Success and Failure in Strategic Alliances: 
Theory and Experimental Evidence∗

Albert Banal-Estañol† Debrah Meloso ‡ Jo Seldeslachts§

Abstract

This paper proposes a theoretical framework of strategic alliances that includes two observable dimensions of participating partners which have been identified in the literature as critical for success or failure. In particular, we first propose a simple static theory that links the degree of alliance partners’ complementarities with the intensity of their competition in product markets. We show that the interrelationship of these factors leads to different types of strategic interaction inside the alliance, where either cooperation or coordination problems are most prevalent. These differences, in turn, feed into different predicted behaviors by partners, and can ultimately be linked to an alliance’s performance. In a next step, we develop a dynamic version of our framework. However, while having the advantage of being more realistic, theoretical predictions become less clear. Therefore, to make further precise inference of alliances’ dynamics over time, partners’ evolving strategies and potential trust building, we present experimental results in which partners interact repeatedly and have the possibility to exit each period. We find coordination alliances to do better than collaborations with problems of cooperation. This better performance can be traced back to partners’ better initial commitment choices.

Keywords: strategic alliances, ex-ante partner conditions, problems of coordination and cooperation, experiments.

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1 Introduction

Strategic alliances, broadly defined as interfirm cooperative arrangements aimed at pursuing mutual strategic objectives, proliferate around the world. However, failure is a frequent outcome of inter-firm partnering. Indeed, empirical research on the topic shows that high failure rates of 30% to 50% in partnerships are not uncommon. The large gap between potential economic value creation and realized economic value creation in strategic alliances suggests that there are formidable impediments to successful alliance outcomes (Anand and Khanna [2000]; Gottschalg and Zollo [2007]). Thus, collaborative agreements often produce disappointing outcomes and are consequently terminated (Kale et al. [2002]; Kale and Singh [2009]; Kogut [1989]; Lunnan and Haugland [2008]; Park and Ungson [1997]; Park and Russo [1996]; Reuer and Zollo [2005]).

On the surface, there are many explanations as to why strategic alliances fail: firms’ rivalry outside the alliance (Kale et al. [2000]; Khanna et al. [1998]; Park and Russo [1996]), too large a priori (technological) differences between partnering firms (Park and Ungson [1997]; Silverman and Baum [2002]), poor management and managerial complexity within the alliance (Park and Ungson [2001]), lack of trust and lack of top management commitment when deploying resources to the alliance (Uzzi [1997]; Zaheer et al. [1998]), etcetera. However, while these reasons appear to be intuitively clear, they also tend to be rather fragmented in their focus and development and center on either partner characteristics or alliance governance features.

This paper proposes first a static game-theoretical model that takes two important partner characteristics as the starting point: interfirm rivalry in markets and partners’ (technological) complementarities. We show that different partner characteristics lead to different types of strategic interaction in the alliance. In other words, we link partner and alliance characteristics. In particular, a high degree of competition in markets combined with relatively low complementarities lead to partners mainly facing problems of cooperation inside the alliance, akin to a Prisoners Dilemma. On the other hand, with relatively higher complementarities and lower interfirm rivalry, the main focus shifts to problems of coordination in the alliance: a partner contributes inside the alliance if it thinks the other contributes as well, but does not if it thinks otherwise. Thus, the first contribution of this study is, based on ex-ante partner characteristics, to provide for a micro foundation of the two main types of alliance interactions - cooperation and coordination - as identified by seminal papers on the topic such as Gulati and Singh [1998], and Park and Ungson [2001].

The predictions for this static alliance framework are straightforward. If partners’ ex-ante conditions are such that they will face cooperation problems in the alliance, they will simply refrain from starting the alliance in the first place. On the other hand, when circumstances lead the alliance to pose mainly problems of coordination, partners could in
fact start the alliance and contribute inside the cooperative venture because the coordination problems are ’solved’ through a partner’s confirmation of participation in the alliance. Indeed, the decision to participate signals a partner’s willingness to contribute and, hence, partners can coordinate on the good outcome in the alliance.

Although it is, thus, easy to prognosticate behavior in the one-shot interactions of the alliances described above, the resulting predictions are unsatisfactory. Based on our framework, one would forecast that (i) problems of cooperation are never observed in alliances since these types of collaborations are never started and (ii) although there are potential issues of coordination in the partnerships that do take place, these are avoided and thus all interfirm relationships are successful. Both predictions are not in line with what we know about strategic alliances.

This is because these relationships in reality are of typically not one-off situations. Indeed, interfirm collaborations develop essentially in a dynamic way. If partners grow a mutual understanding of each other over time, process-based trust may replace the initial conditions. This developed trust may lower coordination and cooperation costs. Indeed, to the extent that the alliance satisfies partners’ expectations, they may experience a virtuous cycle of growing commitments (Doz [1996]; Larson [1992]; Ring and Van de Ven [1994]). These can then create further anticipation of greater gains in the future, which in turn could increase the stability and performance of the relationship (Heide and Miner [1992]; Poppo et al. [2008]). Furthermore, over time, the partners may develop a more accurate shared understanding of their joint task’s coordination requirements, and of how these can complicate or help resolve coordination issues. On the other hand, the dynamic processes can also work in reverse. Unmet expectations and perceptions of opportunism can undermine partners’ initial commitment (Ariño and de la Torre [1998]).

To take into account this essential element of partnerships, we develop in a second step a dynamic model of alliances. But, while being more realistic in nature, this setup generates multiple predictions. More disappointingly, while the static version of our alliance framework provides distinct outcomes for different ex-ante partner characteristics -through the generated dissimilar alliance interactions where either cooperation or coordination problems prevail- the repeated framing yields similar (and multiple) outcomes for our different scenarios. This, however, should come as no surprise, since in frequent interactions trust and understanding can remedy in principle both issues of cooperation and coordination (Gulati et al. [2012]). Thus, while our dynamic theory of alliances now provides for a richer set of scenarios and predictions, it is rather silent on what conditions yield better alliance outcomes.

Therefore, in a third step, we examine both alliance mechanisms in a dynamic setting by employing experimental methodology. Widely employed in economics, psychology, and to an increasing extent in strategic management (Agarwal et al. [2010]; Amaldoss [2010];
Song et al. [2002]), an experimental analysis is often used to study models that have no clear theoretical predictions.

Moreover, our experimental approach complements other empirical research methods used for examining success in strategic alliances (e.g., stock market returns such as Oxley et al. [2009], survival analysis such as Park and Russo [1996], or survey-based post alliance perceptions of success such as Parkhe [1993]), and has several distinct advantages. First, it is hard to identify from field studies what constitutes success or failure in an alliance. For example, is a longer duration good or bad? Furthermore, how should one measure reliably performance? Second, an experimental analysis can isolate the strategic effects from informational issues about the success of the alliance. In reality, termination might happen because the firms discover that the alliance has less potential than initially expected. In our experimental setup, in contrast, partners have perfect information about past actions and payoffs, which allows us to focus solely on strategic issues. Finally, an experiment allows to closely investigate partners’ strategies over time and measure if, how and when trust influence an alliance’s outcome.

