Mergers and Acquisitions: An Experimental Analysis of Synergies, Externalities and Dynamics*

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Abstract

Mergers and acquisitions improve market efficiency by capturing synergies between the firms. However, takeovers between firms also impose externalities (both positive and negative) on the remaining industry. This paper describes a new equilibrium concept designed to explain and predict mergers in this setting. We experimentally compare the new equilibrium concept to that of competing concepts in situations without and with externalities. We also examine the dynamics of takeovers and outcome implications of those dynamics. Our experimental results support the predictions of the new equilibrium concept and provide an organizing explanation for previously observed inconsistent results in event studies.

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Keywords: Mergers, Acquisitions, Synergies, Externalities, Dynamics, Experiment, Bargaining

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Mergers and acquisitions (or takeovers) are an important means through which companies achieve economies of scale, remove inefficient management, or respond to economic shocks. The ultimate goal of a takeover is to realize synergies, but how the synergies are divided between shareholders of the involved companies is still an open question. In this paper we will describe and experimentally test three competing equilibrium solutions that predict how synergies will be shared among merging firms. A second critical question in takeovers concerns the existence of externalities – the effect of two firms merging on a third's value. A second set of experiments will investigate the ability of competing equilibrium predictions to predict how synergies will be shared when externalities are present. The dynamics of takeovers – the order in which multiple takeovers are predicted to occur over time – is another issue that we address. The event-study literature on mergers have investigated whether the sequence of mergers influence the value of (non-) participating firms in a mergers, producing seemingly contradictory results. One of our objectives in this paper is to use our data to reconcile these previous results.

Mitchell and Mulherin (1996) and Andrade, Mitchell, and Stafford (2001) argue that external industry shocks often lead to a wave of consolidation through mergers and acquisitions. For example, they argue that the merger activity in the 1990s was clustered in industries such as telecommunications, banking, and media as a result of technological and regulatory shocks. The dynamics or sequencing of takeovers following an economic shock is a relevant empirical question that we experimentally address in this paper. For example, during the 1990s merger wave there were 3,180 takeovers in the U.S. among publicly traded acquirers and targets, involving a total of 2,078 acquirers. Interestingly, half of the takeovers where made by 24 percent of acquirers making multiple acquisitions (at least two acquisitions). Moreover, 13 percent of acquirers eventually became targets of an acquisition during the same period.[1] Therefore, in well over half of the deals in the 1990s, three or more firms eventually ended up merging after a sequence of takeovers.[2] One of the contributions of our paper is to show experimentally that the sequencing of mergers is not random, and can be predicted based on the values of the synergies created through competing mergers.

Empirical evidence also suggests that takeovers often impose externalities (positive or negative) on the remaining firms in the industry. Positive externalities occur in mergers for market power, when two (large) firms merge and the industry becomes less competitive and more concentrated. An example of this situation is the merger announcement by two German banks on July 21st, 1997 to create the second largest bank in Germany, HypoVereinsbank AG (the merger was completed in

[1] Source: The Thomson Financial SDC Platinum database.

[2] The sequencing of mergers can also be illustrated by several high profile mergers: in pharmaceutical, the Glaxo-Wellcome (1995) and Glaxo-SmithKline mergers (2000); in telecommunications, the Bell Atlantic-NYNEX (1996) and Bell Atlantic-GTE mergers (1998), and the SBC-Pacific Telesis (1996) and SBC-Ameritech mergers (1998); in media, the AT&T- Tele-Communications Inc. (1998) and AT&T-MediaOne mergers (1999).

1998). Following the original announcement the stock price of both companies increased by more than 35%, indicating positive synergies, and the three largest competitors also gained between 12% and 21% while the index (DAX) improved only about 5%. The merger thus seems to have created positive externalities for those banks not included in it. Alternately, negative externalities occur when the merger creates a strong competitor that may drive non-merger participants out of the market. For example, this is the case if the merger decreases marginal costs of production or lead to more aggressive strategies like predatory pricing, which reduce profits of remaining (unmerged) firms. The empirical study of Banerjee and Eckard (1998) illustrate the existence of negative externalities associated with mergers. They show that during the great merger wave of 1897-1903 competitors suffered significant value losses.[3]

This paper experimentally addresses the question of how synergies are shared between the merging firms, with and without externalities, and dynamics of takeovers in an industry, i.e. the path of mergers and the payoffs resulting from those paths. Our experimental design involve three firms who can merge with others in their industry either sequentially or simultaneously and allow us to distinguish between competing bargaining theories to explain how surplus is shared in takeovers. Those theories – the Nucleolus, the Shapley value (and Myerson-Shapley value), and the coalitional bargaining value – are summarized in the next sections.

We would like, of course, to examine these questions in the field. However, in practice the existence, size and division of synergies are often uncertain or unknown. Synergies are typically estimated using adjusted stock market returns but this does not allow the researcher to differentiate between uncertainty about the synergies, outside options and externalities on the one hand and whether the final outcome of a takeover as well as the division of the synergies are as predicted on the other. This has led to competing and/or inconsistent results in field data. For example, Agrawal and Jaffe (1995) find that acquiring firms lose about 10% of their value over the first five years after the merger, and claim that synergies from takeovers are systematically overestimated. In contrast, the results of Franks, Harris, and Titman (1991) find no significant underperformance of acquirers. These mixed results suggest that experimental evidence may be useful in investigating the question of how synergies are shared between firms involved in takeovers.[4]

Clearly, how synergies are shared will depend on the bargaining process leading up to the merger. Previous empirical and theoretical studies have focused mostly on the conditions under which a bargaining process starts and proceeds. For example, Singh (1998) and Burkart (1995) demonstrate how the bidder's initial stake (toeholds) leads to overpaying. Stulz, Walkling, and Song

[3]Note that this early merger wave happened before regulations on mergers were in place.

[4]The existence of synergistic gains rules out a simple transfer of wealth between acquirer and target which is the main argument of the hubris hypothesis (Roll 1986). However, even with synergistic gains it is interesting to analyze how these gains are split up between the involved parties.

(1990) show empirically that the target's share of the total takeover gain depends on the distribution of ownership of the target; managerial ownership increases returns whereas institutional ownership decreases returns. Giammarino and Heinkel (1986) find that value-maximizing behavior with asymmetric information about potential synergies can cause overbidding and the initial rejections of bids. While some work has been done investigating the question of bargaining in the field, our laboratory setting will enable us to directly observe the bargaining process leading up to each merger outcome.

We are not the first to run experiments to investigate questions in finance. Sunder (1995) provides a review of earlier finance experiments, most of which focused on information aggregation in markets. Bloomfield (1996), Bloomfield and O'Hara (1998, 1999, 2000) and Schnitzlein (1996) use experiments to compare different market structures or environments and to test microstructure theories. Weber and Camerer (1998) and Gneezy, Kapteyn, and Potters (2002) use experiments to test competing theories of asset allocation.

One major advantage of experiments is the ability to control and vary parameters. In particular, we present six experiments, varying the synergies and externalities to study their effects on the bargaining process and outcomes. We limit our analyses to situations with three existing companies, each represented by one owner-manager.[5] Each company may remain independent, merge with one other company or merge with two other companies. We use the variation in synergies and externalities to construct situations in which competing bargaining theories make different predictions of how the synergies will be divided among the companies. We can then present evidence to test these theories, and to judge which is a better predictor of actual outcomes.

Two previous experiments address takeover-related questions, both focusing on shareholder reactions to tending bids. Kale and Noe (1997) study the effect of unconditional and conditional tender offers. They find, despite the presence of free riding, takeovers succeed at premiums that are less than the post-takeover value. Since the tendering probability is not as sensitive as expected, this paper raises the question of how the surplus of a takeover would be split between the involved parties if they could negotiate without any restrictions. Our paper investigates this very question. Cadsby and Maynes (1998) also examine the question of shareholder tendering using asymmetric shareholders. They find that shareholders tender only a proportion of their shares, with large shareholders tendering relatively more shares.[6] In contrast to these two experimental

[5]This design eliminates both toehold considerations and principal-agent problems which can result from a separation of ownership and control.

[6]Lindqvist and Stennek (2001) study coalition formation in a different experimental setting with one buyer and two sellers. They look at simultaneous and sequential acquisition games but find no significant differences between the two. However, in their experiment the roles of buyer and seller are fixed and buyers can make only one offer to both sellers which can be accepted or rejected. Hamaguchi, Hirota, Kawagoe, and Saijo (2002) study the free-rider problem with and without toeholds in an experiment.

studies, we use a single decision-maker bargaining model to investigate the sharing of synergies and the dynamics of mergers. This seems realistic, as mergers are usually negotiated between the involved managers and thus free-riding is mostly absent. Thus, in contrast to the previous focus on agency problems in mergers, this paper highlights the important role of strategic elements and studies the process of decision making of managers in this environment.

Previous research has also tested the competing equilibrium theories that we test. Early work in this area can be found in Kahan and Rapoport (1984). More recently, Bolton, Chatterjee, and McGinn (2003) experimentally rejected both Myerson's Shapley value (Myerson 1977) and the modified core in three way coalition formation in the presence of communication. Similarly, Michener and Myers (1998) have shown that the Myerson-Shapley value does a poor job of predicting outcomes in cooperative games with an empty core. Unlike these previous papers, in our experiment we allow for takeovers to occur sequentially, that is, one firm might take over another and then a third firm might take over this newly created first firm. In contrast, in this previous work, once a single takeover has occurred there is no possibility of future takeovers. In reality, takeovers can and often do occur sequentially as in the examples mentioned above.

