an interesting avenue for future research in this field.

Appendix The appendix contains both formal definitions of concepts used in the main text, as well as all proofs of the main text's results.

Definitions.

Definition 2 (of the *history of play*) Let

$$\varphi_t \subseteq \{e_t, q, Q, P_1, P_2, \beta_t\}$$

denote the set of variables jointly observed in period t and let

$$h_t = (\beta_0, \varphi_1, \varphi_2, ..., \varphi_{t-1})$$

denote the history of jointly observed variables up to the beginning of date t. Note that this general formulation nests both cases of perfect, as well as imperfect monitoring. □

Definition 3 Define $R(e; \alpha, \delta) = \delta V(e; \alpha) - (1-\delta)\Delta(e; \alpha)$. □

Proofs.

Proof (of Lemma 1) Let $A_{12}(\alpha)$ denote the set of jointly owned assets under ownership structure α. By renegotiation asset monotonicity, $A_{12}(\alpha^R(\alpha)) \subseteq A_{12}(\alpha)$ for any α. Hence, $z^0(\alpha, \alpha^R(\alpha)) \leq z^0(\alpha^J, \alpha^R(\alpha))$ for any α. Further, since renegotiation asset monotonicity also implies $U^0(\alpha) \geq U^0(\alpha^J)$ for any α, it follows that we must have $\bar{U}^0(\alpha^J) \leq \bar{U}^0(\alpha)$ for any α. ■

Proof (of Lemma 2) If $R(e; \alpha, \delta) < 0$, then there is no payment function such that condition (5) holds for both players $i \in \{1, 2\}$. Hence, (6) is a necessary condition. To prove sufficiency, suppose that $R(e; \alpha, \delta) \geq 0$. In that case, there exists β such that

$$\bar{\beta}_1 (e, \alpha) + \bar{\beta}_2 (e, \alpha) \leq \frac{\delta}{1-\delta} \left[\sum_{i=1,2} u_i^{sg} (e, \alpha) - \beta_i(e, \alpha) - \bar{u}_i^0(\alpha) \right]. \tag{8}$$

Further, suppose that for $i \in \{1, 2\}$,

$$\bar{\beta}_i (e, \alpha) > \frac{\delta}{1-\delta} \left[u_i^{sg} (e, \alpha) - \beta_i(e, \alpha) - \bar{u}_i^0(\alpha) \right]. \tag{9}$$

Then, since $R(e; \alpha, \delta) \geq 0$:

$$\frac{\delta}{1-\delta} \left[u_{-i}^{sg} (e, \alpha) - \beta_{-i}(e, \alpha) - \bar{u}_{-i}^0(\alpha) \right] - \bar{\beta}_{-i} (e, \alpha) > \bar{\beta}_i (e, \alpha) - \frac{\delta}{1-\delta} \left[u_i^{sg} (e, \alpha) - \beta_i(e, \alpha) - \bar{u}_i^0(\alpha) \right] > 0. \tag{10}$$

Next, define a new payment function $\beta^* := (\beta_i^*, \beta_{-i}^*) = (\beta_i - \xi, \beta_{-i} + \xi)$ with

$$\xi := \bar{\beta}_i (e, \alpha) - \frac{\delta}{1-\delta} \left[u_i^{sg} (e, \alpha) - \beta_i(e, \alpha) - \bar{u}_i^0(\alpha) \right] \tag{11}$$

Under this new payment function, the incentive compatibility constraints (4) remain the same. Yet, now we have $\bar{\beta}_i^* = 0$ and by (10) also $\bar{\beta}_{-i}^* = 0$. This proves that if $R(e; \alpha, \delta) \geq 0$, there always exists a payment function that implements e. ■

Proof (of Proposition 1) As δ gets arbitrarily close to zero, for any action profile e, $R(e;\alpha,\delta)$ goes to $-\Delta(e;\alpha)$. Thus, the aggregated incentive is strictly negative for any action profile other than the unique hold-up Nash equilibrium. Therefore, by Lemma 2, no action profile other than the hold-up equilibrium, $e^d(\alpha)$, can be implemented. Further, for any $e^d(\alpha)$, $R(e^d(\alpha);\alpha,\delta)=0$. Thus, by item (i) of definition 1, any short-term efficient ownership structure $\widehat{\alpha}\in\widehat{A}$ is optimal. ■

Proof (of Theorem 1) The stage game is a two-player game with imperfect monitoring. Every player's disagreement payoff P_i depends only on his own action e_i, but not on e_{-i}. Since $\{P_1,P_2\}\in\varphi(e,\alpha,\omega)$, every action profile of the stage game is pairwise identifiable. Thus, by Fudenberg, Levine and Maskin (1994), as $\delta\to 1$, for any ownership structure, any individually rational payoff can be sustained as a perfect public equilibrium without money burning. Hence, also Joint Ownership is optimal.

Second, for all ownership structures that are optimal, the joint surplus $S(e;\alpha)$ is the same. It then follows from Lemma 1 that Joint Ownership maximizes the relationship value. ■

Proof (of Theorem 2) If the unit-cost of renegotiation increases, then $z^0(A)$ increases for any A and $z^0(A)-z^0(A')$ increases for any pair A and A' with $A'\subseteq A$. By the definition of $\bar{U}^0(\alpha)$, this reduces $\bar{U}^0(\alpha)$ for any α. Let $A_{12}(\alpha)$ denote the set of jointly owned assets under ownership structure α. By asset monotonicity, any jointly owned asset in the ex-post ownership structure (i.e. after renegotiation) was also jointly owned in the ex-ante ownership structure (i.e. before renegotiation), i.e. $A_{12}(\alpha^R(\alpha))\subseteq A_{12}(\alpha)$ for any α. Hence, when the unit-cost of renegotiation increases, $\bar{U}^0(\alpha^J)$ decreases by more than any other $\alpha\neq\alpha^J$. Thus, the increase in $R(e,\alpha,\delta)$ for a given action profile e and discount factor δ is largest for Joint Ownership $\alpha=\alpha^J$. Thus, for any δ for which α^J is optimal for a given level of the unit-cost of renegotiation, α^J will also be optimal under a higher level of the unit-cost of renegotiation.