Our experimental results show first that coordination alliances lead to higher partner contributions than alliances with cooperation problems. These higher contributions feed into better alliance outcomes, and therefore, to both greater individual and alliance profits. Furthermore, the fact that coordination partnerships function better makes that partners are willing to stay longer on board; they last significantly longer.

Interestingly, the fact that coordination collaborations yield more favorable results is not due to distinct dynamics over time. It is solely due to partners in coordination alliances getting it more often right from the start. In other words, if both partners choose from the get-going to contribute, then the alliance is likely to be successful, and this for both types. Thus, trust works always in the same way: it is mainly established at the start and can not easily be built if initially wrong actions are undertaken. Thus, the other contribution of this study is to show through experiments that (i) problems of coordination in dynamic alliances are easier overcome than problems of cooperation and (ii) this better performance can be attributed to partners’ initial better choices.

The remaining of the paper looks as follows. The next section builds static and dynamic game-theoretical models of alliances. Section three shows the experimental setup and results of a dynamic alliance framework. Section four concludes.

2 A theory of alliances

We introduce a theoretical model describing strategic behavior within alliances. In the first subsection, we introduce the static setup. The model is then solved in the following two subsections. Finally, we introduce a dynamic version of our model.
2.1 Setup

Two symmetric firms, denoted $i = 1, 2$, can form an alliance to reduce their production costs. The alliance is formed if and only if both firms agree, simultaneously, to create and maintain the alliance, by paying a fixed participation cost $F$ (e.g., by having to dedicate a team of employees to the alliance).\(^1\) Once created, alliance members have to commit further resources to reduce their production costs (or increase product market size).\(^2\) Assuming a binary choice, we denote each partner’s cost of committing resources by $e$. Each firm’s resulting marginal costs of production, $\tilde{c}$, assumed constant, are equal to $c$ if the alliance is not formed or no partner commits resources, reduced to $c - r$, $r \in (0, c)$, if one firm commits resources and to $c - kr$, $k \in (0, c/r)$, if they both commit resources. The parameter $k$ captures the degree of complementarity between members in the alliance.

Given the production costs coming out of the potential alliance, firms compete in quantities in the product market. Individual demand for each product, $x_i$, is assumed to be linear,

$$p_i = a - x_i - d x_j,$$

where $x_j$ is the quantity produced by the (potential) partner firm $j$, and $p_i$ denotes price. Parameter $a$ is positive and $d \in [0, 1]$ captures the degree of substitution between the products and therefore how fiercely the two firms compete in the product market. If $d = 0$ both goods are completely independent and each firm is a monopolist in an isolated market, while if $d = 1$ the goods are homogeneous. Solving by backwards induction, firm $i$ chooses $x_i$ in the third stage to maximize its profits, gross of participation and resource commitment costs, given by

$$\pi_i = (a - x_i - dx_j - \tilde{c}) \cdot x_i.$$  \hspace{1cm} (1)

Equilibrium (Cournot) quantities produced and gross profits are symmetric, $x^* (\tilde{c}) \equiv x^*_i (\tilde{c})$ and $\pi^* (\tilde{c}) \equiv \pi^*_i (\tilde{c})$, and given by

$$x^* (\tilde{c}) = \frac{a - \tilde{c}}{2 + d} \text{ and } \pi^* (\tilde{c}) = \left( \frac{a - \tilde{c}}{2 + d} \right)^2.$$  \hspace{1cm} (2)

To make our analysis interesting, we make two additional assumptions. First, contributions to cost reductions require privately costly non-contractible actions. Resource commitments are of course non-contractible because these actions are difficult to observe and describe in sufficient detail and are often plagued by ambiguity. Action interdependencies make it even more difficult to measure separate contributions. Unlike internal development

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\(^1\)In the static model, the decision to create and maintain is the same. In the dynamic model below, partners decide to maintain the alliance in each period, or exit.

\(^2\)In our simple linear model, increasing market size ($a$) is equivalent to reducing production costs ($c$). We use the latter interpretation for simplicity.
Table 1: Profits (gross of participation costs) as a function of the decision to contribute resources.

<table>
<thead>
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<th></th>
<th>$C$</th>
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<tbody>
<tr>
<td>$C$</td>
<td>$\pi^<em>(c - kr) - e, \pi^</em>(c - kr) - e$</td>
<td>$\pi^<em>(c - r) - e, \pi^</em>(c - r)$</td>
</tr>
<tr>
<td>$nC$</td>
<td>$\pi^<em>(c - r), \pi^</em>(c - r) - e$</td>
<td>$\pi^<em>(c), \pi^</em>(c)$</td>
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</table>

and growth, alliance members cannot rely on preexisting coordination mechanisms, such as standard operating procedures, routines, shared language and identification, which are all consequences of long-term relationships within the firm. Indeed, if all contributions into an alliance were contractible, efficient decisions would always be made, which is inconsistent with what we observe in reality.

Second, by integrating joint resources, alliance members can achieve complementarities, i.e. gains that exceed the return of individual actions. Indeed, the adaptation and modification of the products or processes of both parties leads to knowledge and capabilities that cannot be obtained through the actions of a single party. As a result, the gains from committing resources are greater if the other party has also committed resources, $\pi^*(c - kr) - \pi^*(c - r) > \pi^*(c - r) - \pi^*(c)$, i.e. efforts exhibit strategic complementarities.\(^3\) Thus, alliance benefits can be divided into gains through individual contributions (given by the right-and side of the previous inequality), and gains through joint efforts (given by the difference between the left-hand side and the right-hand side of the inequality).\(^4\) As we will show in the next section, this framework might lead to problems of cooperation (free-riding) as well as coordination.

### 2.2 Cooperation and Coordination

When firms make contribution choices they know the profits they will make in the market thereafter. Table 1 shows the profits of each firm as a function of both firms’ choices within the alliance.

The following proposition states the essential features of the strategic interaction and the resulting equilibria as a function of the degree of complementarity and the degree of competition between alliance members.

\(^3\)Strategic complementarities are also consistent with the findings of a large literature in management that concludes that tasks are more valuable when they cluster together (see Dessein and Santos [2006]) for an overview.

\(^4\)If there were no complementarities, then it would be optimal to not contribute when the other does (i.e. we would have strategic substitutes), or not to contribute would be a dominant strategy (if $k < 1$).
**Proposition 1. Different Types of Alliance Interactions.**

There exist critical degrees of competition between partners, $d^*$, and complementarities, $k^*(d)$ and $k^{**}(d)$, such that if $\frac{\partial k^*}{\partial d}, \frac{\partial k^{**}}{\partial d} > 0$, different types of alliances are generated.

(i) **Easy alliance:** for $d \leq d^*$, both partners contributing resources is an equilibrium in dominant strategies.

(ii) **Alliance with coordination problems:** for $d > d^*$ and $k > k^*(d)$, there are two equilibria: the two partners contributing or none of them contributing.

(iii) **Alliance with cooperation problems:** for $d > d^*$ and $k \leq k^*(d)$, no partner contributing is an equilibrium in dominant strategies. If, within this case, $k^{**}(d) < k \leq k^*(d)$, then this equilibrium is Pareto-dominated, as in the Prisoners Dilemma.

