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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 firms. But takeovers also impose externalities (both positive and negative) on the remaining firms in the industry. This paper describes a new equilibrium concept designed to explain and predict takeovers in this setting. We experimentally compare the new equilibrium concept to that of competing concepts in situations without and with externalities. Moreover, we examine the predicted dynamics of takeovers and outcome implications of those dynamics. Our experimental results support the predictions of the new equilibrium concept and provide implications for further empirical tests.

1. Introduction

Mergers and acquisitions (more generally, takeovers) are an important means through which companies achieve economies of scale, remove inefficient management, or respond to economic shocks. In 2003, 1180 US-listed companies announced takeovers for about US$ 262 bn (Thomson Financial SDC Platinum database). Mitchell and Mulherin (1996) and Andrade et al. (2001) argue 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 ultimate goal of a takeover is to realize synergies, but how the synergies are divided between the involved companies is an open question that is critical for identifying

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winners and losers in mergers and acquisitions. We use the experimental method to investigate these questions.

We would like, of course, to examine this question in the field. In practice, however, the existence, size and division of synergies are uncertain or unknown. Synergies are typically estimated using adjusted stock market returns but this confounds uncertainty about the synergies with their levels and divisions. In addition, these analyses do not incorporate externalities – the effect of two firms merging on a third's value – or sequences of takeovers within an industry. The results of our experimental study would have been difficult to obtain using field data because counterfactuals (e.g., what would have been the value of takeovers that did not occur) are rarely observed by researchers. Industry participants, however, imperfectly know these counterfactuals and take them into account in their decision making. Thus, running an experiment to analyze the division of synergies can yield new insights which are useful not only for developing further empirical tests but also for participants in future takeovers and their advisors. In this paper, we describe and experimentally test three competing equilibrium solutions that predict how synergies will be shared among merging firms. One major advantage of experiments is the ability to control and vary parameters (see Friedman and Sunder (1994)). In particular, we present six experiments, varying the synergies and externalities (see Section 5) in the takeover setting.

Our research focuses on the bargaining process among owner-managers in the division of fixed and known synergies.[1] We limit our analyses to situations with three existing companies in an industry, each represented by one owner-manager.[2] Each company may remain independent, merge with one other company or merge with two other companies either sequentially or simultaneously. As a result, our experiment provides an answer to a question raised by Kale and Noe (1997). They study the effect of unconditional and conditional tender offers and ask, based on their results, how the surplus of a takeover would be split between the involved parties if they could negotiate without any restrictions.[3]

[1] The capture of synergistic gains contrasts with other explanations for takeovers which rely on a simple transfer of wealth between acquirer and target as a result of biased perceptions of the value of unknown synergies, the main argument of the hubris hypothesis (Roll, 1986), as well as agency motivations such as empire-building. Here we assume the existence of synergies as the main motivator of takeover activity although in practice many motivations undoubtedly exist.

[2] This design also eliminates both toehold considerations, i.e., an acquirer possesses a stake of his future target before negotiating the complete acquisition, and principal-agent problems which can result from a separation of ownership and control. Three previous experiments address other takeover-related questions focusing on shareholder reactions to tending bids – Kale and Noe (1997), Cadsby and Maynes (1998), Hamaguchi et al. (2002).

[3] In the study perhaps closest to ours, Lindqvist and Stennek (2001) use simultaneous and sequential acquisition games with fixed roles of one buyer and two sellers. In their experiment, however, the roles of buyer and seller are fixed and buyers can make only one offer to both sellers which can be accepted or rejected. Our experiment is substantially more flexible (any firm can participate as a buyer or a seller). Our experiment also examines externalities and dynamics of takeovers.

Previous empirical and theoretical studies have focused mostly on the conditions under which a bargaining process starts and proceeds; using the experimental method we can provide much more detailed information about bargaining processes and outcomes. In addition to the comparison of equilibrium concepts, we thus examine three further questions: the order in which sequences of takeovers occur (dynamics), the timing of the takeovers, and the benefits of participating in an early takeover. For each of these analyses we discuss implications for empirical research, including reinterpretations of existing explanations for observed regularities and new predictions which could be tested.