There are three main results of our experimental study. First, in settings without externalities, the coalitional bargaining value outperforms the Nucleolus and the Shapley value as a predictor of how synergies are shared. Second, in settings with externalities, the coalitional bargaining value also outperforms its nearest competitor, the Myerson-Shapley value. Finally, we explore the dynamics of takeovers and the value implications from those dynamics. Our results help to organize previous inconsistencies in the literature on event-studies of mergers and acquisitions (e.g. Banerjee and Eckard 1998, Eckbo 1983 and Stillman 1983) by identifying situations in which significant changes in values will and will not be observed.

The article is organized as follows. The next section contains a summary of the competing theoretical solutions. The experimental design and procedures are presented in section 2. We present our experimental results without and with externalities in sections 3 and 4, respectively. The dynamics of mergers and their payoff implications are analyzed in section 5. Conclusions and remaining questions are described in the final section 6.

1 Competing Equilibrium Predictions

As mentioned in the introduction we analyze situations in which three firms can merge. Two-way takeovers are possible as well as a three-way takeovers. In addition, our setting allows for two consecutive two-way takeovers to reach a final state with one unified firm.

In this section we summarize the three solution concepts that make unique point predictions about how the synergies will be shared in this experimental setting: the Nucleolus (Schmeidler 1969), the Shapley Value (Shapley 1953) and the Coalitional Bargaining Value (CBV) (Gomes 2001a,b).[7] We begin here with the case of no externalities, and extend our analyses to include externalities in section 4.

The takeover synergies are described by the following parameters, also known as the characteristic function of the game: We denote the stand-alone payoffs of each firm as v_i and normalize them to zero.[8] The values of merged companies AB, AC, and BC are, respectively, V_{AB}, V_{AC}, and V_{BC} (all positive), and the value of the ABC firm is V (where $V > V_{AB}, V_{AC}, V_{BC}$).

1.1 The Nucleolus

Schmeidler (1969) first introduced the concept of the nucleolus.[9] Kohlberg (1971) then showed that the nucleolus is a piecewise linear function of the characteristic function of the game, and Brune (1983) computed the nucleolus for all regions of linearity for three-person games like the ones we run here. According to Brune (1983), when without loss of generality we assume $V_{AB} \geq V_{AC} \geq V_{BC}$, that piecewise linear function is described in Table 1.

Table 1: The Nucleolus (Brune 1983)

The value of each firm as calculated using the Nucleolus solution concept under varying assumptions of the values of the varying coalitions.

Nuc_A	Nuc_B	Nuc_C	**when**
$\frac{V}{3}$	$\frac{V}{3}$	$\frac{V}{3}$	$V_{AB} \leq \frac{V}{3}$
$\frac{(V+V_{AB})}{4}$	$\frac{(V+V_{AB})}{4}$	$\frac{(V-V_{AB})}{2}$	$V_{AB} \geq \frac{V}{3}$ and $V_{AB} + 2V_{AC} \leq V$
$\frac{(V_{AB}+V_{AC})}{2}$	$\frac{(V-V_{AC})}{2}$	$\frac{(V-V_{AB})}{2}$	$V_{AB} + 2V_{BC} \leq V$ and $V_{AB} + 2V_{AC} \geq V$
$\frac{(V+V_{AB}+V_{AC}-2V_{BC})}{3}$	$\frac{(V+V_{AB}+V_{BC}-2V_{AC})}{3}$	$\frac{(V+V_{AC}+V_{BC}-2V_{AB})}{3}$	$-V_{AB} + 2(V_{AC} + V_{BC}) \geq V$
$\frac{(V+2V_{AC}+V_{AB}-2V_{BC})}{4}$	$\frac{(V+2V_{BC}+V_{AB}-2V_{AC})}{4}$	$\frac{(V-V_{AB})}{2}$	$V_{AB} + 2V_{BC} \geq V$ and $-V_{AB} + 2(V_{AC} + V_{BC}) \leq V$

Although, the nucleolus concept is piecewise-linear, its intuitive meaning is hard to grasp. Maschler

[7]We will not examine the core or other solution concepts that make multivalue predictions.

[8]The restriction to 0-normalized games is without any loss of generality, because any game is strategically equivalent to the 0-normalized game $V' = V - v_A - v_B - v_C$, $V'_{AB} = V_{AB} - v_A - v_B$, $V'_{AC} = V_{AC} - v_A - v_C$, and $V'_{BC} = V_{BC} - v_B - v_C$. The equilibrium payoff of player i in the general game (V_i) is i's equilibrium payoff in the 0-normalized game plus v_i.

[9]Schmeidler (1969) proved that for any game with a nonempty core, the nucleolus of any characteristic function game exists and is a unique point in the core.

(1992) provides an intuitive description of the principles behind the nucleolus. The idea involves minimizing the excess that each possible merger earns over its next-best alternative.

1.2 The Shapley Value

Shapley (1953) first introduced the concept of the Shapley value. The solution begins with axioms of linearity, symmetry, and efficiency. Shapley then proved that the value was the unique solution satisfying these properties. The Shapley value for a three-player (0-normalized) game is simply given by the formula

$$Shap_i = \frac{1}{6}\left(2V - 2V_{jk} + V_{ij} + V_{ik}\right),$$

where i, j and k denote distinct players. Intuitively, this solution can be described as awarding to each player the marginal contribution made by joining the already-existing merged firm, averaged over the possible ways which the takeovers could occur.

1.3 The Coalitional Bargaining Value (CBV)

Gomes (2001a,b) introduced the CBV, based on a non-cooperative game theory model of coalition formation. In this model, firms are randomly chosen to make offers to buy other firms, who can accept or reject the offers.[10]

One main result from Gomes (2001a) is that the CBV coincides with the Nucleolus for any characteristic function game when the synergies from two-way mergers are low relative to the synergies from the three-way merger ($V_{AB} + V_{AC} + V_{BC} \leq V$). In contrast, when the synergies from two-way mergers are high relative to the synergies from the three-way merger, the CBV coincides with the Shapley value ($V_{AB} + V_{AC} + V_{BC} \geq V$). Predictions of the CBV in situations involving externalities are described in section 4 below.

These predictions of the CBV form the basis of our first two experiments. In section 3, we will examine these two situations without externalities, and compare the predictions of the CBV against the predictions of competing equilibrium concepts. Within each of these regions, we will choose parameters that maximize the differences between the CBV and the competing equilibrium concept. In section 4, we will extend our analyses to include cases with externalities.

[10] The model is similar to the two-player model of Rubinstein (1982), but differs in that it accommodates negotiations with an arbitrary number of agents and coalitions can be gradually formed.

2 Experimental Methods and Procedures

Participants were 138 undergraduate and graduate students from multiple universities in the Boston area. Participants were solicited through advertisements in campus newspapers. The experiments were run in the experimental lab at Harvard Business School. Participants attended one of six experiments, with 18 to 27 participants in each. Each experiment included five repetitions of a given set of parameters (described below) and lasted 90 to 120 minutes. Participants were paid a base rate of US$ 15 for their participation, plus incentive pay based on their earnings in a randomly selected round. Incentive pay ranged from US$ 0 to US$ 27.50.

Each participant was randomly assigned to play one of three roles with the same parameters five times, each time with different partners. Thus we have 230 observations in our data set.[11] Each experiment was run in a single session with the same three experimenters attending.[12] Aside from the particular parameters unique in each of the six experiments, procedures were identical across all sessions.

Upon arrival, participants were asked if they knew any of the other participants. Those indicating that they did were assigned the same role so that they would never play against one another. Each participant was assigned to play one of three roles (Axel.com, BRing.com, or Cparts.com), and played the same role for all five rounds. All play was anonymous. No names were used, and the players were instructed not to reveal their identity during the negotiation.[13] Participants were seated at individual monitors in the computer lab, with partitions between the computers so that no one could see anyone else's screen. Partners were rotated such that no player ever played another in more than one round. The payoffs in each round were independent of those in all other rounds, i.e., there were no carryovers in earnings across rounds. The participants were not told how many rounds they would play. Final earnings were determined by a lottery selecting one round to be paid after the last round.

After the participants were seated at the monitors, the experimenters handed out written information about the exercise to all participants. A sample of this information is included in Appendix A.[14] In the written materials, participants were told that each of them represented a business-to-business Internet company, and that "the consensus among analysts is that acquisitions and consolidations in the B2B sector are opportunities for creating greater value in the marketplace. Specifically, Axel.com, BRing.com, and Cparts.com have all independently concluded that there

[11] Since we found no evidence of learning, we will pool all data for each experiment in our analyses.

[12] Our thanks to Nicole Nasser and Nick McKinney for their assistance in data collection.

[13] Our procedure involved saving transcripts of the negotiations as they unfolded. No instances of revelation of personal identity were found in these transcripts, thus we conclude that the negotiations were indeed anonymous.

[14] A full copy of the experimental materials is available by request at kmcginn@hbs.edu.

are quantifiable synergies that could be achieved by combining operations." To successfully consolidate, they would have to agree on who would be included in the consolidation and how much each included company would earn. They were provided with the set of possible earnings to be divided among the merging companies, which varied by the different combinations of companies included. These parameters are described in sections 3 and 4, below. Though formally only one company in a consolidation could be the acquirer, the potential synergies varied only by who was included in the final consolidation, not who played the role of acquirer.

When the participants finished reading the materials describing the exercise and the payoffs, they completed a quiz to ensure their understanding of the game. An example of the quiz is included in Appendix B. Two participants (out of 138) were unable to correctly answer the questions on the quiz and were replaced with alternates. All other participants correctly answered the questions.

After all participants were familiar with the exercise, and had successfully completed the quiz, there was a brief tutorial on the use of the web-based software used for communication. A sample screen is shown here as Figure 1.

The software was programmed to connect the three players for a given round, and to ensure that no player ever played the same person more than once.[15] The game screen used for playing each round included an input box for all communication other than offers, offer boxes to input offers, and a communication box which showed the communication of the other players in the group.[16] Outstanding offers were noted in a separate box, in red. This box included accept and reject buttons. Accepted offers were recorded in a separate location on the screen. When the participants were comfortable with the software, the rounds began.