Therefore, if the degree of market competition is sufficiently low (case (i)), the strategic interactions in the alliance pose no problems: both partners contribute resources since it is, independently of what the partner does, the best action to undertake. These are what we call the easy alliances, since they will generate always the projected benefits.

If the competition between partners in the market is stronger, however, inefficient outcomes become possible. For a certain level of competition, if complementarities are relatively high (case (ii)), partners interact as in what we call a coordination game. Although there is no real conflict of interest, it is difficult for partners to coordinate on the good outcome where both contribute. This is due to the fact that a partner only wants to contribute if it believes the other will do so as well. Intuitively, higher complementarities lead to a relatively higher payoff when contributing resources, but only if the other will contribute as well.

Finally, for a certain level of competition, if complementarities are low (case (iii)), partners will not contribute. Indeed, not contributing becomes a dominant strategy. This is because as competition becomes stronger, the gains from not contributing resources when the other has done so become more important, as this gives now an important extra competitive edge in the market where both firms are competing. Thus, it is always better for a partner to not contribute. If the complementarities are such that partners will under no circumstance contribute, but both doing so would have been more efficient, then the alliance has the same characteristics as the well-known Prisoners Dilemma.

The results are illustrated in Figure 1, where we have taken as an example $(a - c) = 1$, the cost reduction if only one firm commits, $r = 0.25$, and the cost of contributing resources to the alliance, $e = 0.1$. Case (i) corresponds to the dark area below the horizontal line ($d < d^*$, very low competition in the product markets), case (ii), in which we have the coordination game, corresponds to the dark area above the horizontal line ($d > d^*$ and $k > k^*(d)$, some competition and high synergies), whereas case (iii) corresponds to the the two lighter areas above the horizontal line ($d > d^*$ and $k < k^*(d)$, some competition and low synergies). Out of the last two, the darker area corresponds to the Prisoners Dilemma.
Figure 1: Type of strategic interaction and equilibrium alliance resource contributions as a function of the degree of competition (d) (vertical axis) and degree of complementarities (k) (horizontal axis).

2.3 Participation

Of course, firms decide whether to take part in an alliance. Therefore, in a first stage, anticipating the nature of the strategic interaction in the alliance and product market, firms decide whether to set up the alliance. If any of the two firms refuses to participate, both of them obtain the outside option (“Exit” or “E”). Thus, when a firm has to compute the expected gross profits from participating, it can already condition on the other deciding to participate. As a result, the partner decision to participate does not release any relevant information. Hence, the decision to participate can be bundled together with the decision to contribute resources. The following table describes the net profits from each combination of actions.

<table>
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<th>C</th>
<th>nC</th>
<th>E</th>
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<tbody>
<tr>
<td>C</td>
<td>( \pi^* (c - kr) - e - F, \pi^* (c - kr) - e - F )</td>
<td>( \pi^* (c - r) - e - F, \pi^* (c - r) - F )</td>
<td>( \pi^* (c), \pi^* (c) )</td>
</tr>
<tr>
<td>nC</td>
<td>( \pi^* (c - r) - F, \pi^* (c - r) - e - F )</td>
<td>( \pi^* (c) - F, \pi^* (c) - F )</td>
<td>( \pi^* (c), \pi^* (c) )</td>
</tr>
<tr>
<td>E</td>
<td>( \pi^* (c), \pi^* (c) )</td>
<td>( \pi^* (c), \pi^* (c) )</td>
<td>( \pi^* (c), \pi^* (c) )</td>
</tr>
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</table>

5In the light area below the horizontal line, resource commitments are not strategic complements, as we have assumed.
If firms now have to decide to participate in the alliance, they will only do so if they foresee a good outcome in the collaboration (and, of course, the cost of doing so is not excessively high). If firms are looking at an *easy alliance*, i.e., where they would both always contribute, they of course participate. More interestingly, when firms would face coordination problems in the alliance, they will also participate and collaborate therein. Indeed, the participation decision of one firm now signals that it will contribute, because if not it would earn less than its outside option and, hence, better stay out. Thus, the (costly) participation helps to coordinate on the best outcome in the alliance. However, when the collaboration is such that partners would face problems of cooperation, both firms know that it is best to not contribute in the alliance. Therefore, they will decide not to participate. The following proposition summarizes this reasoning.

**Proposition 2. Participating and contributing resources in the alliance**

(i) There exists a cost of entering $F^*(k, d)$ such that for the *easy alliance* and for the *alliance with coordination problems*, both firms participating and contributing is an equilibrium.

(ii) In the *alliance with cooperation problems* firms never participate.

Thus, while the participation decision helps in the coordination alliance, there is still a conflict between outcome and efficiency in the cooperation alliance. Indeed, if the participation costs are low enough, partners anticipate the incentives to free-ride on the partner once in alliance. As a result, even if the profits could be higher when participating and contributing, both of them decide not to participate.

Of course, the results results hinge on the static nature of the modeled alliance interaction, and are perhaps unsatisfactory since all formed alliance are predicted to perform well. Indeed, the main goal of our static model was to provide for micro-foundations of the two main types of alliances as identified by the alliance literature: problems of coordination and cooperation. In order for our alliance framework now also to generate more realistic outcomes, we move to a dynamic framework.

### 2.4 A dynamic alliance framework

The analysis so far has assumed that alliance partners decide only once whether to contribute resources. In reality, alliance partners interact repeatedly, can change their decisions over time, and react to partner’s past choices. For example, a partner might decide to stop

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6 Remark that not participating is also an equilibrium for any combination of parameters. This equilibrium, however, is an equilibrium in weakly dominated strategies if firms would contribute resources in the alliance and the participation costs are not large.

7 Our model has generated a third category, the *easy alliances*. While we think that these types also occur in reality, they in principle need less attention here, since they always lead to success.
contributing resources if her partner does not collaborate, and can even decide to terminate the alliance. In this section, therefore, we introduce dynamics.

A natural way to model a dynamic version is to consider an infinite repetition of our static alliance model. This would result that in each period, alliance partners decide whether to continue the alliance (or to start the alliance in the beginning), by maintaining, for example, a team of dedicated employees. If both partners choose to stay, they also have to decide whether to contribute further resources, which affect their costs of production. With the resulting production costs, firms then compete in the product market. Firms take decisions after observing past actions and anticipating future choices and payoffs. Each firm should maximize the discounted sum of stream of static profits, where the discount factor is given by \( \delta \).  

We introduce two restrictions in the dynamic setup. First, if one partner refuses at a particular moment to continue the alliance once, then the alliance has ended and cannot be restarted in a next period. In this case, both partners obtain the outside option for the remaining of the game. Indeed, in the real world, if one partner decides to exit an alliance, the collaboration is broken. Second, we assume that alliance partners choose the competitive outcome in the product market. We do this to focus on the effects of repeated interaction within the alliance and not on the effects of repeated interaction in the product market. That is, we assume away collusion in the product market and interactions between product market coordination and alliance coordination. In essence, we are assuming that competition authorities monitor effectively the product market and ensure that firms do not coordinate product market decisions, independently on whether they form the alliance or not.