Since many takeovers unfold dynamically, for example when one firm acquires another and then is acquired by yet a third firm, we test a set of dynamic predictions in different settings (see Section 6.1). These sequences of takeovers are often observed in the field; 24 percent of publicly traded acquirers had been involved in at least two acquisitions. As a result, these acquirers accounted for about one half of the 3,180 takeovers in the U.S. among acquirers and targets in the 1990s. Moreover, 13 percent of acquirers eventually became targets of an acquisition during the same period (Thomson Financial SDC Platinum database). In well over half of the deals in the 1990s, three or more firms eventually ended up merging after a sequence of takeovers.[4] These dynamics may influence the division of synergies. One of the contributions of our paper is to show experimentally that the sequencing of takeovers is not random, and can be predicted based on the values of the synergies created through competing takeovers. The results on dynamics offer implications for empirical research. First, they highlight the importance of estimating the synergies and externalities involved in takeovers. If these can be estimated by the researcher (presumably in consultation with industry participants), then the order of takeovers within an industry can be predicted, and those predictions tested. Note that other researchers have suggested competing models that predict the order of takeovers that will be observed in an industry (e.g., Shleifer and Vishny (2003) or Rhodes-Kropf and Viswanathan (2004)). Empirical tests could be designed to compare the predictive power of these alternative models.[5]

A second set of results discusses the timing of takeovers and suggests an explanation for why takeovers may occur in waves. If one company believes that a takeover creates synergies and thus begins a negotiation process, all other firms in this industry whose values will be affected by a takeover through the externalities should consider their takeover options, too. Thus our theory and experiment identifies conditions under which one takeover will trigger another. As we show in our

[4] 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).

[5] Rhodes-Kropf et al. (2003) show that the models by Shleifer and Vishny (2003) and by Rhodes-Kropf and Viswanathan (2004) have descriptive power without testing them formally.

experiment this process influences not only the bargaining outcome but may result in a merger wave, with mergers happening quickly once the first has occurred. This observation is consistent with established empirical results and can be used to explain previous observations of merger waves and to predict in which industries merger waves are likely to occur and in which they are not.

A third contribution to empirical research involves the benefits from being involved in an early takeover. The theory we describe distinguishes between situations in which it is better to participate in the first takeover and those in which staying out yields a higher return. In these situations different players make the first bid and the synergies and externalities can be used to predict who will eventually be the acquirer and who the target. In addition to the implications of these predictions for empirical research, our experiment can be used by the firm's management or its advising investment bank when thinking about whether and how to pursue a merger or takeover. Thus our research provides structural guidelines for the empirical analysis of these takeovers.

Finally, in addition to these empirical predictions, the model and experimental results described here can be used to (re)interpret existing results that have previously been attributed to the acquisition mode, the existence of toeholds and the management structure of both target and acquirer. Our experimental results demonstrate that many of these existing empirical results can also be caused by the existence of externalities and the industry structure. Like all empirical and theoretical research, we focus on specific questions and design elements. We discuss the limitations of our experimental design and propose future research to address those limitations in Section 6.4.

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 3. We present our experimental results without and with externalities in Sections 4 and 5, respectively. Empirical implications resulting from the dynamics of takeovers and the existence of externalities are analyzed in Section 6. Conclusions and remaining questions are described in the final Section 7.

2. Competing Equilibrium Predictions

As mentioned in the introduction, we analyze situations in which three firms can merge. Two-way and three-way mergers are possible. In addition, our setting allows for two consecutive two-way mergers to reach a final state with one unified firm. We choose parameters involving positive synergies from takeovers.

Many readers will be more familiar with non-cooperative game theory, in which the order of moves is given and equilibria are often unique. In cooperative game theory in contrast, equilibrium predictions are typically multi-valued (the core). A number of competing solution concepts have been suggested for selecting which *unique point* out of the core will be observed, including the Nucleolus (Schmeidler, 1969), Shapley value (Shapley, 1953) and the Coalitional Bargaining Value (*CBV*)

(Gomes 2003a, b). We test these competing concepts against each other in this research. We will not examine other solution concepts that make multivalue predictions. These include the bargaining set (Davis and Maschler (1963, 1967)), the kernel (Davis and Maschler (1965)), and stable-sets of von Neumann and Morgenstern (1944) (see survey by Maschler (1992)). We begin here with the case of no externalities, and extend our analyses to include externalities in Section 5.