All communication – discussion as well as offers and acceptances/rejections – was public information.[17] When a party wanted to make an offer, she selected the players to be included in the takeover, and specified the earnings for each of the included players. Offers remained active for 15 seconds. Only one offer could be outstanding at a time. If the offer was not accepted or rejected by the end of the fifteen seconds, it was automatically withdrawn. If an offer was made to two firms simultaneously (i.e., a three-way merger was proposed), both selling firms had to accept within the 15-second limit in order for the consolidation to take place.

If the selling firm(s) agreed to the offer, the transaction took place and the points were distributed as listed in the offer box(es). Once a sale was final, the seller could no longer participate in

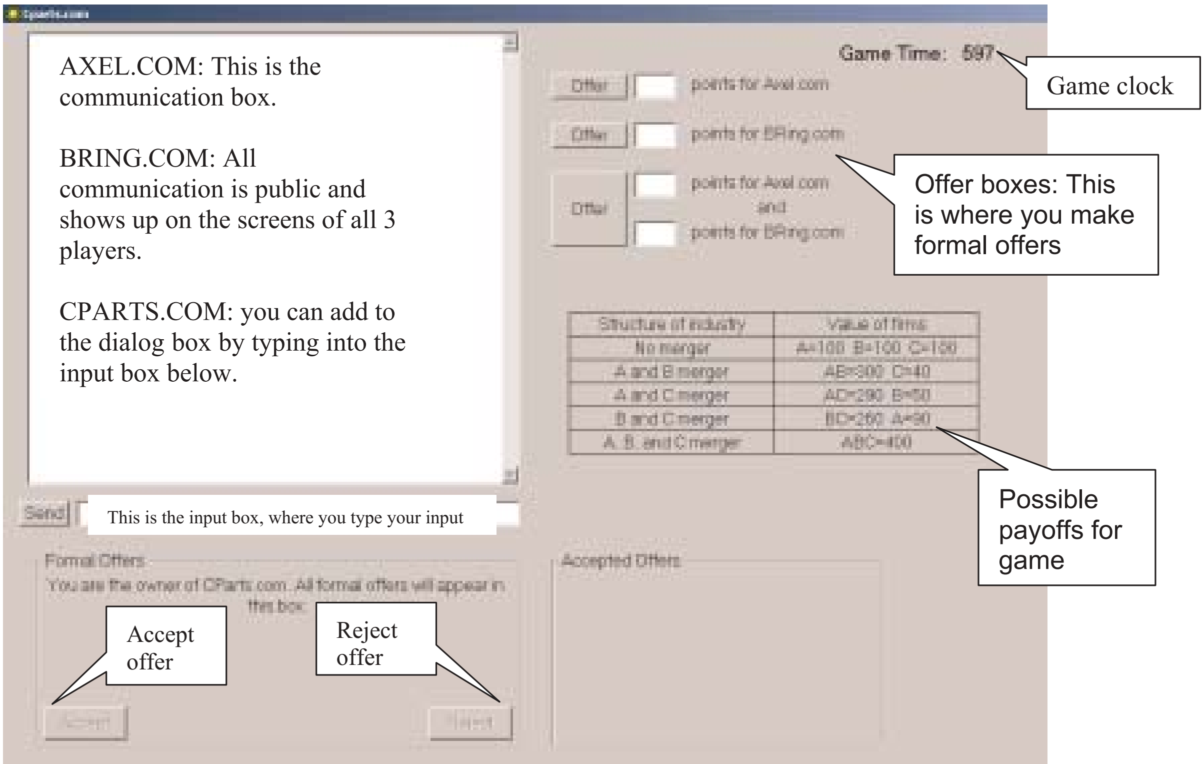
[15] The custom-made software by Nick McKinney is available upon request.

[16] Note that in this experiment all communication was public. There was no secret communication between two parties. Extensions to our research might introduce this factor of secret communication to test the robustness of the theories.

[17] We used the fully public communication structure in order to promote competitive bidding, as shown by Bolton, Chatterjee, and McGinn (2003).

Figure 1: A Sample Screen from the Experiment

This figure shows a sample screen of our experiments. The white box in the upper left corner displays the communication between the three firms. The input field below this box can be used to enter a new message. In the upper right corner players can make offers either to one of the other firms or to both of them simultaneously. In the second case the offers are accepted only if **both** firms accept within 15 seconds. The possible payoffs for this specific game are shown on the right side of the screen. In the lower left corner are buttons to accept or reject an offer within 15 seconds.



the communication, though she could still read all of the communication between the remaining two firms. More than one sale could occur during a period (e.g., in the first sale, Axel.com sold to BRing.com, and in a subsequent sale BRing.com sold the consolidated, Axel-BRing firm to Cparts.com). The round ended when all three firms consolidated, or when the ten-minute time limit was reached. A game timer was included on the bargaining screen, so that all were aware of the remaining time within a round.

Participants were provided with a paper "history form" to record the specifics of all deals. At the end of each round, they were given time to record their outcomes on the form. They were permitted to reference this form at any time during the session. At the end of the five rounds, the participants were told the experiment was over. To avoid wealth effects, subjects were paid for just one round, selected by lottery after all the rounds were complete.[18] All participants were paid individually (US$ 0.11 for each point earned in the payoff round plus their US$ 15 show-up fee), given a one-sheet debrief of the study, and released.

As mentioned above, these procedures were identical for the six experiments we ran. The only differences across experiments were the payoffs for the varying consolidation structures, as discussed in the next two sections. The synergies in experiments 1 and 2 were selected to separate competing solutions concepts in contexts without externalities (section 3), while experiments 3 through 6 were designed to explore synergies and dynamics in the presence of externalities (section 4).

3 Two Experiments Comparing Solution Concepts Without Externalities

The parameters for experiments 1 and 2 were designed to test the predictions of the CBV against competing solution concepts.[19] This design involves identifying parameters which maximize the geometric distance between the competing predictions in the two regions described above, thus increasing the likelihood of identifying differences in predictive power. In experiment 1, the parameters used in the game were chosen to maximize the distance between the predictions of the CBV and of the Nucleolus. In experiment 2, the parameters were chosen to maximize the distance between the predictions of the CBV and of the Shapley value.[20] Summary statistics for all the experiments can be found by the interested reader in Table 9 in Appendix D.

3.1 Experiment 1: Comparing the CBV and the Nucleolus

Our first experiment was designed to differentiate between CBV and the Nucleolus in their predictions of how synergies will be shared. The parameters were chosen so as to maximize the distance

[18] Index cards numbering 1-5 were put in a box, and one of the participants selected a card to determine the payoff round.

[19] In situations like these without externalities, the CBV can be thought of as simply a more flexible solution concept than either the Nucleolus or the Shapley value. Indeed, these two are nested in the CBV. Depending on the parameters, the CBV predicts either one or the other will be observed. In this sense, the CBV selects which of these competing solution concepts will occur under different parameter values. Experiments 1 and 2 can thus alternatively be seen as testing the CBV's selection ability.

[20] Although the CBV uses a non-cooperative game structure to generate its solutions, we do not impose that structure on the experimental procedure. This gives competing equilibrium concepts their "best chance." An experiment which used the non-cooperative game structure assumed by the CBV would almost certainly support its predictions.

between equilibrium predictions of interest. These parameters (and the resulting equilibrium predictions) are shown in Table 2.

Table 2: CBV versus Nucelolus

The structure of industry column describes the possible takeovers that could occur. The value of firms column describes the value of the independent or merged firms under each possible industry structure. The final two rows describe the equilibrium predictions of the CBV and of the Nucelolus.

Structure of Industry	**Value of Firms**		
$[A], [B], [C]$	$v_A = 50$	$v_B = 50$	$v_C = 50$
$[AB], [C]$	$V_{AB} = 300$	$V_C = 50$	
$[AC], [B]$	$V_{AC} = 300$	$V_B = 50$	
$[BC], [A]$	$V_{BC} = 150$	$V_A = 50$	
$[ABC]$	$V_{ABC} = 400$		
CBV prediction	$CBV_A = 183.3$	$CBV_B = 108.3$	$CBV_C = 108.3$
Nucleolus prediction	$Nuc_A = 300$	$Nuc_B = 50$	$Nuc_C = 50$

Twenty-four subjects participated in this experiment. As described above, the game was repeated five times, each time the three-person groups were re-assigned so that no subject met any other subject more than once during the experiment. Thus we have 40 observations. Because each player participated in five games, the observations may not be completely independent. We deal with this possibility in our second analysis, below.

We first examine the closeness of the group outcomes to those predicted by the competing solution concepts. For each game, we calculate the geometric distance[21] between the outcome and the prediction.[22] We then compare the distribution of distances to determine which equilibrium concept is closer to the actual outcomes.

Over all 40 observations, the average distance between the actual outcomes and the CBV was 62.27 ($\sigma = 16.58$). The average distance between the actual outcomes and the Nucleolus was 174.2 ($\sigma = 26.95$). Because these distances are not normally distributed (in particular, they're all positive) a nonparametric test to distinguish them statistically is appropriate. The paired Wilcoxon test demonstrates a significant difference between these two distributions of distances

[21] Using the absolute difference leads to the same results.

[22] So, for example, if the outcome of a given game was 250 points for player A, 75 points for player B and 75 points for player C, the geometric distance between that outcome and the CBV would be $\sqrt{(250-183.3)^2 + (75-108.3)^2 + (75-108.3)^2} = 81.65$ and the geometric distance between that outcome and the Nucleolus would be $\sqrt{(250-300)^2 + (75-50)^2 + (75-50)^2} = 61.24$.

$(n = 40, U = 0, z = 7.698, p = .0001)$.[23].