Our dynamic framework leads to many more possible outcomes. Indeed, the Folk theorem states that in repeated settings every series of outcomes that yield on average as least as much as the minimax payoff in the static setup, can be sustained as an equilibrium (Fudenberg and Maskin [1986]). The minimax payoff is the payoff that minimizes the maximum harm done for a given choice. Given the payoff structure of the static framework (see Table 2), it is obvious that this is the no participation option. Indeed, by choosing not to participate, the maximum harm is clearly minimized, since participating where the other partner does not contribute lead to worse payoffs. Therefore, any series of outcomes that yield at least on average the outside option of \( \pi^* (c) \) is sustainable.

This means that now also in dynamic alliances with potential problems of cooperation, partners can actually participate and contribute. The same outcomes are of course also possible for dynamic versions of the coordination and easy alliances. However, while partners on average earn at least the outside option, it can of course occur that if inside the

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\( \delta \)This setup would be equivalent to firms maximizing their expected utility, but instead of having a discount factor facing an exogenous probability of alliance termination.
alliance, for some periods partners are alternating in some sequence between contributing and not contributing, as long as this yields on average better (or equal) results as staying out. Finally, as in the static framework, it is still possible that partners do not start the alliance in the first place. The following proposition summarizes these insights, where “SPNE” stands for subgame perfect Nash equilibrium.

Proposition 3. Dynamic alliances
(i) For any type of alliance, there exist SPNE equilibria where both partners participate in the alliance.
(ii) Any sequence of actions inside the alliance that yields on average better payoffs than the outside option can be part of a SPNE.
(iii) For any type of alliance, there exists SPNE equilibria where both partners stay out.

Thus, while our dynamic setup is now realistic enough to obtain a wide set of outcomes, we are now faced with the issue that all our alliance types can generate participation in the collaboration and contributions therein (potentially alternated with periods of no contribution), or no participation. This is of course not surprising, given that partners have a wide set of strategies over time at their disposal, given that the framework is now much richer. Therefore, we move to an experimental setting.

3 Experimental Evidence

As shown in section 2, product market competition and the complementarities between both partners affect the strategic properties of the alliance between partners. Indeed, behavior and outcomes change significantly in the static framework depending on whether firms are close competitors and whether they are a good “fit”. Proposition 1 shows that in a given period, alliance members might have incentives to free-ride on their partner or partners might face a coordination problem when choosing whether to contributing resources.

In the dynamic framework of alliances, in contrast, the successful outcomes can be sustained in both alliances with problems of cooperation and coordination. Indeed, provided that the future is not too highly discounted, free-riding and coordination problems can be averted, given that (potential) future periods in the alliance give rise to a much broader set of available strategies (see Proposition 3). More generally, the outcomes that can be sustained in equilibrium are not that different for our distinct alliance interactions. We, thus, look for better predictions using an experimental setup.
3.1 Experimental Setup

In our experimental study, we use two normal-form games with the same payoff orderings and strategic properties as the two main specifications of our static alliance.\(^9\) Remark that, for ease of exposition we will from now on call the alliance with coordination problems, “Coordination Game” or “CG”, and the alliance with cooperation problems, “Prisoners Dilemma” or “PD”. We do not use the payoffs that would arise in a specific parameter specification for two reasons. First, we use single-digit payoffs and avoid unnecessarily complex cyphers and decimals, to make the setups easy to implement in the laboratory. Second, we choose two situations with minimal payoff differences, as if we were taking a discontinuity approach. In other words, the payoff matrices of the two games are exactly identical, except for the payoff of \((nC, C)\), which is one unit larger than the payoff of \((C, C)\) in the Prisoners Dilemma and one unit smaller in the Coordination Game.

The dynamic game is implemented experimentally by assuming that ex-ante, after each period, there is a probability of termination of the infinitely-repeated game. Using a probability of termination of 0.1 we induce a discount factor of \(\delta = 0.9\). In the Coordination Game, \((C, C)\) in all periods is a SPNE play of the dynamic game, since the strategy profile \((C, C)\) is an equilibrium of the stage game. Such a play can also be sustained in an equilibrium of the PD–alliance game for the chosen value of \(\delta\), as shown in the Appendix.

We ran six experimental sessions during the Fall of 2010, three of which were CG and another three were PD alliance games. In every session subjects played only one type of stage game, either CG (table 2a) or PD (table 2b). We identify sessions with a number (1, 2, or 3) followed by either PD or CG. Dates, number of participants, and other details explained below are summarized in table 3. All sessions were run at the experimental economics laboratory (LeeX) of University Pompeu Fabra, in Barcelona, with subjects

\(^9\)Given that the predictions in the easy alliance are straightforward, we do not experimentally test this type of alliance.
Table 3: Setup of all experimental sessions. An *iteration* is one play of a repeated alliance game with a partner. *PD* sessions had the same number of iterations, each with the same number of periods as in the equally-numbered *CG* session. Mean and variance are presented as \((\text{Mean}, \text{Variance})\).

<table>
<thead>
<tr>
<th>Session</th>
<th>Date</th>
<th>Stage</th>
<th># of subjects</th>
<th># of iterations</th>
<th>Periods in each iteration</th>
<th>Mean and Variance of payoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1CG</td>
<td>13-09-10</td>
<td>CG</td>
<td>18</td>
<td>4</td>
<td>(1, 21, 12, 17)</td>
<td>(15.5, 0.01)</td>
</tr>
<tr>
<td>1PD</td>
<td>14-09-10</td>
<td>PD</td>
<td>20</td>
<td>−</td>
<td>−</td>
<td>(14.08, 1.44)</td>
</tr>
<tr>
<td>2CG</td>
<td>27-09-10</td>
<td>CG</td>
<td>20</td>
<td>6</td>
<td>(1, 12, 6, 9, 3, 4)</td>
<td>(12.74, 0.82)</td>
</tr>
<tr>
<td>2PD</td>
<td>28-09-10</td>
<td>PD</td>
<td>20</td>
<td>−</td>
<td>−</td>
<td>(11.41, 0.8)</td>
</tr>
<tr>
<td>3CG</td>
<td>22-11-10</td>
<td>CG</td>
<td>18</td>
<td>4</td>
<td>(13, 3, 5, 18)</td>
<td>(12.96, 0.97)</td>
</tr>
<tr>
<td>3PD</td>
<td>30-11-10</td>
<td>PD</td>
<td>20</td>
<td>−</td>
<td>−</td>
<td>(12.5, 1.05)</td>
</tr>
</tbody>
</table>

being students at this university of all disciplines. Pilot sessions were run at Bocconi University, in Milan. All sessions were run in English. Subjects in the laboratory were randomly matched in pairs and participated in several *infinitely* repeated game interactions. Matching, instructions, and choices were all electronically administered using the software z-tree (Fischbacher [2007]).

In line with our theoretical setup and to mimic reality (as alliances are mostly not restarted once a partner has decided to break up the alliance), we experimentally restricted subjects to the use of strategies of *E* if either player had played *E* in a previous period. In other words, if either player chose *E* in period \(t\), the software automatically registered subjects’ choices to be *E* in all consecutive periods, \(t + 1, t + 2, \ldots\). Subjects were aware of this fact.