We are not the first to test the predictive powers of competing equilibrium theories. Previous work, like ours, relies on equilibrium concepts from game theory. Early work in this area can be found in Kahan and Rapoport (1984). More recently, Bolton et al. (2003) experimentally rejected both Myerson-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. Our research, however, extends this literature in two ways. First, in addition to the situations examined in this previous work we also examine situations in which firms' takeover decisions impose externalities on the remaining industry. Second, in this previous work once a single takeover has occurred there were no possibilities of future takeovers. In reality, takeovers can and often do occur sequentially. Thus, we allow for takeovers to occur sequentially in our experiment, i.e., one firm might take over another and then a third firm might take over this newly created first firm. We derive predictions for the sequences of takeovers and test these predictions with our experiment.

The synergies are described by the following parameters, also known as the *characteristic function* of the game. We denote the stand-alone values for firms A, B and C as v_i normalized to zero.[6] 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 $V > V_{AB}, V_{AC}, V_{BC}$).

2.1. THE NUCLEOLUS

Schmeidler (1969) first introduced the concept of the nucleolus.[7] 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 I. Although, the nucleolus concept has a simple mathematical definition, its intuitive meaning is hard to grasp. Maschler

[6] 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.

[7] 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.

Table I. 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.

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

(1992) provides an intuitive description of the principles behind the nucleolus, as the value that minimizes the excess that each possible takeover earns over its next-best alternative.

2.2. 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 derived the unique solution satisfying these properties; the value. The Shapley value for our 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 A, B, and C in our game. 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.

2.3. THE COALITIONAL BARGAINING VALUE (*CBV*)

Gomes (2003a, b) introduced the *CBV*, based on a non-cooperative game theory model of coalition formation.[8] In this model, firms are randomly chosen to make offers to buy other firms, who can accept or reject the offers.[9] One main result from Gomes (2003b) 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 ($V_{AB} + V_{AC} + V_{BC} \geq V$). Thus in our first two experiments we will test whether *CBV* is selecting appropriately between these competing predictions. Depending on the parameters, the *CBV* predicts either one or the other will be observed.

This selection property of the *CBV* forms the basis of our first two experiments. We begin in Section 4, with two experiments without externalities. Within each of the experiments, we will choose parameters that maximize the differences between

[8] Although the *CBV* uses a non-cooperative game structure to generate its solutions, we do not impose that structure on the experimental procedure. 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.

[9] 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 sequentially formed.

the competing equilibrium concepts. In Section 5, we will extend our analyses to takeovers with externalities.

3. 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.[10] Each experiment was run in a single session with the same three experimenters attending.[11] 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.[12] 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 participants were seated at the monitors, the experimenters handed out written information about the exercise to all participants.[13] In the written materials, participants were told that each of them represented a business-to-business

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

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

[12] 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.

[13] A sample of this information is included in the supplemental online material (http://www.revfin.org). A full copy of the experimental materials is available by request at kmcginn@hbs.edu.

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 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 4 and 5, below. Though formally only one company in a consolidation would 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 the supplemental online material. 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.[14] The game screen included an input box for all negotiation other than offers and offer boxes to input takeover offers. All communication – negotiation as well as offers and acceptances/rejections – was public information.[15] When a party wanted to make an offer, she selected the players to be included in the takeover, and specified the payments for each of the included players. Offers remained active for 15 seconds. Only one offer could be outstanding at a time. Outstanding offers were noted in a separate box, which included accept and reject buttons. 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.

Once an offer had been made and accepted, the seller no longer participated in the negotiation, though she still could read the exchange between the remaining players written in the communication box. We allow for sequential takeovers (e.g., Axel.com might be sold to BRing.com, and in a subsequent sale BRing.com sells

[14] The custom-made software by Nick McKinney is available upon request from kmcginn@hbs.edu.