This previous analysis overstates the differences a bit, however, as each game is counted as an independent observation when, in fact, individuals played games repeatedly, always in the same role against different partners. For our second analysis, we examine the data at the individual rather than at the group level. For this analysis, we collect, for each individual, their outcomes over the five games they played. We then calculate the geometric distance between the individual's outcomes and the predictions of the competing equilibrium concepts.[24] We compare the distances to determine which equilibrium concept is closer to actual outcomes. Note that in this analysis we generate one observation for each individual, avoiding the previous problem of non-independence.

Over all 24 individuals, the average distance between the actual outcomes and the CBV was 80.13 ($\sigma = 22.62$). The average distance between the actual outcomes and the Nucleolus was 214.77 ($\sigma = 76.68$). We again use a paired Wilcoxon test to demonstrates a significant difference between these two distributions of distances $(n = 24, U = 5, z = 5.835, p = .0001)$.[25]

Our conclusion from this first experiment is that the CBV does a significantly better job at predicting how firms will share synergies than the competing solution concept, the Nucleolus.

[23]Note that both equilibrium concepts being tested here predict that the industry structure will involve all three firms merged in this experiment. This prediction is generally correct. Out of the 40 games, this occurred in 35 of them. If we restrict our sample to these 35 games, the statistical results remain consistent $(n = 35, U = 0, z = 7.199, p = .0001)$. In Experiment 1, the CBV makes path-dependent predictions. That is, the predictions of the CBV depend on who is randomly chosen to move first in the underlying non-cooperative game. In the previous analysis, we test outcomes against the "average" CBV predictions, assuming ex ante that each player is equally likely to be chosen. But we can also compare the path-dependent CBV predictions with those of the nucleolus. For this analysis, we calculate the geometric distance between the outcome of a game and the CBV prediction given who made the first offer in that game, even though that person was not randomly chosen to make the first offer but was instead self-nominated. The average distance between negotiated outcomes and the path-dependent CBV prediction is 56.20, thus actual agreements were closer to the path-dependent CBV predictions than to the ex-ante CBV predictions. As one might expect, the path-dependent CBV outperforms the nucleolus as well $(U = 0, z = 7.198, p = .0001)$.

[24]For example, if one subject assigned to the role of player A earned 100, 200, 150, 100 and 300 points in his five games, the geometric distance between these outcomes and the CBV would be $\sqrt{(100-183.3)^2 + (200-183.3)^2 + (150-183.3)^2 + (100-183.3)^2 + (300-183.3)^2} = 169.95$. The geometric distance between these outcomes and the Nucleolus would be
$\sqrt{(100-300)^2 + (200-300)^2 + (150-300)^2 + (100-300)^2 + (300-300)^2} = 335.41$.

[25]As before, restricting the outcomes to those in which all three firms merged does not change our results, $(n = 24, U = 4, z = 5.86, p = .0001)$. The non-cooperative game structure of the CBV assumes that each individual has an equal chance of being selected to make the first offer to purchase the other firm(s). The equilibrium outcome depends on who is selected. In this sense the predictions are path-dependent. Since ex-ante all players are equally likely to be selected to make the initial offer, the prediction of the CBV which we will use in this paper is the equally-weighted average of these path-dependent outcomes. Results using the path-dependent predictions are available from the authors, but are in all cases more favorable to the CBV than the results we present here.

3.2 Experiment 2: Comparing the CBV and the Shapley Value

Our second experiment was designed to differentiate between CBV and the Shapley Value. These parameters (and the resulting predictions) are shown in Table 3.

Table 3: CBV versus Shapley

The structure of industry column describes the possible mergers that could occur. The value of firms column describes the value of the independent or merged firms under each possible industry structure. The final two rows describe the equilibrium predictions of the CBV and of the Shapley value.

Structure of Industry	**Value of Firms**		
$[A], [B], [C]$	$v_A = 0$	$v_B = 0$	$v_C = 0$
$[AB], [C]$	$V_{AB} = 130$	$V_C = 0$	
$[AC], [B]$	$V_{AC} = 5$	$V_B = 0$	
$[BC], [A]$	$V_{BC} = 5$	$V_A = 0$	
$[ABC]$	$V_{ABC} = 400$		
CBV prediction	$CBV_A = 133.3$	$CBV_B = 133.3$	$CBV_C = 133.3$
Shapley prediction	$Shap_A = 154.2$	$Shap_B = 154.2$	$Shap_C = 91.6$

Eighteen subjects participated in this experiment. As before, the game was repeated five times, each time the three-person groups were re-assigned so that no subject met any other subject more than once during the experiment. Thus we have 30 negotiated group outcomes. Again, we deal with potential non-independence across observations in our analyses, below.

We first examine the closeness of the group outcomes to those predicted by the competing solution concepts. We again begin by calculating the geometric distance between the outcome and the predictions and comparing the distances to determine which equilibrium concept is closer to actual outcomes. Over all 30 observations, the average distance between the actual outcomes and the CBV was 38.47 ($\sigma = 58.64$). The average distance between the actual outcomes and the Shapley value was 71.58 ($\sigma = 44.41$). The paired Wilcoxon test demonstrates a significant difference between these two distributions of distances ($n = 30, U = 226, z = 3.312, p = .0024$).[26]

At the individual level, the average geometric distance between the actual outcomes and the CBV was 72.45 ($\sigma = 54.03$). The average geometric distance between the actual outcomes and the

[26] As before, both equilibrium concepts being tested here predict that all three firms will merge in this experiment. This prediction is generally correct. Out of the 30 games, all three firms merged in 27 of them. If we restrict our sample to these 27 games and perform the same Wilcoxon test, the results remain consistent ($n = 27, U = 141, z = 3.90, p = .0006$).

Shapley value was 98.68 ($\sigma = 45.78$). The Wilcoxon test to demonstrates a marginally significant difference between these two distributions of distances ($n = 18, U = 113, z = 1.98, p = .0632$).[27]

Our conclusion from this second experiment is that the CBV does a significantly better job at predicting how synergies will be shared than the competing solution concept, the Shapley value.

3.3 Discussion of Experiments 1 and 2

These first two experiments provide evidence that CBV performs well compared with the Nucleolus and the Shapley value. This can be thought of as a direct performance improvement, or as evidence that the CBV correctly predicts when each of the competing equilibrium concepts of Nucleolus and Shapley will be selected. We purposefully chose a setting that mirrored the real-world environment of takeovers, allowing for sequential takeovers to occur and the parties to communicate amongst themselves. This procedural difference is likely to be important. For example, in Michener and Myers (1998) experiment on coalition formation, more than 50% of their games result in inefficient outcomes. In our experiments inefficient outcomes occurred in less than 12.5% of the games. The procedures used in previous experiments sometimes preclude efficient outcomes that would be observed in reality – after one merger has occurred participants cannot renegotiate to the efficient three-way merger as they can in our experiment.

The performance of the CBV is demonstrated both when examined at the group level and at the individual level. Next, we provide some further tests of the CBV, including its ability to predict in conditions of externalities when takeovers affect the value of the firms who are not invited and its ability to predict the dynamic path of takeover formation in various settings.

4 Externalities

Our previous experiments focused on comparing the predictive abilities of competing equilibrium predictions, thus we focused on settings where those competing concepts could make a prediction. However, an observed regularity from the field is that takeovers often impose externalities on the remaining firms in the industry. These externalities can be positive or negative as the examples in the introduction illustrate.

In order to model the creation and division of synergies associated with takeovers with externalities, we use a generalization of characteristic function known as a *partition function* (Lucas and Thrall 1963). A partition function assigns a value to each firm depending on the mergers of other firms. In

[27] Restricting the outcomes to those in which all three firms merged only strengthens our results ($n = 18, U = 72, z = 2.85, p = .0106$).

particular, in an industry with three firms A, B, and C, there are five possible industry structures: $[A][B][C]$ where there are no takeovers, $[AB][C]$ where firms A and B merge (as well as the other two symmetric cases) and $[ABC]$ where all firms merge. A partition function assigns a value to each firm for all industry structures: if the industry structure is $[A][B][C]$ the value of each firm is v_i. If it is $[AB][C]$ the value of AB and C are respectively V_{AB} and V_C (and symmetrically for the other cases); and finally if the industry structure is $[ABC]$ the value of ABC is simply V. Without any loss of generality, we consider 0-normalized partition functions where we set $v_i = 0$ for all firms.

Externalities can be captured in this framework quite easily. For example, if the merger of A and B creates externalities for firm C this can be represented by a partition function with $v_C < V_C$ or $v_C > V_C$. In the experiments above without externalities, the partition functions correspond to a special case where $v_C = V_C$. The CBV solutions described in section 1 are also applicable to situations with externalities. However, the competing solution concepts we have been exploring, the Nucleolus and the Shapley value, are not defined in conditions of externalities. Instead, for these situations we will compare the predictions of the CBV with the Myerson-Shapley value, which is the only other known solution concept that makes pointwise predictions for situations with externalities.

4.1 Equilibrium Predictions with Externalities

Myerson (1977) introduced a natural extension of the Shapley value to partition function games like these. Myerson's generalization was also based on the three axioms used by Shapley. Myerson showed that for a (0-normalized) three-player partition function game the only solution satisfying these axioms (the Myerson-Shapley value) is given by the formula

$$MS_i = \frac{1}{6}\left[2\left(V - V_{jk}\right) + 4V_i - 2V_j - 2V_k + V_{ij} + V_{ik}\right].$$

Note that the Myerson-Shapley value coincides with the Shapley value for situations where $V_i = v_i$ for all players i, that is, situations without externalities.

The predictions of the CBV in situations with externalities depend on the parameters used. Here, we detail four types of experiments that completely describe the possible space of parameters, and discuss the predictions of the CBV. We will then describe four experiments, one modeling each situation, and compare the synergy-sharing predictions of the CBV with those of the Myerson-Shapley value in each experiment.