Infinite repetition with a discount rate of \(\delta = 0.9\) was implemented through a probability of termination. This means that subjects knew that conditional on having reached a given period, the probability that this period be the last was 0.1. With a probability of termination of 0.1 in every period, the expected number of periods of duration of a repeated alliance game was 10. We will refer to each repeated alliance game within a single experimental session as an *iteration*. We warned subjects that if an iteration was ongoing two hours after the beginning of the session, a follow-up session would be scheduled at subjects’ convenience to continue play. Also, we chose to rematch subjects for a new iteration as long as the total number of *periods* played so far in the session was less than 45. Subjects were not told the exact rule of thumb, but they were told that time permitting they would be re-matched to play a new repeated alliance game.

Subjects were informed of the beginning of a repeated alliance game that they were playing with a new partner. At the beginning of every consecutive period subjects were reminded that they were still interacting with the same partner in a repeated alliance game.
Subjects were informed of the choice of their partner and their stage-game payoff at the end of every period. At the end of a period subjects were told via a message on their screens about chance’s outcome regarding the continuation of the repeated game. Either they continued on to period $t + 1$ or the current interaction finished.

The randomization deciding continuation of the repeated game was implemented by the same program running all other elements of the experiment. Therefore, in all $CG$—alliance game sessions, the number of periods of each iteration was ex-ante unknown even to the experimenters. For comparability of our two setups, we used the same realization of the random variable for the $CG$—alliance game and its sister $PD$—alliance game. Sessions are thus paired, each element being either a $CG$ or a $PD$ alliance game, both having the same number of iterations and the same number of periods per iteration, and both identified with the same number.\footnote{In addition to the repeated alliance games, we had subjects participate in one-shot alliance games in the beginning of the session and in between iterations. The one-shot games were implemented to see whether subjects played in accordance with the predictions of proposition 2. We emphasized that one-shot games were with different partners whom they would be matched with for a single period of play. While we do not report results from these one-shot interactions in this paper, they show that after early iterations, most subjects stay out of the alliance in the $PD$-alliance. In the $CG$-alliance, while most subjects contribute or stay out (the two predicted outcomes), some inefficient outcomes ($C, nC$) are observed, indicating that subjects have some difficulty to coordinate.}

In each session subjects were matched and re-matched several times with partners to play either a one-shot or a repeated alliance game. The matching was random and independent across re-matchings. In all re-matchings every subject was equally likely to be paired to every other subject (even subjects who had already been matched). An often-mentioned problem with such a matching technology is that subjects may be aware that their behavior in an early match may influence the play in a successive match, either directly (by matching again with the same partner) or indirectly (by matching with an ex-partner of an ex-partner). Instead of adopting a different matching technology, which may actually increase bias and correlations in subject behavior (see Dal Bo and Frechette [2011], and Frechette [2011]), we take into account potential differences across iterations when we analyze our data.

Our repeated alliance games (iterations) were presented as long term relationships. The stage-game actions were, respectively, Enter and Cooperate, Enter and not Cooperate, and not Enter in the alliance with the potential partner. Full instructions are given in the Appendix.
3.2 Experimental results

3.2.1 Success and Failure

We consider several dimensions of what can constitute success or failure in an alliance. First, we look at partners’ actions and alliances’ outcomes in ongoing alliances. These measures tell us whether partners contribute, both individually and jointly. The underlying idea, of course, is that the more often partners contribute, the more the alliance can be considered a success. In a second step, we check individual partner’s profits. Indeed, while overall it is better to contribute, it still may be that a partner in the Prisoners Dilemma achieves higher profits through free-riding on the other. While, this scenario can hardly be considered a success for the alliance, for a free-riding alliance member profits may still be higher. Finally, if partners feel cheated upon (in the Prisoners Dilemma) or if they do not manage to coordinate on the good outcome (in the Coordination Game), they will exit the alliance. Therefore, in a last step and in accordance with most empirical papers on the topic, we look at alliance duration, captured both by the frequency of occurrence of the choice E and by the period when this choice is first made in any given iteration.

First, for partners’ actions in an ongoing alliance, Figure 2a indicates that both in the first period and over all periods, the Coordination Game yields more positive commitment choices than the Prisoners Dilemma: C is more frequent in the CG, while NC is more frequent in the PD. These individual choices translate into better alliance outcomes, as Figure 2b illustrates. Outcome (C, C), which is joint-surplus maximizing, represents 73.33% of all period outcomes for each alliance in the CG, while only 40.27% in the PD. Outcome (nC, nC) is rare in both alliance games, but less frequent in the CG (2.43% vs.
Action in Stage Game\textsuperscript{a} & Outcome in Stage Game\textsuperscript{b} \\
\hline
$C$ & (\textit{C}, \textit{nC}) or (\textit{nC}, \textit{C}) & (\textit{C}, \textit{C})\textsuperscript{c} & (\textit{nC}, \textit{C})\textsuperscript{d} & (\textit{nC}, \textit{nC})\textsuperscript{d} \\
$\text{nC}$ & E\textsuperscript{d} & 0.4046 & 0.2668 & 0.1818 \\
$E$ & & 0.0046 & 0.0000 & 0.0076 \\
\hline
\text{K-S statistic} & 0.3786 & 0.3011 & 0.2795 & 0.4046 & 0.2668 & 0.1818 \\
\text{p-value} & (0.0000) & (0.0000) & (0.0000) & (0.0000) & (0.0000) & (0.0076) \\
\hline
\textsuperscript{a}Unit is frequency of play of an action by \textit{one subject in one iteration}. Sample: 292 in \textit{CG} and 280 in \textit{PD}. \textsuperscript{b}Unit is frequency of occurrence of one outcome (pair of actions) in \textit{one iteration}. Sample: 146 in \textit{CG} and 140 in \textit{PD}. \textsuperscript{c}One sided test with alternative hypothesis: \textit{the distribution for CG FOSD the distribution for PD}. \textsuperscript{d}One sided test with alternative hypothesis: \textit{the distribution for PD FOSD the distribution for CG}.

Table 4: Kolmogorov-Smirnov tests comparing stage game choices and outcomes across treatments (\textit{CG} and \textit{PD}).

7\% in the \textit{PD}), and the same holds for outcomes (\textit{C}, \textit{nC}) and (\textit{nC}, \textit{C}).

These differences are confirmed statistically in Table 4. In the first column, we test the null hypothesis that each subject’s frequency of play of action \textit{C} in each iteration in the \textit{CG} comes from the same distribution as the corresponding frequencies in the \textit{PD}. A one-sided Kolmogorov-Smirnov test (“K-S test”) rejects this null in favor of the alternative where the distribution for the \textit{CG} first-order stochastically dominates (“FOSD”) the distribution for the \textit{PD}. In other words, in the Coordination Game, subjects more frequently contribute in the alliance. The second column, on the other hand, rejects the null of \textit{nC} actions coming from the same distribution, and this in favor of the alternative where the distribution for the \textit{PD} first-order stochastically dominates (“FOSD”) the distribution for the \textit{CG}. Thus, subjects choose more often to not contribute in the alliance when being in a Prisoners Dilemma type of alliance. These different actions are translated in distinct outcomes. Indeed, by applying the same one-sided Kolmogorov-Smirnov tests (see the last 3 columns of Table 4), it is easy to see that the best outcome where both partners contribute (outcome (\textit{C}, \textit{C})) more often occurs in the Coordination Game, whereas all other three outcomes (\textit{(C}, \textit{C}), \textit{(nC}, \textit{C}), \textit{(C}, \textit{nC}) and \textit{(nC}, \textit{nC})) occur with a higher frequency in the Prisoners Dilemma type of alliance. Thus, actions and outcomes in ongoing alliances clearly favor the coordination alliances over those with cooperation problems.