[15] There was no secret negotiation between two parties. We used the fully public negotiation structure in order to promote competitive bidding, as shown by Bolton et al. (2003). Extensions to our research might introduce this factor of secret negotiation to test the robustness of the theories.

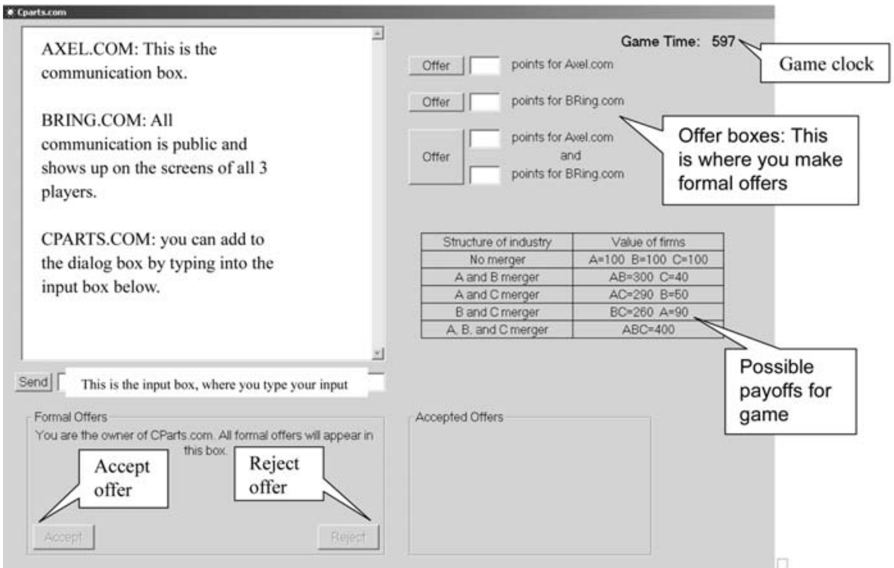

Figure 1. A sample screen from the experiment.
This figure shows a sample screen of our experiments. The white box in the upper left corner displays the negotiation between the three firms. The input field below this box can be used to enter a new message. In the upper right corner players can make offers 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 this case all three players face negative externalities if they do not participate in a two-way merger. In the lower left corner are buttons to accept or reject an offer.

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.

Participants were provided with a paper "history form" to record the specifics of all deals, as shown in the supplemental online material. At the end of each round, they were given time to record their outcomes on the form. 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.[16] 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

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

contexts without externalities (Section 4), while experiments 3 through 6 were designed to explore synergies in the presence of externalities (Section 5). Dynamics and timing of the bargaining process will be analyzed in Sections 6.1 and 6.2 for all six experiments.

4. Comparing and Selecting Solution Concepts Without Externalities: Experiments 1 and 2

The parameters for experiments 1 and 2 were designed to test the ability of the *CBV* to select among competing solution concepts of how synergies will be shared. The experimental design identified parameters which maximized the geometric distance between the competing predictions, thus increasing the likelihood of identifying differences in predictive power. In experiment 1, the parameters maximize the distance between the predictions of the *CBV* = Shapley and of the Nucleolus. In experiment 2, the parameters maximize the distance between the predictions of the *CBV* = Nucleolus and of the Shapley value. Summary statistics for all the experiments can be found by the interested reader in Table IX in Appendix A.

4.1. EXPERIMENTAL RESULTS

Table II contains the parameters and equilibrium predictions of the two experiments without externalities. In both cases the *CBV* prediction coincides with either the Shapley or the Nucleolus prediction.

Twenty-four subjects participated in experiment 1. 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 observe 40 separate negotiations. Because each player participated in five games, these observations may not be completely independent. Therefore, we examine the data at the individual as well as at the group level. In both analyses, we examine the closeness of the outcomes to those predicted by the competing solution concepts.

In the first analysis we calculate the geometric distance between the outcome and the prediction for each of the 40 negotiations.[17] We then compare the distribution of distances to determine which equilibrium concept is closer to the actual outcomes.