In describing the predictions made by the CBV in all four situations, it is convenient to define an adjusted measure of the value of a takeover by

$$\bar{V}_{AB} = V_{AB} - V_C$$

(similarly for other partial takeovers). The adjusted measure describes the value of the merged firm minus the amount of positive externalities (or plus the amount of negative externalities) that it creates for the excluded firm. Note that V_C is not the stand-alone value of the firm C when no takeovers occur (v_C – the stand-alone value – has been normalized to zero), but is instead the value of C in the presence of a takeover between A and B. For situations without externalities $\bar{V}_{AB} = V_{AB}$.

1. In the first situation, all takeovers create significant synergies, that is, $\bar{V}_{AB}+\bar{V}_{AC}+\bar{V}_{BC} \geq V$ (the sum of the adjusted measures of value for all partial takeovers is greater than the value of the final three-way takeover). In this situation the CBV predicts,

$$CBV_i = \frac{1}{6}\left(2V - 2\bar{V}_{jk} + \bar{V}_{ij} + \bar{V}_{ik}\right).$$

   This was the case investigated in Experiment 1 when externalities were not present, and will be captured in Experiment 3 in a setting with externalities.[28]

2. In the second situation, only one firm's takeovers create synergies. Any takeovers which do not involve that firm are not valuable. Without loss of generality, we will say that takeovers involving company A create synergies, while others do not. In this region, $\bar{V}_{AB}+\bar{V}_{AC}+\bar{V}_{BC} \leq V$, $2\bar{V}_{AC} + \bar{V}_{AB} \geq V$, and $2\bar{V}_{AB} + \bar{V}_{AC} \geq V$. In equilibrium, the only takeovers that should happen are AB and AC, and the (subsequent) three-way takeover ABC. The equilibrium predictions are, then

$$CBV_A = \frac{1}{2}\left(\bar{V}_{AB} + \bar{V}_{AC}\right), CBV_B = \frac{1}{2}\left(V - \bar{V}_{AC}\right), \text{ and } CBV_C = \frac{1}{2}\left(V - \bar{V}_{AB}\right).$$

   Our experiment 4 will examine this type of synergy-creation situation.

3. In the third situation, only one two-way takeover creates synergies (here, without loss of generality, we will say it is AB). The others do not. In this situation, then, $\bar{V}_{AB} \geq \frac{1}{3}V$, $2\bar{V}_{AC} + \bar{V}_{AB} \leq V$, and $2\bar{V}_{BC} + \bar{V}_{AB} \leq V$. Thus in equilibrium, we can predict either that firms A and B merge, or that all three firms merge, with C collecting a relatively small share of the synergies created. The equilibrium prediction is thus

$$CBV_A = \frac{1}{4}\left(V + \bar{V}_{AB}\right), CBV_B = \frac{1}{4}\left(V + \bar{V}_{AB}\right), \text{ and } CBV_C = \frac{1}{2}\left(V - \bar{V}_{AB}\right).$$

   This situation will be captured in our experiment 5.

[28]Note that while in situations of this type without externalities the CBV and the Shapley value predict the same outcome, in situations of this type with externalities, the CBV and the Myerson-Shapley value predict different outcomes. In particular, the CBV and the Myerson-Shapley value handle externalities differently.

4. In the final situation, all partial takeovers create very little value, that is, $\bar{V}_{AB} \leq \frac{1}{3}V$, $\bar{V}_{AC} \leq \frac{1}{3}V$, and $\bar{V}_{BC} \leq \frac{1}{3}V$. Since all partial takeovers are non-credible, and all firms need to unanimously agree in a three-way takeover, the CBV predicts that the three firms will split the synergies equally. In this situation the CBV predicts,

$$CBV_i = \frac{1}{3}V.$$

This was the case investigated in experiment 2 when externalities were not present, and will be captured in experiment 6 in a setting with externalities.[29]

Table 10 in Appendix D summarizes the CBV predictions in these four distinct situations.

In the next section, we will present four experiments with externalities, one representing each of these four types. As before, parameter values in each type of game were chosen to differentiate the competing equilibrium predictions – CBV and Myerson-Shapley.

The CBV also makes predictions about the dynamics of mergers which are expected in each of these types of games – these predictions and their experimental tests will be discussed in section 5.

4.2 Four Experiments Examining Externalities

The analyses below will compare predictions of how synergies are shared in takeovers from the CBV and Myerson-Shapley. As before, parameters will be chosen so as to differentiate the predictions and enable us to identify differences in predictive ability. The experiments described in this section test these predictions in four different domains. Table 4 depicts the parameters and the two equilibrium predictions for all four of these experiments.

As in the previous section, our first analysis compares the geometric distance between the two solution concepts for each experiment. Table 5 presents the average distances (and standard deviations) as well as the statistical comparisons for each experiment and for the pooled data.[30]

[29]Without externalities (as in experiment 2), the CBV predicts the same as the Nucleolus in this situation.

[30]As before, both the CBV and the Myerson-Shapley value predict that the final three-way merger will form in these experiments. This prediction is generally correct: the final three-way merger resulted in 26 out of 35 games in experiment 3, 35 out of 35 games in experiment 4, 38 out of 45 games in experiment 5 and 41 out of 45 games in experiment 6, yielding 140 observations of the final three-way merger out of 160 games in all four experiments. If we restrict our sample to these games and perform the same Wilcoxon tests, the results remain consistent ($n = 26, U = 281, x = 1.044, p = .148$ for experiment 3; $n = 35, U = 99.5, x = 6.026, p = .0001$ for experiment 4; $n = 38, U = 10, x = 7.410, p = .0001$ for experiment 5, and $n = 41, U = 40, x = 7.561, p = .0001$ for experiment 6, $n = 140, U = 20,948, z = 4.997, p = .0001$ for all experiments with externalities combined). In Experiment 3, the CBV makes path-dependent predictions as it did in Experiment 1. The average distance between

Table 4: CBV vs. Myerson-Shapley in Four Experiments

The structure of industry column describes the possible mergers that could occur. The value of firms column describes the value of the independent or merged firms under each possible industry structure. The final rows after each experiment describe the equilibrium predictions of the Coalitional Bargaining Value (CBV_i) and of the Myerson-Shapley (MS_i) value.

Structure of Industry	Value of Firms					
	Experiment 3			Experiment 4		
$[A],[B],[C]$	$v_A = 100$	$v_B = 100$	$v_C = 100$	$v_A = 100$	$v_B = 100$	$v_C = 100$
$[AB],[C]$	$V_{AB} = 300$	$V_C = 40$		$V_{AB} = 230$	$V_C = 50$	
$[AC],[B]$	$V_{AC} = 290$	$V_B = 50$		$V_{AC} = 220$	$V_B = 70$	
$[BC],[A]$	$V_{BC} = 260$	$V_A = 90$		$V_{BC} = 210$	$V_A = 160$	
$[ABC]$	$V_{ABC} = 400$			$V_{ABC} = 400$		
CBV prediction	$CBV_A = 160$	$CBV_B = 125$	$CBV_C = 115$	$CBV_A = 165$	$CBV_B = 125$	$CBV_C = 110$
MS prediction	$MS_A = 175$	$MS_B = 120$	$MS_C = 105$	$MS_A = 205$	$MS_B = 110$	$MS_C = 85$

	Experiment 5			Experiment 6		
$[A],[B],[C]$	$v_A = 100$	$v_B = 100$	$v_C = 100$	$v_A = 50$	$v_B = 50$	$v_C = 50$
$[AB],[C]$	$V_{AB} = 220$	$V_C = 20$		$V_{AB} = 240$	$V_C = 140$	
$[AC],[B]$	$V_{AC} = 220$	$V_B = 150$		$V_{AC} = 210$	$V_B = 150$	
$[BC],[A]$	$V_{BC} = 210$	$V_A = 140$		$V_{BC} = 180$	$V_A = 180$	
$[ABC]$	$V_{ABC} = 400$			$V_{ABC} = 400$		
CBV prediction	$CBV_A = 150$	$CBV_B = 150$	$CBV_C = 100$	$CBV_A = 133.3$	$CBV_B = 133.3$	$CBV_C = 133.3$
MS prediction	$MS_A = 173.3$	$MS_B = 178.3$	$MS_C = 48.3$	$MS_A = 171.6$	$MS_B = 126.6$	$MS_C = 101.6$

Table 5: Geometric Distances and Statistical Tests by Experiment

For each experiment, this table describes the number of games played, the average and standard deviation of the distances between the predictions and the actual outcomes, and details of the nonparametric Wilcoxon test comparing those distances. The final column describes the same results for all four experiments pooled together.

		Experiments				
		Exp3	Exp4	Exp5	Exp6	Exp3-6 (pooled)
# observations		35	35	45	45	160
distance CBV		65.30	42.13	43.90	12.62	39.40
		(18.86)	(30.03)	(23.41)	(32.18)	(32.64)
distance $My - Shap$		69.34	84.91	98.08	55.86	77.06
		(19.37)	(26.60)	(18.76)	(22.97)	(27.45)
Wilcoxon details	U	536.5	99.5	109	132	34061
	z	0.894	6.026	7.291	7.204	5.066
	p	0.1862	0.0001	0.0001	0.0001	0.0001

In all four experiments with externalities, the CBV's predictions are closer to the actual outcomes (lower geometric distance) than the predictions of the Myerson-Shapley solution, and in all comparisons except one (experiment 3) this difference is statistically significant.[31]

A similar analysis can be performed at the level of the individual rather than at the level of the group. Table 6 presents the summary statistics and statistical tests for experiments 3-6 for this analysis.[32]

In all experiments, the CBV's predictions are again closer to the actual outcomes (lower geometric distance) than the predictions of the Myerson-Shapley solution, and in all comparisons except one (experiment 3) this difference is statistically significant.