Nevertheless, the fact that the best alliance outcome is more frequent in \textit{CG} than in \textit{PD} does not immediately imply that \textit{CG} settings lead to higher individual profits, since a sustained outcome (\textit{nC}, \textit{C}) is the most profitable scenario for a subject playing \textit{nC} in the \textit{PD}. However, profits are not higher in the \textit{PD}. This is because the advantageous outcome (\textit{nC}, \textit{C}) is not sustainable in time. Indeed the outcome (\textit{nC}, \textit{C}) in the \textit{PD} is never repeated. As reported in the upper half of Table 5, this makes that average profits in the \textit{CG} of about 4.4 are significantly higher than those in the \textit{PD} of about 3.6, \textit{even though} the maximum attainable payoff in the \textit{PD} is higher than in the \textit{CG} (when reaching
Table 5: Comparison of per-period payoffs across CG and PD

<table>
<thead>
<tr>
<th></th>
<th>CG(^a)</th>
<th>PD(^a)</th>
<th>KS Test(^b)</th>
<th>Format of Average Payoff= 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Payoff</td>
<td>4.3988</td>
<td>3.6365</td>
<td>0.3682</td>
<td>0.7192 0.3214</td>
</tr>
<tr>
<td>(0.1385)</td>
<td>(0.3040)</td>
<td>p−value&lt; 0.001</td>
<td>p−value&lt; 0.001</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Mean across all iterations of the per-period average payoff of individual subjects. In parenthesis the session-cluster adjusted standard error of estimated mean.

\(^b\)Kolmogorov-Smirnov test of equality of the distribution of per-period average payoff of individual subjects across treatments.

\(^c\)Fraction of all iterations × subjects where per-period payoff is equal to 5 (maximum possible in CG).

\(^d\)Pearson’s χ\(^2\) test of equality of frequencies across treatments.

The outcome \((nC, C)\) in PD, which gives a payoff of 6, while the best attainable outcome in the CG is \((C, C)\) with a payoff of 5; see Table 2).

On the other hand, the outcome \((C, C)\) is sustainable in time, as evidenced by the large fraction of subjects/iterations that have an average payoff equal to 5 in both treatments, but especially in the CG. If we look at the frequency of obtaining the “successful” profit of 5 where both partners contribute, the lower part of Table 5 shows that in the CG, this is obtained in about 72% of all periods, while only in about 32% of periods in the CG. The Pearson’s χ\(^2\) test of equality of frequencies shows that this difference is significant.

This leads us to alliance duration. Figure 3a shows the frequency with which action E is chosen by subjects in either alliance game. This frequency accounts for subjects’ choice to terminate the alliance (or never initiate it, if chosen in period 1), but also for how soon they make this choice. In our setup, E is automatically recorded as a subjects’ choice in every period of an iteration after either she or her partner first chooses E. Hence, the sooner the first E occurs in a given iteration, the more choices of E are recorded for the remaining periods. In the Figure it is obvious that this frequency is very different for the two alliance games, and we corroborate this statistically. We test the null hypothesis that each subject’s frequency of play of action E in each iteration in the CG comes from the same distribution as the corresponding frequencies in the PD. A one-sided Kolmogorov-Smirnov test rejects this null in favor of the alternative where the distribution for the PD first-order stochastically dominates the distribution for the CG (see column 3 in Table 4). Thus, subjects choose more often to exit PD-alliances.

Figure 3b further illustrates the difference between the two alliance games in terms of
E as a fraction of all recorded stage game choices. First period considers only choices in the first period of every iteration.

(a) $E$ as a fraction of all recorded stage game choices. First period considers only choices in the first period of every iteration.

(b) Fraction of all first choices of $E$ that happens in a given period

Figure 3: Duration, as measured by the frequency of play of action $E$ and by the period when this action is first chosen.

\begin{table}
\begin{tabular}{lcc}
\hline
Intercept & $PD$ Dummy \\
\hline
12.8310$^{**}$ & -8.9827$^{**}$ \\
(1.9199) & (1.7183) \\
\hline
\end{tabular}
\end{table}

\textit{Table 6: Interval regression of exit time on alliance game type.} The interval regression takes into account that exit times are truncated by the randomly-determined duration of the iterations. Iteration and session controls included in the regression but not reported. The sample has 286 observations, of which 188 are right-censored.

We conclude that the type of interaction faced by partners in an alliance – either $CG$ or $PD$ – significantly affects its chances to succeed. Indeed, partners’ choices and alliance outcomes are clearly more conducive towards contributing in the coordination alliances. These better choices and outcomes feed into higher individual profits, and lead coordination alliances to have a longer duration. We now explore partners’ strategies over time to further understand how problems of coordination are easier overcome than problems of cooperation.
Figure 4: Frequency of play of each action in period $t$ after each possible outcome in period $t-1$, divided by type of alliance game. Outcomes involving a choice of $E$ are always followed by $E$ (automatically) and are therefore not considered.

### 3.3 Partners’ strategies

We now further explore the distinctive determinants of success for the CG and PD alliances by more closely investigating partner’s strategies. Mainly, we wish to know how subjects behave over time or as a reaction to past behavior and where exactly this strategic behavior is different depending on the alliance game played. We have experimental data that allow us to study the dynamics of alliance success and termination at a high level of detail, which allows for a deeper understanding of alliance dynamics.

We do this by analyzing the strategies that subjects in our experiment are playing. These strategies are given by a specification of action in the first period of an iteration and a reaction to every possible history for later periods. We start with subjects’ choice in period $t$ as a function of the outcome in period $t-1$ of an ongoing alliance (i.e. subjects are continuing in period $t$ the same iteration as in period $t-1$).\footnote{\begin{itemize} \item One could also have looked at current choices as a function of both partner’s past choices. But this information is included in past outcomes, so we prefer the latter. \end{itemize}} Figure 4 shows frequencies of different reactions to previous-period outcomes. One can see that for both CG and PD alliances, reactions to particular outcomes seem to be rather similar for both types. It can be seen especially that, for both alliance interactions, if the two partners have contributed

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4}
\caption{Frequency of play of each action in period $t$ after each possible outcome in period $t-1$, divided by type of alliance game. Outcomes involving a choice of $E$ are always followed by $E$ (automatically) and are therefore not considered.}
\end{figure}
in the previous period, they keep on doing so with a frequency of almost 100%. Responses
to other outcomes are more varied, but not different across alliances. In fact, for each
outcome in period \( t - 1 \) we compare the choice of action in period \( t \) for the two treatments
using Pearson’s \( \chi^2 \) test and are never able to reject the null hypothesis of independence.