In the second analysis, we collect, for each individual, their outcomes over the five games they played. We then calculate the geometric distance between the in-

[17] 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 61.24. Using the absolute difference (rather than the geometric distance) leads to the same results in this and all future analyses.

Table II. Selection abilitity of *CBV*: Shapley versus Nucleolus
The first column describes the possible takeovers that could occur. The second and third columns describe the value of the independent or merged firms under each possible industry structure. The final two rows describe the equilibrium predictions of the competing solution concepts.

Structure of industry	Exp 1: *CBV* (= Shapley) vs. Nucleolus value of firms			Exp 2: *CBV* (= Nucleolus) vs. Shapley value of firms		
$[A], [B], [C]$	$v_A = 50$	$v_B = 50$	$v_C = 50$	$v_A = 0$	$v_B = 0$	$v_C = 0$
$[AB], [C]$	$V_{AB} = 300$	$V_C = 50$		$V_{AB} = 130$	$V_C = 0$	
$[AC], [B]$	$V_{AC} = 300$	$V_B = 50$		$V_{AC} = 5$	$V_B = 0$	
$[BC], [A]$	$V_{BC} = 150$	$V_A = 50$		$V_{BC} = 5$	$V_A = 0$	
$[ABC]$	$V_{ABC} = 400$			$V_{ABC} = 400$		
CBV prediction	$CBV_A = 183.3$	$CBV_B = 108.3$	$CBV_C = 108.3$	$CBV_A = 133.3$	$CBV_B = 133.3$	$CBV_C = 133.3$
other prediction	$Nuc_A = 300$	$Nuc_B = 50$	$Nuc_C = 50$	$Shap_A = 154.2$	$Shap_B = 154.2$	$Shap_C = 91.6$
# observations	24 subjects / 40 negotiations			18 subjects / 30 negotiations		

Table III. Selection ability of *CBV*: Results
This table contains the average geometric distance between outcomes and equilibrium predictions for two experiments without externalities.

	Experiment 1: *CBV* (= Shapley) vs. Nucleolus				Experiment 2: *CBV* (= Nucleolus) vs. Shapley			
	Group		Individual		Group		Individual	
	CBV	Nucleolus	*CBV*	Nucleolus	*CBV*	Shapley	*CBV*	Shapley
# obs	40 games		24 participants		30 games		18 participants	
Geom. dist.	62.27	174.20	80.13	214.77	38.47	71.58	72.45	98.68
Std. dev.	(16.58)	(26.95)	(22.62)	(76.68)	(58.64)	(44.41)	(54.03)	(45.78)
Wilcoxon $z(p)$	7.698 (<0.0001)		5.835 (<0.0001)		3.312 (=0.0024)		1.980 (=0.0632)	

dividual's outcomes and the predictions of the competing equilibrium concepts.[18] Again, 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.

Table III contains the resulting average geometric distances and test results for both analyses and both experiments.[19]

As Table III shows, the distance between the *CBV*'s selected equilibrium prediction and the actual outcomes is significantly lower than the distance between the other equilibrium prediction and the actual outcomes, using both the group and individual analyses and for both experiments 1 and 2. For example, in experiment 1 the average distance between the actual (group) outcomes and the Nucleolus was 174.20 whereas the average distance between *CBV* = Shapley and the outcomes was only 62.27. Because these distances are not normally distributed (in particular, they're all positive), we use the nonparametric paired Wilcoxon test to compare the distances. We find a significant difference between these two distributions of distances ($n = 40, z = 7.698, p < 0.0001$).[20] Similarly, over all 24 individu-

[18] 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 335.41.

[19] Instead of using the equally-weighted average of the *CBV* path-dependent outcomes, we could generate the *path-dependent predictions* by using 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. Statistical 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.