Results from this analysis demonstrate that in a wide variety of situations with externalities, CBV's predictions of how synergies will be shared in takeovers are significantly closer to the experimental observations than the predictions of the Myerson-Shapley solution.

negotiated outcomes and the path-dependent CBV prediction is 43.15, thus actual agreements were closer to the path-dependent CBV predictions than to the ex-ante CBV predictions. As one might expect, the path-dependent CBV outperforms the Myerson-Shapley value as well ($U = 155, z = 2.801, p = .003$).

[31] These results are depicted graphically in Figure 2 in the appendix.

[32] As before, restricting the outcomes to those in which the final three-way merger formed does not change our results. For experiment 3, $n = 21, U = 185, z = 0.893, p = 0.1863$, for experiment 4, $n = 21, U = 80, z = 3.53, p = 0.0016$, for experiment 5, $n = 27, U = 41, z = 5.60, p = 0.0001$ and for experiment 6, $n = 27, U = 74, z = 5.03, p = 0.0001$. For all four experiments together, $n = 96, U = 1831, z = 7.21, p = 0.0001$.

Table 6: Geometric Distances and Statistical Tests by Individual

For each experiment, this table describes the number of individuals who participated, the average and standard deviation of the distance between the predictions and the actual outcomes, and details of the nonparametric Wilcoxon test comparing those distances. The final column describes the same results for all four experiments pooled together.

		Experiments				
		Exp3	Exp4	Exp5	Exp6	Exp3-6 (pooled)
# individuals		21	21	27	27	96
distance CBV		80.77	57.20	57.98	33.74	56.57
		(34.88)	(29.51)	(27.80)	(40.50)	(37.16)
distance MS		88.40	107.93	123,71	73.24	98.33
		(29.53)	(39.89)	(36.78)	(38.85)	(41.30)
Wilcoxon details	U	188.5	80	44	162	2020
	z	0.808	3.534	5.545	3.503	6.721
	p	0.2105	0.0019	0.0001	0.0016	0.0001

5 The Dynamics of Takeovers and Other Predictions of the CBV

5.1 Dynamics of Takeovers

The CBV also makes predictions about the *dynamics* of the takeovers that we expect to observe in our four experiments.[33]

In the first situation with high synergies, the sum of the adjusted measure of value of all partial takeovers is greater than the value of the three-way takeover. In equilibrium, partial takeovers should occur first, followed by a second step takeover to the three-way merger. The CBV argues that in this case there is a first mover advantage, and firms are expected to rush to merge, with the firm left out of the first takeover ending up worse off. This situation was captured in experiments 1 and 3.

In the second situation (experiment 4), only one firm's takeovers create synergies. Takeovers not involving that firm are not value-creating. Without loss of generality, we say that takeovers involving company A create synergies, while others do not. Here, the AB and AC mergers are the only partial takeovers that create synergies. In equilibrium, the only takeovers that should

[33]Note that Myerson (1977) makes no predictions with respect to dynamics.

happen are AB and AC, and the (subsequent) three-way takeover ABC.[34]

In the third situation (experiment 5), only one two-way takeover creates synergies (here, without loss of generality, we say it is AB) – the others do not. Thus in equilibrium, we can predict either that firms A and B will merge, or that all three firms will merge, with C collecting a relatively small share of the synergies created.[35]

In the final situation, all partial takeovers create very little value. Since synergies are low, in equilibrium we expect a three-way merger to occur directly, with no partial takeovers observed in between.[36] This situation was captured in experiments 2 and 6.

Table 7 presents a summary of the predicted dynamics of takeovers for all six of the experiments described in this paper. We can test these predictions by examining the dynamics of takeovers observed in our experiments and comparing them with these predictions. Table 7 includes the percentage of games in which the various dynamics were observed, as well as the percentage of predicted sequences observed overall. In all six experiments combined, 75.7% of the games involved takeover dynamics that were predicted by the CBV.

In addition to these aggregated results, it is useful to analyze the negotiation process. The CBV predicts that there will be a "rush to merge" in experiments 1 and 3, where two-way coalitions produce high synergies. The average time to the first two-way coalition in experiments 1 and 3 is less than 1 minute (33.6 seconds in experiment 1 and 43.7 seconds in experiment 3). Contrast this with the average time to the first two-way coalition in experiments 4 and 5 where there is no rush, of more than 2 minutes (133 seconds in experiment 4 and 130 seconds in experiment 5). Thus in situations where the CBV predicts a rush to merge, we see agreements reached significantly faster.

As expected, it takes longer to negotiate a three-way coalition than a two-way coalition. However, in experiments 2 and 6 where two-way coalitions create little value we expect a "delay to merge." In these situations the average time to a three-way coalition is around 5 minutes (326 seconds for experiment 2 and 291 seconds for experiment 6). Contrast this with the average time to a three-way coalition in experiments 4 and 5 where there is no incentive to delay. There the time to a three-way coalition was around 4 minutes (268 seconds for experiment 4 and 219 seconds for

[34]The takeover BC is not credible, because the merger of firms B and C yields $\frac{1}{2}\left(V+\bar{V}_{BC}\right)$, which is smaller than the value that B and C can get conforming to the equilibrium strategies because $\bar{V}_{AB}+\bar{V}_{AC}+\bar{V}_{BC}\leq V$.

[35]Any partial takeovers other than AB are not credible, given the parameters. A deviation from equilibrium, say a merger between A and C, is unprofitable because the merged firm value is $\frac{V+V_{AC}}{2}$, which is less than the sum of the equilibrium values of A and C because $2\bar{V}_{AC}+\bar{V}_{AB}\leq V$. A similar argument applies to a deviation by B and C because $\bar{V}_{AB}\leq\frac{1}{3}V$.

[36]The threat of any partial takeover is not credible. Say that firms A and B deviate and merge (the same argument applies to the other partial takeovers). The value of the merged firm AB is $\frac{1}{2}\left(V+\bar{V}_{AB}\right)\leq\frac{2}{3}V$ because $\bar{V}_{AB}\leq\frac{1}{3}V$, which is less than what they can get in a three-way merger.

Table 7: Predicted (and Actual) Dynamics of Takeovers

For each experiment, this table describes the percentage of games whose outcomes are described by the sequence of takeovers in the column headings. Percentages displayed in bold indicate outcomes that were predicted by the CBV. The final column summarizes the percentage of merger sequences that were predicted by the CBV for each experiment.

Exp	N	*ABC* one step	*AB* → *ABC*	*AC* → *ABC*	*BC* → *ABC*	*AB* only	*AC* only	*BC* only	no takeover	predicted dynamics
1	40	2.5%	**47.5%**	**30.0%**	**7.5%**	2.5%	10.0%			**85.0%**
2	30	**66.7%**	16.6%		6.7%	10.0%				**66.7%**
3	35	2.9%	**25.7%**	**34.3%**	**11.4%**	17.1%	5.7%	2.9%		**71.4%**
4	35	**45.7%**	**20.0%**	**22.9%**	11.4%					**88.6%**
5	45	**60.0%**	**22.2%**		2.2%	4.4%		4.4%	6.7%	**82.2%**
6	45	**84.4%**	6.7%	2.2%		4.4%	2.2%		2.2%	**84.4%**

experiment 5). Thus in situations where the CBV predicts a delay to merge, we see agreements reached significantly slower.

5.2 Other Predictions of the CBV

Given these results on dynamics it is interesting to analyze now whether the sequence of events influences the realized values of (non-)participating firms in the first merger.

The CBV predicts the value that firms will realize for a given sequence of takeovers. In particular, for experiments 1 and 3 (situations of the first type where two-way takeovers create significant synergies), the firm that is left out of the initial takeover is predicted to earn less. Similarly, for experiments 4 and 5, there should be no differences in value between firms that were included or left out of the initial takeover.[37]

This theoretical result helps to shed light on contradictory findings in empirical research using event studies to analyze the value impacts of takeovers. For example, Eckbo (1983) and Stillman (1983) showed that the stock price of competitors did not change significantly for takeovers announced in the 1960's and 1970's, but Banerjee and Eckard (1998) showed that during the great merger wave of 1897-1903 the stock price of competitors dropped significantly. The theoretical predictions of the CBV provide some clues for why different studies obtain these different results.

[37]In experiments 2 and 6, CBV predicts a three-way merger in one step, i.e. no firm is left out.

To test our explanation, we limit our attention to experiments 1, 3, 4 and 5 and to those rounds in which all three firms eventually merged, but in which the merger occurred in two steps (columns 2, 3 and 4 of the table above). We then compare the final value of each firm in situations when they were involved in the first takeover (IN first takeover) with their value in situations where they were not (OUT first takeover). The CBV predicts that in experiments 1 and 3 there will be a significant difference between these two, but that in experiments 4 and 5 there will not be. We use a two-sample Wilcoxon test for this comparison (as the results are not paired). The average value, number of observations, and statistical differences are shown in Table 8.