The multinomial logistic regressions reported in table 7 study in more detail subjects’
strategies, allowing for reaction to past outcomes. The dependent variable is a subject’s
choice, whereas the independent variables are the different outcomes in the previous period,
the alliance type (\( CG \) or \( PD \)), and the outcomes interacted with the alliance type. Table 7
first confirms that a subject’s choices are indeed influenced by past outcomes. Indeed, the
first two columns show that any other outcome than \((C, C)\) leads not contributing \((nC\)
in the first column) and exit \((E\) in the second column) to become a more likely choice than
contributing \((C)\). Furthermore, any other outcome than \((C, C)\) leads subjects to more
likely exit the alliance than to not contribute (see the third column). However, the type
of alliance does not make contributing more or less likely. Indeed, the categorical variable
\( PD \) is insignificant in all three shown regressions. Finally, and most importantly, when

Table 7: Multinomial Logistic regression of choice in the current period as a reaction to
the partnership’s choices in the previous period. Base is varied to allow for comparison
between all choices. All regressions include controls for session and iteration effects.

<table>
<thead>
<tr>
<th></th>
<th>Base: ( C )</th>
<th></th>
<th>Base: ( nC )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( nC )</td>
<td>( E )</td>
<td>( nC )</td>
</tr>
<tr>
<td>Intercept</td>
<td>-4.0048**</td>
<td>-20.031**</td>
<td>-16.026**</td>
</tr>
<tr>
<td></td>
<td>(0.3914)</td>
<td>(0.6374)</td>
<td>(0.7022)</td>
</tr>
<tr>
<td>Partnership play last period(^a)</td>
<td>4.2229**</td>
<td>19.465**</td>
<td>15.242**</td>
</tr>
<tr>
<td></td>
<td>(0.8268)</td>
<td>(0.7286)</td>
<td>(0.8790)</td>
</tr>
<tr>
<td>( [nC, C] )</td>
<td>4.8849**</td>
<td>18.752**</td>
<td>13.867**</td>
</tr>
<tr>
<td></td>
<td>(0.7463)</td>
<td>(0.6806)</td>
<td>(0.8641)</td>
</tr>
<tr>
<td>( [nC, nC] )</td>
<td>6.7754**</td>
<td>22.640**</td>
<td>15.865**</td>
</tr>
<tr>
<td></td>
<td>(0.5266)</td>
<td>(0.7437)</td>
<td>(0.7149)</td>
</tr>
<tr>
<td>( PD ) Dummy</td>
<td>0.5018</td>
<td>-0.5097</td>
<td>-1.0114</td>
</tr>
<tr>
<td></td>
<td>(0.7872)</td>
<td>(0.9746)</td>
<td>(0.9982)</td>
</tr>
<tr>
<td>( Interaction: )</td>
<td>( [C, nC] )</td>
<td>0.6194</td>
<td>0.1728</td>
</tr>
<tr>
<td></td>
<td>(1.1047)</td>
<td>(1.2555)</td>
<td>(1.2399)</td>
</tr>
<tr>
<td>( [nC, C] )</td>
<td>-0.2721</td>
<td>0.6349</td>
<td>0.9071</td>
</tr>
<tr>
<td></td>
<td>(0.8890)</td>
<td>(1.0067)</td>
<td>(1.1145)</td>
</tr>
<tr>
<td>( [nC, nC] )</td>
<td>-1.2123</td>
<td>-1.5089</td>
<td>-0.2967</td>
</tr>
<tr>
<td></td>
<td>(1.1155)</td>
<td>(1.2077)</td>
<td>(1.0032)</td>
</tr>
</tbody>
</table>

\(^a\) Profile of strategies played by partners last period. Base profile is \([C, C]\).

\(^*\) Significant at the 1% level.
we interact the type of alliance with the outcomes in the previous period, we see that these interaction effects are never significant. In other words, while reactions are different according to distinct outcomes in the previous periods, these reactions are similar for both the CG and PD alliances.

On the other hand, both Figure 5 and $\chi^2$ tests show that subjects choose significantly different actions (leading to significantly different outcomes) in the first period of each iteration. Our data thus strongly suggest that the difference in duration and profitability of the two types of alliances is solely driven by a difference in choices in the first period of interaction.

---

12For first period actions, the null of independence is always rejected except when we restrict attention to behavior in the first iteration of a session ($p$-value 0.061). For outcomes the null is rejected for all iterations separately and jointly.
4 Conclusion

We presented a framework to analyze alliances. Our static game-theoretical model first showed that, depending on the degree of alliance complementarity and product market competition, the strategic interaction in the alliance shows either problems of coordination or cooperation. Given that alliances are not typically a one-time event, we then presented a theory of dynamic alliances where firms can each period decide to terminate the relationship. However, while this is a more realistic setting, our dynamic framework yields multiple outcomes that cannot distinguish between different alliance types. Given that theory cannot guide us which situations are more conducive to alliance success, we, therefore, conducted an experiment where we compared the two types of alliances in a dynamic setup.

We found that on average coordination alliances perform better in all dimensions (choices, profits and duration) than alliances with problems of cooperation, due to partners cooperating more often from the start of the alliance. Thus, interestingly, the dynamics of both types of games are similar: initial cooperation breeds trust, whereas initial no-cooperation leads to un-repairable distrust and alliance break-up.

There are several managerial implications. First, partners need to get it right from the start. The most easy way to do this is to set up an alliance where complementarities are high and partners do not directly compete. This setup naturally induces partners to better cooperate. However, if this is not possible and an alliance can only be formed with partners that are less suited, mechanisms need to be set in place where partners are induced to cooperate. Indeed, once cooperation has been started, partners quickly develop the necessary trust to stick to cooperation, even if the temptation is high to cheat.

References


5 Appendix

Proof of Proposition 1

Consider the row firm in Table 1. Notice first that the profits in \((C, nC)\), gross of the participation costs, are larger than those of \((nC, nC)\) if and only if

\[
\left( \frac{a - c + r}{2 + d} \right)^2 - e \geq \left( \frac{a - c}{2 + d} \right)^2,
\]

or rewriting in terms of \(d\),

\[
d \leq d^* \equiv \max \left\{ \sqrt{\left( \frac{a - c + r}{2 + d} \right)^2 - \frac{(a - c)^2}{e}} - 2, 0 \right\}. \tag{3}
\]

If this condition is satisfied, then committing resources is a dominant strategy if and only if

\[
\left( \frac{a - c + kr}{2 + d} \right)^2 - e \geq \left( \frac{a - c + r}{2 + d} \right)^2,
\]

or rewriting in terms of \(k\),

\[
k \geq k^* \equiv \sqrt{\left( \frac{a - c + r}{2 + d} \right)^2 + \frac{e(2 + d) - (a - c)}{r}}. \tag{4}
\]

in which case \((C, C)\) is an equilibrium in dominant strategies. If (3) is satisfied but (4) is not, then committing is preferred than no committing if the other does not but not committing is better when the other does. As a result, we have two asymmetric equilibria, in which one commits and the other does not.

Suppose now that (3) is not satisfied. If (4) is satisfied, then committing is preferred than no committing if the other commits but not committing is better when the other does
not. As a result, there are two equilibria: one in which both commit and the other in which both do not. If instead, (4) is not satisfied not committing is a dominant strategy. Within this case, the equilibrium \((nC, nC)\) is Pareto dominated by \((C, C)\) if
\[
\left(\frac{a-c+kr}{2+d}\right)^2 - e \geq \left(\frac{a-c}{2+d}\right)^2,
\]
or rewriting in terms of \(k\),
\[
k \geq k^{**} \equiv \sqrt{\frac{(a-c)^2 + e(2 + d) - (a-c)}{r}},
\]
Clearly, \(k^{**} < k^*\).