[20] 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 ($n = 35$, $z = 7.199$, $p < 0.0001$).

als, the average distance between the actual outcomes and the *CBV* = Shapley 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 demonstrate a significant difference between these two distributions of distances ($n = 24$, $z = 5.835$, $p < 0.0001$).[21]

Comparing the *CBV* = Nucleolus and Shapley predictions with the actual outcomes in experiment 2 yields the same result, i.e., the average geometric distances between the observed outcomes and *CBV* = Nucleolus predictions are significantly smaller than these distances between the observed outcomes and the Shapley prediction, in both the group and individual analyses.[22]

4.2. DISCUSSION OF EXPERIMENTS 1 AND 2

These first two experiments provide evidence that *CBV* selects accurately between the Nucleolus and the Shapley value in situations without externalities. The *CBV* correctly predicts when each of the competing equilibrium concepts of Nucleolus and Shapley will be realized, analyzing the results both at the group level and at the individual level.

We purposefully chose a setting that mirrored the real-world environment of takeovers, allowing for sequential takeovers to occur and the parties to negotiate freely. These procedural details are likely to be important. For example, in the 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 13% of the games. The procedures used in previous experiments sometimes preclude efficient outcomes that would be observed in reality – after one takeover has occurred participants cannot renegotiate to the efficient three-way merger as they can in our experiment.

Next, we examine the equilibrium predictions of the *CBV* and other solution concepts in settings with externalities, when takeovers affect the value of the firms who are not invited.

5. Externalities

Our previous experiments focused on the predictive abilities of competing equilibrium predictions, thus we designed settings where those competing concepts could make a prediction. An observed regularity from the field, however, is that takeovers

[21] As before, restricting the outcomes to those in which all three firms merged does not change our results, ($n = 24$, $z = 5.86$, $p < 0.0001$).

[22] Both equilibrium concepts, *CBV* = Nucleolus and Shapley, being tested here predict that all three firms will merge in this experiment. 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 ($n = 27$, $z = 3.90$, $p = 0.0006$). If we restrict the individual outcomes to those in which all three firms merged, our results improve ($n = 18$, $z = 2.85$, $p = 0.0106$).

often impose externalities on the remaining firms in the industry. Positive externalities can occur in takeovers with market power, when two (large) firms merge and the industry becomes less competitive and more concentrated. An example 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 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 main stock market index (DAX) improved only about 5%. The merger thus seems to have created positive externalities for those banks not included in it. Alternatively, negative externalities occur when the takeover creates a strong competitor that may drive non-merger participants out of the market. For example, the takeover can decrease marginal costs of production or lead to more aggressive strategies like predatory pricing, which reduce the profits of remaining (unmerged) firms. The empirical study of Banerjee and Eckard (1998) illustrates the existence of negative externalities associated with mergers. They show that during the great merger wave of 1897–1903 competitors suffered significant value losses.[23]

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 takeovers of other firms. In 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 again 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. 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 point predictions for situations with externalities.

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

5.1. 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. We will then describe four experiments, one capturing 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.[24]

[24] 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.

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

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

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

$$CBV_A = \frac{1}{4}\left(V + \bar{V}_{AB}\right), CBV_B = \frac{1}{4}\left(V + \bar{V}_{AB}\right),$$

and

$$CBV_C = \frac{1}{2}\left(V - \bar{V}_{AB}\right).$$

This situation will be captured in our experiment 5.

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.[25]

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

Table X in Appendix A 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 takeovers which are expected in each of these types of games – these predictions and their experimental tests will be discussed in Section 6.1.

5.2. FOUR EXPERIMENTS EXAMINING EXTERNALITIES

The analyses below will compare predictions from the *CBV* and Myerson-Shapley, regarding how synergies are shared in takeovers. 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 IV 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 V presents the average distances (and standard deviations) as well as the statistical comparisons for each experiment and for the pooled data.

In all four experiments with externalities, using data from group outcomes 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.[26]

A similar analysis can be performed at the level of the individual rather than at the level of the group. Table VI presents the summary statistics and statistical tests for experiments 3-6 for this analysis.[27]

In all experiments, 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 sig-

[26] 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 experiment 3: ($n = 26, z = 1.044, p = 0.148$); experiment 4: (35, 6.026, 0.0001); experiment 5: (38, 7.410, 0.0001); experiment 6: (41, 7.561, 0.0001); all experiments with externalities: (140, 4.997, 0.0001).