Table 8: Payoff Implications of Takeover Dynamics

For each of four experiments, this table describes data only from those settings where all three firms merged in two stages. For each cell we describe the number of outcomes in which a given player was in (or out of) the first takeover that occurred (in parenthesis) and the average end-value of that firm. The third row describes details of the statistical tests comparing the two distributions of earnings.

first takeover		**Experiment 1**				**Experiment 3**			
		A	*B*	*C*	All	*A*	*B*	*C*	All
IN		161	155	134	153	157	159	148	155
		(31)	(22)	(15)	(68)	(21)	(13)	(16)	(50)
OUT		163	85	88	93	122	86	83	91
		(3)	(12)	(19)	(34)	(4)	(12)	(9)	(25)
Wilcoxon	U	45	1.5	44	205	1	0	13	44
details	z	0.091	4.72	3.43	6.64	3.08	4.25	3.35	6.65
	p	0.4633	0.0001	0.0016	0.0001	0.0049	0.0001	0.0026	0.0001

first takeover		**Experiment 4**				**Experiment 5**			
		A	*B*	*C*	All	*A*	*B*	*C*	All
IN		141	130	122	132	132	139	85	133
		(15)	(11)	(12)	(38)	(10)	(11)	(1)	(11)
OUT		169	133	122	136	85	NA	130	126
		(4)	(8)	(7)	(19)	(1)		(10)	(11)
Wilcoxon	U	1	29.5	40.5	332	0		0	53
details	z	2.91	1.20	0.127	0.449	1.58	NA	1.58	0.492
	p	0.0089	0.2448	0.4492	0.3081	0.1424		0.1424	0.6259

In the first two experiments (1 and 3), the prediction is supported in all but one case (experiment 1, firm A). Thus in situations of the first type, firms who are left out of the first takeover, earn less than those (in the same role) who are involved in the first takeover, consistent with the equilibrium predictions and the empirical results of Banerjee and Eckard (1998).

In the second two experiments (4 and 5), the predictions are again supported. In these situations, pooling over the three firms those who are left out of the first takeover earn the same as those who are involved in the first takeover, consistent with the equilibrium predictions and the empirical results of Eckbo (1983) and Stillman (1983). This pattern is mirrored at the level of the individual firms, with the exception of firm A in experiment 4 which earned significantly *more* when excluded from the first takeover, rather than less as in experiments 1 and 3.[38]

In this section, we tested the predictions of the CBV not simply in the domain of how synergies are shared but also the *dynamics* of takeovers that will occur and the implications of the values that will result. Under a variety of experimental parameters, these dynamics predictions are correct over 75% of the time. The value implications of these dynamics of takeovers are also consistent with the theory. The dynamic predictions also help to synthesize previously-observed contradictions in empirical research, by identifying situations in which being left out of a takeover hurts the excluded firm's value and those in which there is no effect on the excluded firm's value. Our experimental results are consistent with these theoretical predictions as well.

6 Conclusion

Firms appear willing to consider a merger or acquisition as soon as synergies are identified – as soon as the new company can enjoy additional value. The question remains, however, how these synergies are shared between the companies. The existing empirical literature faces a challenge when examining this question using market valuations to measure synergies. These empirical tests are really tests of the joint hypotheses of theories of how synergies are shared and of efficient markets. The actual synergies (and/or externalities) created from the takeover remain unknown. In our experimental approach, in contrast, we can control exactly the synergies (and/or externalities) created from takeovers, and then examine competing theories of how they will be shared.

Our first set of results suggests the inadequacy of existing solution concepts for predicting how synergies will be shared in this setting. We propose a new solution concept, the CBV, which outperforms both the Shapley value and the Nucleolus in predicting synergy sharing.

Our second set of results suggests that the CBV also performs well in predicting how synergies will be shared in situations with externalities – when two firms' merger activities impact a third firm's

[38]While there are marginally significant differences in experiment 5, firms A and C, note that these go in opposite directions. Firms A in this experiment tend to earn more when being in the first takeover, while firms C tend to earn less. We can also supplement Table 8 to include the cases when all three firms merge in one step. The results are qualitatively the same and are presented in Table 11 in Appendix D.

value. In these settings the CBV outperformed its nearest competitor: the Myerson-Shapley value in predicting how synergies would be shared.[39]

The third major result involves the *dynamics* of takeovers. The CBV's predictions of the order in which takeovers would occur were observed in over 75% of the rounds. These dynamic predictions carry with them other outcome predictions. In settings where high synergies are created by the first takeover, for example, the CBV predicts that companies who first participate in a two-way takeover and then later merge with the remaining firm will earn more than companies who are left out of the first two-way takeover. In contrast, in other settings the order of takeovers will not affect the value of the firms. Our experimental outcomes are also consistent with these predictions.

Our results shed light on aspects of the process of mergers and acquisitions that cannot be observed by using empirical stock market data. Synergies are known and all alternatives are well defined. This experimental setting allows us to test competing equilibrium predictions in a way that could not be done in the field, and suggests which equilibrium concepts should be discarded and which further investigated.

Another important contribution of our paper is the analysis of the dynamics of mergers in the field. For example, the emergence of GlaxoSmithKline out of two previous two-way mergers may be attributed to the available merger options and the synergies associated with these options at sequential points in the lives of the involved companies. Our results formalize the necessary conditions under which we would expect to see three-way mergers instead of a series of two-way mergers in a given industry. This suggests further (empirical) ways in which this theory could be tested in the field.

Like all research, this study has a number of limitations. No experiment can capture all of the interesting features of the field setting. In particular, we left out a number of real-world features of mergers and acquisitions like asymmetric information about valuations and synergies, agency problems between managers and shareholders, and post-takeover fights for control. Many of these are cited as causes of the winner's curse, where buyers of a company overpay. We did not observe systematic overpayment in our data, most likely because these features were absent.

These limitations as well as our existing results suggest further experiments to explore the question of sharing synergies in other merger and acquisition settings. For example, future experiments might investigate behavior in the presence of (realistic) uncertainty of how much synergy will

[39] As one reader points out, one common result in ultimatum and other bargaining experiments is that subjects split earning equally (e.g. Croson 1996). Note that in experiments 2 and 6 this is exactly what the CBV predicts will happen. In these experiments, we saw an equal split of the surplus in 40% and 58% of the negotiations, respectively. In the other experiments however, the equal split was rarely observed (in 14% of the negotiations). We suspect that the takeover context used in our experiment reduced the number of equal splits observed, compared to the context-free settings of ultimatum games.

be produced. Bolton, Chatterjee, and McGinn (2003) have explored the possibility of secret negotiation or bidding (unlike our setting of common information), but future research may add the possibility of private information regarding synergies to see if behavior is sensitive to informational asymmetries. Finally, the role of outside options (like white knights) would be interesting to explore in this setting.

This paper uses experimental methods to examine questions in mergers and acquisitions including the sharing of synergies in the absence and presence of externalities, the dynamics of takeovers and the payoff implications of those dynamics. We believe this methodology is useful both for theory-testing as well as for suggesting refinements for empirical researchers to consider in their analyses, and will lead to a deeper understanding of which takeovers occur, at what prices, and when.

Appendix

A Instructions for the sessions

Overview

There are three roles in this exercise: Axel.com, BRing.com, or Cparts.com. All three are business to business (B2B) Internet companies. Each of you has at your seat a role assignment sheet with your role assignment (along with some other information that will be explained later) printed on it. This is the role you will play throughout the session.

The consensus among analysts is that acquisitions and consolidations in the B2B sector are opportunities for creating greater value in the marketplace. Specifically, Axel.com, BRing.com, and Cparts.com have all independently concluded that there are quantifiable synergies that could be achieved by combining operations. All three are currently considering either acquiring or being acquired by the other companies.

In this session, you will participate in a number of periods of potential consolidation. In each of the periods you will have the opportunity to acquire or be acquired. You will earn points as a result of your acquisition decisions. **When a new period begins, everything starts over with independent firms and new acquisition activity.**

At the end of the session, we will randomly choose one of the periods as the payoff period. You will receive \$ 0.11 for each point you earned in that period. For example, if you earned 150 points in the payoff period, we would pay you \$ 16.50 (plus the \$ 15 base pay for your participation). The more points you earn, the more the shareholders of your firm (yourself included) will earn and (in real life) the more money you will earn from this session.

Procedure

- All interactions will take place over the computer. You will be connected through an online communication tool with two other parties. The attachments at the end of this packet provide pictures of the computer screens at different points during a period and explain how you will communicate and make / accept / reject offers during each period.
- All interactions will be anonymous, please do not identify yourself in any way.
- You will have one role throughout the periods, as noted on your role assignment sheet.
- You will be interacting with representatives of both of the other companies in each period. You will never interact with the same parties more than once. In particular, your counterparts in period 1 will be different than your counterparts in period 2, and so on.

- Each period will last **ten minutes**.
- When each period is over, please wait until instructed before you exit your screen to begin a new period.
- Each period is completely independent of all other periods. When a new period begins, the screen will be cleared and you will be connected with two new and different players.
- All communication, including offers and acceptances/rejections is public information and will be displayed on all three parties' screens throughout the entire period.
- You may not enter an offer greater than the value of the three-way consolidation. For example, if an A - B - C merger is worth 400 points, A's offers to B and C cannot sum to more than 400 points. If A makes offers (or a single offer) that total more than 400 points, the offer(s) will not be transmitted. Likewise, any offer less than 0 points (or a blank offer box) will not be transmitted.
- Only one offer can be outstanding at a time. Offers remain active for 15 seconds. If the seller either rejects the offer or fails to respond within 15 seconds, the offer is automatically withdrawn. Similarly, if an offer is made to two sellers simultaneously, **both** firms must accept within 15 seconds in order for the deal to proceed.
- If the seller(s) agree to the offer, the transaction takes place and the points are distributed as listed in the offer box (See computer screen shots, attached). Once an offer is formally accepted, the sale is final. Payoffs are noted on your screen.
- Once a sale is final, the representative of the selling company is restricted from taking part in any further communication. If only one company has been purchased, the remaining companies (one consolidated and one independent) may continue communicating up to the ten-minute time limit. All three parties will still be able to see all messages exchanged, but only the parties still holding companies are able to communicate.
- More than one sale may occur in a single period. Note that a second sale will change the earnings of the parties involved.
- *History Form.* A blank 'History' form is provided in your folder. At the conclusion of each period, please fill out this form. The completed form provides you with a history of your past deals, and you may reference it at any time during the session.
- You will be paid for only one, randomly selected period.