Further, consider some δ for which α^J is not optimal incentives for a given level of the unit-cost of renegotiation, while α' does. That is, the surplus maximizing effort profile $e(\delta)$ is implementable under α' but not under α^J, implying $R(e(\delta),\alpha',\delta)\geq 0>R(e(\delta),\alpha^J,\delta)$. If the unit-cost of renegotiation increases, $R(e,\alpha^J,\delta)$ increases by more than $R(e,\alpha',\delta)$ for any e and α'. Hence, for some δ, if α^J is not optimal for given unit-costs of renegotiation, it may do so for higher unit-costs of renegotiation. ■

Proof (of Proposition 2) In each of the three binary comparisons we make use of the following structure. Let $\alpha_1,\alpha_2\in\{\mathcal{I},\mathcal{O},\mathcal{J}\}$ where α_1 is the ownership structure with the larger relationship value $V^1\geq V^2$. Further, since money burning can never be optimal, the critical discount factor $\underline{\delta}(e^c,\alpha_i)$ such that for all $\delta\geq\underline{\delta}(e^c,\alpha_i)$, e_c can be implemented, is given by $\underline{\delta}(e^c,\alpha_i)\equiv\delta_i=\frac{\Delta^i}{\Delta^i+V^i}$. By definition, for $\delta<\underline{\delta}=\min\{\frac{\Delta^1}{\Delta^1+V^1},\frac{\Delta^2}{\Delta^2+V^2}\}$ cooperation e^c cannot be implemented. Then, to prove all the claims of the proposition we use the following auxiliary results.

- A1 Ownership α_2 is always short-term efficient. This follows from $V^1\geq V^2\Rightarrow U^0(\alpha_2)\geq U^0(\alpha_1)$ and the joint holdup equilibrium surplus which is in this setup given by $U^0(\alpha)$.
- A2 If the required liquidity of α_1 is sufficiently small, i.e. $\Delta^1\leq\tilde{\Delta}$, then α_1 always provides optimal incentives for all $\delta\geq\underline{\delta}=\delta_1$ where the critical required liquidity is given by $\tilde{\Delta}=\frac{V^1}{V^2}\Delta^2\geq\Delta^2$. This follows from $\Delta^1\leq\tilde{\Delta}$ and $V^1\geq V^2\Rightarrow\delta V^1-(1-\delta)\Delta^1\geq\delta V^2-(1-\delta)\Delta^2$ for $\delta\geq\underline{\delta}=\delta_1$ and thereby $\Rightarrow R(e^c,\alpha_1,\delta)\geq R(e^c,\alpha_2,\delta)$ for the same range.
- A3 If, conversely, the required liquidity of α_1 is above the critical level $\Delta^1>\tilde{\Delta}$ then both ownership structures can provide optimal incentives if e^c can be implemented depending on the level of patience. Specifically, α_2 provides optimal incentives in the lower range of discount factors $\delta\in[\underline{\delta},\tilde{\delta}]$

and α_1 provides optimal incentives in the upper range $\delta \in [\tilde{\delta}, 1]$ where the critical level of patience is given by $\tilde{\delta} = \frac{\Delta^1 - \Delta^2}{\Delta^1 - \Delta^2 + V^1 - V^2} > \delta_1 > \delta_2 = \underline{\delta}$. This follows by $V^1 \geq V^2$ together with

$$\begin{aligned}
R(e^c, \alpha_1, \tilde{\delta}) &= \tilde{\delta} V^1 - (1 - \tilde{\delta})\Delta^1 \\
&= \frac{(\Delta^1 - \Delta^2)V^1}{\Delta^1 - \Delta^2 + V^1 - V^2} - \left(1 - \frac{\Delta^1 - \Delta^2}{\Delta^1 - \Delta^2 + V^1 - V^2}\right)\Delta^1 \\
&= \frac{\Delta^1 V^2 - \Delta^2 V^1}{\Delta^1 - \Delta^2 + V^1 - V^2} \\
&= \frac{(\Delta^1 - \Delta^2)V^2}{\Delta^1 - \Delta^2 + V^1 - V^2} - \left(1 - \frac{\Delta^1 - \Delta^2}{\Delta^1 - \Delta^2 + V^1 - V^2}\right)\Delta^2 \\
&= \tilde{\delta} V^2 - (1 - \tilde{\delta})\Delta^2 \\
&= R(e^c, \alpha_2, \tilde{\delta}).
\end{aligned}$$

Claim 1 of the proposition then follows from lemma 1, i.e. $V^{\mathcal{J}} \geq V^{\mathcal{I}}$ and $\Delta^{\mathcal{J}} = \Delta^{\mathcal{I}}$ together with auxiliary results A1 and A2. Claim 2 of the proposition follows again from lemma 1, i.e. $V^{\mathcal{J}} \geq V^{\mathcal{O}}$ together with auxiliary results A1, A2 and A3. By applying both cases $V^{\mathcal{I}} \geq V^{\mathcal{O}}$ and $V^{\mathcal{I}} < V^{\mathcal{O}}$ to claims A1, A2 and A3, we obtain all 4 subcases of Claim 4. ■

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