[27] As before, restricting the outcomes to those in which the final three-way merger formed does not change our results experiment 3: (21, 0.893, 0.1863); experiment 4: (21, 3.53, 0.0016); experiment 5: (27, 5.60, 0.0001); experiment 6: (27, 5.03, 0.0001); all four experiments with externalities: (96, 7.21, 0.0001).

Table IV. *CBV* vs. Myerson-Shapley in four experiments
The first column describes the possible mergers that could occur. The second and third columns describe 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 V. Geometric distances and statistical tests by group
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 non-parametric Wilcoxon test comparing those distances. The final column describes the same results for all four experiments pooled together.

	Experiments				
	Exp 3	Exp 4	Exp 5	Exp 6	Exp 3–6 (pooled)
# Observations	35	35	45	45	160
Distance *CBV*	65.30 (18.86)	42.13 (30.03)	43.90 (23.41)	12.62 (32.18)	39.40 (32.64)
Distance *MS*	69.34 (19.37)	84.91 (26.60)	98.08 (18.76)	55.86 (22.97)	77.06 (24.45)
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

Table VI. 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 their 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				
	Exp 3	Exp 4	Exp 5	Exp 6	Exp 3–6 (pooled)
# Individuals	21	21	27	27	96
Distance *CBV*	80.77 (34.88)	57.20 (29.51)	57.98 (27.80)	33.74 (40.50)	56.57 (37.16)
Distance *MS*	88.40 (29.53)	107.93 (39.89)	123,71 (36.78)	73.24 (38.85)	98.33 (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

nificant.[28] 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

[28] In experiment 3, the *CBV* makes path-dependent predictions as it did in experiment 1. The average distance between 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 ($z = 2.801$, $p = 0.003$).

are significantly closer to the experimental observations than the predictions of the Myerson-Shapley solution.

As one reader points out, one common result in ultimatum and other bargaining experiments is that subjects split earnings 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. Alternatively, efficiency gains from equal splits in other games could account for these differences. The interested reader is referred to Bolton et al. (2003) who discuss the equal-split issue in greater depth.

6. Empirical Implications and Limitations

Existing empirical analyses typically do not incorporate externalities or sequences of takeovers. This has led to competing and/or inconsistent results in field data. For example, Agrawal et al. (1995) find that acquiring firms lose about 10% of their value over the first five years after mergers, and claim that synergies from takeovers are captured by targets rather than acquirers. In contrast, the results of Franks et al. (1991) find no significant underperformance of acquirers indicating that acquirers do not pay too much for the target firm and thus synergies are divided appropriately between the two involved firms. These mixed results suggest that missing information about synergies and externalities may be needed to reconcile our observations.

As a second example Bange and Mazzeo (2004) show that target board characteristics have an influence on the offer premiums. In contrast, our analysis demonstrated that the division of surplus can vary due to the synergies and externalities present even without considering different takeover types and board characteristics. Since previous empirical studies do not control for these factors, it is possible that their results rely more on them than on the factors identified.

More generally, our results show that industries where takeovers create positive or negative externalities have very distinct economic features, and thus should be analyzed separately. Predictions about how synergies are shared are very different. Moreover, although the precise values of synergies and externalities may not known by the empirical researcher, tests of the comparative static predictions of the theory can still be conducted by comparing industries that are characterized by positive and by negative externalities.

Knowledge of the existence and direction of externalities (if not their magnitude) can predict other features about the industry as well. For example, in conditions of (or industries with) positive externalities rivals' stock price should rise conditional on other firms merging. Thus there is not much need for the use of protective deal contracts such as termination fees, and lock-up stock options as rivals have little incentive to break up a deal that will only benefit them as well. In contrast, in conditions of (or industries with) negative externalities, the stock price reaction of rivals to a takeover is harmful. In this case, we expect that firms should be more likely to use protective mechanisms like termination fees and lock-up stock options. These mechanisms erect costly barriers for rivals who may be attempting to prevent a takeover in order to avoid their own losses associated with being excluded.