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(Please Note: The payoffs and role on these screens may not match your own payoffs or role)

1. Initial Screen
2. Second Screen: After signing in (Example for Cparts.com)
3. Example of screen when Bring.com proposes an offer for Axel.com (screen of Bring.com)
4. Picture of screen after the "Make Offer" button was selected. Bring.com made offer for Axel.com. (screen of Axel.com)
5. Example of Cparts.com screen after an offer by Bring.com for Axel.com is accepted
6. Example of final screen after two offers were accepted:

B Quiz

Please fill in the missing numbers.

Problem 1:

Axel.com and Cparts.com agree to consolidate. Cparts.com offers Axel.com **3** points to purchase Axel.com, and Axel.com accepts. No other consolidation takes place.

- Axel.com earns _____ points (from sale to Cparts).
- BRing.com earns _____ points (default points from AC consolidation).
- Cparts.com earns **2** points (_______ AC consolidation points - _____ to Axel).

Problem 2a:

Imagine that the above negotiation between Cparts.com and BRing.com continues after Cparts.com purchase of Axel.com in the question above.

BRing.com offers to buy the newly consolidated company of Axel/Cparts.com. BRing.com offers Cparts.com **50** points to purchase the Axel/Cparts.com consolidated company. Cparts.com accepts.

- Axel.com earns _____ points (from previous sale to Cparts.com).
- BRing.com earns _____ points (**400** ABC consolidation points - _______ to Cparts.com).
- Cparts.com earns **47** points (_____ from BRing.com - _____ previously paid to Axel.com).

Problem 2b:

Again imagine that the negotiation between Cparts.com and BRing.com continues after Cparts.com purchase of Axel.com in problem #1.

In this scenario, Cparts.com offers to buy BRing.com to form the consolidation of all three companies. Cparts.com offers to buy BRing.com for **350** points. BRing.com accepts.

- Axel.com earns _____ points (from previous sale to Cparts.com).
- BRing.com earns _____ points from Cparts.com.
- Cparts.com earns **47** points (**400** ABC consolidation points - _____ from Cparts' previous payment to Axel - _____ to buy BRing's rights to the consolidated firm).

C Negotiation History

At the end of each negotiation, record all points in points and then your own earnings (if this negotiation were selected in the lottery) in dollars. Each point is worth US$ 0.11.

Negotiation 1 Axel.com points _____ BRing.com points _____ Cparts.com points _____
Your earnings if this negotiation is chosen for payment: US$ _____

Negotiation 2 Axel.com points _____ BRing.com points _____ Cparts.com points _____
Your earnings if this negotiation is chosen for payment: US$ _____

Negotiation 3 Axel.com points _____ BRing.com points _____ Cparts.com points _____
Your earnings if this negotiation is chosen for payment: US$ _____

Negotiation 4 Axel.com points _____ BRing.com points _____ Cparts.com points _____
Your earnings if this negotiation is chosen for payment: US$ _____

Negotiation 5 Axel.com points _____ BRing.com points _____ Cparts.com points _____
Your earnings if this negotiation is chosen for payment: US$ _____

Negotiation 6 Axel.com points _____ BRing.com points _____ Cparts.com points _____
Your earnings if this negotiation is chosen for payment: US$ _____

Negotiation 7 Axel.com points _____ BRing.com points _____ Cparts.com points _____
Your earnings if this negotiation is chosen for payment: US$ _____

Negotiation 8 Axel.com points _____ BRing.com points _____ Cparts.com points _____
Your earnings if this negotiation is chosen for payment: US$ _____

(...)

D Additional Tables and Figures

Table 9: Average Payoffs and Standard Deviations

For each experiment, this table contains the average payoff for each firm and the standard deviation of these payoffs. In addition, the number of observations is provided.

Experiment		A	B	C
1	μ	162.70	122.78	108.28
	σ	(20.31)	(43.27)	(36.31)
	# obs.		40	
2	μ	125.27	126.43	121.30
	σ	(42.73)	(19.66)	(49.93)
	# obs.		30	
3	μ	150.03	121.89	112.94
	σ	(19.59)	(42.55)	(49.34)
	# obs.		35	
4	μ	142.14	133.77	124.09
	σ	(17.06)	(28.99)	(27.88)
	# obs.		35	
5	μ	131.93	134.82	117.24
	σ	(14.47)	(18.53)	(33.06)
	# obs.		45	
6	μ	129.82	128.53	129.20
	σ	(18.71)	(24.84)	(25.45)
	# obs.		45	

Table 10: CBV Predictions: Predicted Unconditional Payoffs

For each experiment, this table contains the predicted unconditional payoff for each firm using the Coalitional Bargaining Value (CBV).

Experiment	**Coalitional Bargaining Value (CBV)**
	Type of Experiment
1 & 3	$CBV_i = \frac{1}{6}\left(2V - 2\bar{V}_{jk} + \bar{V}_{ij}\bar{V}_{ik}\right)$ if $\bar{V}_{AB} + \bar{V}_{AC} + \bar{V}_{BC} \geq V$
4	$CBV_A = \frac{1}{2}\left(\bar{V}_{AB} + \bar{V}_{AC}\right)$, and $CBV_B = \frac{1}{2}\left(V - \bar{V}_{AC}\right)$, and $CBV_C = \frac{1}{2}\left(V - \bar{V}_{AB}\right)$ if $\bar{V}_{AB} + \bar{V}_{AC} + \bar{V}_{BC} \leq V$, and $2\bar{V}_{AC} + \bar{V}_{AB} \geq V$, and $2\bar{V}_{AB} + \bar{V}_{AC} \geq V$
5	$CBV_A = \frac{1}{4}\left(V + \bar{V}_{AB}\right)$, and $CBV_B = \frac{1}{4}\left(V + \bar{V}_{AB}\right)$, and $CBV_C = \frac{1}{2}\left(V - \bar{V}_{AB}\right)$ if $\bar{V}_{AB} \geq \frac{1}{3}V$, and $2\bar{V}_{AC} + \bar{V}_{AB} \leq V$, and $2\bar{V}_{BC} + \bar{V}_{AB} \leq V$
2 & 6	$CBV_i = \frac{1}{3}V$ if $\bar{V}_{AB} \leq \frac{1}{3}V$, and $\bar{V}_{AC} \leq \frac{1}{3}V$, and $\bar{V}_{BC} \leq \frac{1}{3}V$

Figure 2: Geometric Distance by Experiment

For each experiment, this figure shows the average geometric distance of the outcomes from the Coalitional Bargaining Value (CBV) predictions and from the Myerson-Shapley predictions.

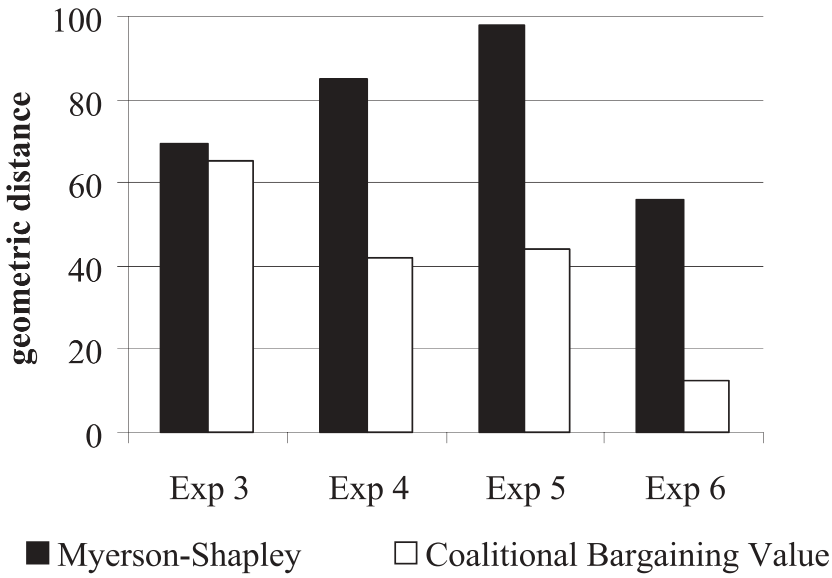

Table 11: Payoff Implications of Takeover Dynamics

For each of four experiments, this table describes data only from those settings where all three firms merged. For each cell we describe the number of outcomes in which a given player was in (or out of) the first takeover that occurred (in parenthesis) and the average end-value of that firm. The third row describes details of the statistical tests comparing the two distributions of earnings. In contrast to Table 8 in the main text, this table includes one-step, three-way mergers in which all players are included in the first takeover.

first takeover		**Experiment 1**				**Experiment 3**			
		A	*B*	*C*	All	*A*	*B*	*C*	All
IN		160	154	134	152	158	152	149	153
		(32)	(23)	(16)	(71)	(22)	(14)	(17)	(53)
OUT		163	85	88	93	122	86	83	90
		(3)	(12)	(19)	(34)	(4)	(12)	(9)	(25)
Wilcoxon	U	53	71	382	752	10	82	54	366
details	z	0.0280	6.258	1.334	9.236	5.458	4.029	4.169	3.785
	p	0.9778	0.0001	0.1909	0.0001	0.0001	0.0001	0.0003	0.0001

first takeover		**Experiment 4**				**Experiment 5**			
		A	*B*	*C*	All	*A*	*B*	*C*	All
IN		139	134	125	133	135	137	127	133
		(31)	(27)	(28)	(86)	(37)	(38)	(28)	(103)
OUT		169	133	122	136	170	NA	130	133
		(4)	(8)	(7)	(19)	(1)		(10)	(11)
Wilcoxon	U	129	93	98	748	38		188	560
details	z	1.306	2.056	1.541	1.704	1.304	NA	0.2169	0.6932
	p	0.2000	0.0473	0.1323	0.0913	0.2000		0.8294	0.4896

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