**Proof of Proposition 2**

Notice that not participating is always an equilibrium, possibly in weakly dominated strategies, as one’s profits do not change with any action if the other decides not to participate. Notice that, if in the second stage, \((nC, nC)\) is the SPNE, then participating in the alliance is not chosen by any of the partners because the net profits are strictly reduced by the participation costs.

Participating is an equilibrium if \((C, C)\) is an equilibrium in the second stage and
\[
F \leq F^* \equiv \left(\frac{a-c+kr}{2+d}\right)^2 - e - \left(\frac{a-c}{2+d}\right)^2,
\]
whereas it is an equilibrium if \((C, nC)\) is an equilibrium in the second stage and
\[
F \leq F^{**} \equiv \left(\frac{a-c+r}{2+d}\right)^2 - e - \left(\frac{a-c}{2+d}\right)^2,
\]
Clearly, \(F^{**} < F^*\).

**Cooperation in equilibrium in the experimental PD-alliance game**

Given the induced utility function,
\[
P_i \left(\left(a^{t}\right)_{t=1}^{\infty}\right) = \sum_{t=1}^{\infty} (0.9)^{(t-1)} p_i (a_{1t}, a_{2t}),
\]
we show below that play of \((C, C)\) forever can be sustained in equilibrium with a strategy specifying play of \(C\) for history \(h_1 = \emptyset\), a play of \(E\) at every history except those where \(C\) was played in all previous periods, and a play of \(C\) at every history where \(C\) was played in
all previous periods.

Take the most profitable deviation for player 1 from the strategy specified below. This would require him to play $nC$ at some point $t$, with the corresponding response of player 2. This deviation would yield the payoff on the left-hand side below. We want to show that it is less than the payoff from not deviating and, hence, achieving a play of $(C, C)$ forever, which is the payoff on the right-hand side below:

$$
\sum_{\tau=1}^{t-1} (0.9)^{\tau-15} + (0.9)^{t-1}6 + \sum_{\tau=t+1}^{\infty} (0.9)^{\tau-13} \leq \sum_{\tau=1}^{t-1} (0.9)^{\tau-15} + (0.9)^{t-1}5 + \sum_{\tau=t+1}^{\infty} (0.9)^{\tau-15}.
$$

This inequality simplifies to the following expression, which is clearly satisfied for all $t$.

$$(0.9)^{t-1} \leq 2 \sum_{\tau=t+1}^{\infty} (0.9)^{\tau-1} \Rightarrow 1 \leq 2 \sum_{\tau=t+1}^{\infty} (0.9)^{\tau-t} = 2 \sum_{\tau=1}^{\infty} (0.9)^{\tau} = \frac{0.9}{0.1} = 18.$$

Analogous calculations can show that strategies leading to a play of $(nC, nC)$ forever cannot be a SPNE of neither repeated game ($PD$ nor $CG$). However, equilibria are possible where $(nC, nC)$ is played at some $t$ but not all.

**Experimental Instructions**

Subjects in our experiment were given instructions on different screens of the game, embedded in the z-tree program where their choices were also made. The following paragraphs appeared on separate screens. Wherever relevant, we indicate transitions between screens:

**WELCOME to the Alliance experiment**

- You will be asked repeatedly whether you want to form an alliance with a given partner and, if the alliance is formed, whether you wish to cooperate or not with your partner.

- During the experiment you will be matched with several different partners. With the first two (2) partners you will interact only once. Each time, your partner will be randomly chosen among all subjects in the room.

- With your third partner you will establish a long-term relationship: he/she will remain your partner until a random variable determines the end of the relationship. If this happens early on in the experiment, you will be matched with a new (fourth) partner for another long-term relationship, and so on.
• Each long-term relationship will last for an unknown number of periods. At the end of every period the computer randomly decides whether the relationship will end or continue for one more period. The probability of ending is 10% and that of continuing on to the next period is 90%.

IMPORTANT: If in two (2) hours the experiment has not yet ended, we will agree to meet again and continue play some other day.

All payoffs for your and your partner’s decisions are given in Francs. You accumulate payoff in Francs until the end of the experiment. You will then receive 1 Euro for every 25 Francs you made in the experiment. You will also receive a 5 Euro show-up fee in addition to your experimental payoff.

Instructions specific to the one-shot games:

Your partner for this game will only play with you ONCE.

You must choose one of the following options:

• Enter in an alliance with your partner and cooperate while in the alliance.

• Enter in an alliance with your partner and not cooperate while in the alliance.

• Not enter in an alliance with your partner.

Your payoffs depend on your choice and your partner’s choice:

• If either you or your partner chooses NOT to enter the alliance, each one of you gets 3 Francs.

• If you and your partner both choose to enter, the alliance is formed and payoffs will depend on your choice to cooperate or not.

• If in the alliance you choose to cooperate and your partner not, you receive -1 Francs, while your partner receives 6 Francs. Vice-versa if your partner cooperates while you don’t.

• If both you and your partner choose to cooperate, each one of you receives 5 Francs.

On the following screen subjects saw the payoff table and played game one. After seeing their payoff from game one, subjects came to a next screen where they were reminded that they had a new partner and played a second one-shot game (game two). They next faced the instructions for the repeated game (game three):

You will now start a long-term relationship
From now on you will interact repeatedly with the same partner until chance determines the end of your relationship.

Your partner for this long-term relationship has been randomly chosen among all the subjects of this experiment.

The length of this relationship is unknown. At the end of every period the computer randomly decides whether it will end or continue. The probability that it will decide to end is 10%, while with 90% probability it will decide to continue to the next period.

If by chance this long-term relationship is relatively short, you will proceed to form a new long-term relationship with a different partner. On the other hand, if it is very long, you may be asked to return on a different day to continue your interaction.

**Your payoffs depend on your choice and your partner’s choice:**

- If either you or your partner chooses NOT to enter the alliance, each one of you gets **3 Francs forever!**

**NOTICE:** If in one period you or your partner choose NOT to enter the alliance, you will not be given the opportunity to choose again in future periods. This choice means that your payoff in every remaining period of the relationship will be equal to 3 Francs.

- If you and your partner both choose to enter, the alliance is formed and payoffs will depend on your choice to cooperate or not.

- If in the alliance you choose to cooperate and your partner not, you receive **-1 Francs** while your partner receives **6 Francs**. Vice-versa if your partner cooperates while you don’t.

- If both you and your partner choose to cooperate, each one of you receives **5 Francs**.
  If both you and your partner choose not to cooperate, each one of you receives **0 Francs**.

*On the following screen subjects saw the payoff table for the long-term relationship plus warnings for its start:*

**Long-term Relationship**

- You will now start a long-term relationship.

- From now on you will interact repeatedly with the **same** partner until chance determines the end of your relationship.
Subjects who chose or their partners chose not to enter the alliance in some past period, did not have an opportunity to choose again and were instead given the following screen:

Your partnership was ended in a previous period. Hence, you cannot make any choices this period.