Additional findings suggest some novel implications for empirical finance researchers to explore. For example, in Section 6.1 we consider the sequences of takeovers and who makes the first offer and show that the order of takeovers within an industry are not only predictable but can influence the division of synergies. In Section 6.2 we consider the timing of takeovers and make predictions of when we will observe merger waves. In Section 6.3 we investigate the impact of staying out of a first takeover in an industry and show when this has a positive and when a negative impact on the realized value of a firm. Finally, in Section 6.4 we discuss the limitations of our experiment and make some suggestions for further research.

6.1. DYNAMICS OF TAKEOVERS: PATH PREDICTIONS

The *CBV* makes predictions about the order in which takeovers will occur, which can be tested using our experimental data. When there are high synergies, the sum of the adjusted measure of value of all partial takeovers is greater than the value of the three-way takeover, partial takeovers are predicted to 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 experiment 3, and experiment 1 with no externalities.

When only one firm's takeovers create synergies (as in experiment 4), a different merger path is predicted. 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. The *CBV* predicts that the only takeovers that should happen are AB and AC, and the (subsequent) three-way takeover ABC.[29]

When only one two-way merger creates synergies (as in experiment 5), then yet a different path is predicted. Here, without loss of generality, we say it is AB. The *CBV* predicts 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.[30]

[29] 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 $\bar{V}_{AB} + \bar{V}_{AC} + \bar{V}_{BC} \leq V$.

[30] 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 $\frac{V+V_{AC}}{2}$,

When all partial takeovers create very little value we predict a three-way merger to occur directly, with no partial takeovers observed in between.[31] This situation was captured in experiment 6 with externalities, and experiment 2 with no externalities.

Table VII 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 VII 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*.

While the *CBV* makes multiple predictions about which path will be taken, it is interesting to examine conditions under which each path is most likely to emerge. For example, consider Game 1. We can look at the paths chosen when A makes the first offer in the game. Ninety-one percent of the time when A makes the first offer the paths chosen involve A being included in the first takeover (AB then ABC or AC then ABC). Only 9% of the time does A make the first offer and then is excluded from the first takeover. A similar analysis can be done for B and C. When B makes the first offer, 78% of the time they are included in the first takeover, and 22% of the time they are not. When C makes the first offer 71% of the time they are included in the first takeover and 29% of the time they are excluded.

Results from Game 3 (where the *CBV* also predicts multiple paths) look much the same. When A makes the first offer he is included in the first takeover 93% of the time, and excluded 7% of the time. When B makes the first offer he is included in the first takeover 65% of the time and excluded 35% of the time, and when C makes the first offer he is included 83% of the time and excluded 17% of the time. While the *CBV* does not predict who in our setting will make the first offer, its predictions are consistent with the observation that whoever makes the first offer will be involved in an early takeover. This is exactly what we observe in our experimental data.

This analysis of the path of takeovers suggests new predictions that can be tested empirically. The researcher would need some estimate of the size of the synergies and externalities in a given industry (possibly gleaned from the industry participants). This information could then be used to predict the path of takeovers that would be observed. Note that others have suggested competing models predicting the order of takeovers. For example, Shleifer and Vishny (2003) present a model of mergers and acquisitions based on stock market misvaluations. In their

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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 $\bar{V}_{AB} \leq \frac{1}{3}V$.

[31] 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 VII. 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	$AB \rightarrow ABC$	$AC \rightarrow ABC$	$BC \rightarrow ABC$	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%**

model relative valuations of the merging firms predict who acquires whom and the choice of the medium of payment. Our approach also provides predictions of which firms should merge, but the story is not based on stock market mispricing. In contrast, we focus on the division of synergies and the sequencing of takeovers. New empirical work could tease apart these competing models.

Other empirical investigations might identify industries in which the paths of consolidation are more or less predictable. For example, in industries with characteristics like experiments 1 and 3, many dynamic paths are predicted, while in industries with characteristics like experiments 2 and 6, only one (the multiple-way merger) is predicted. Empirical research could test these predictions as well.

6.2. TIMING AND MERGER WAVES

In addition to these results, a further analysis examines the negotiation process with respect to the time needed to reach an agreement. The *CBV* predicts that there will be a "rush to merge" in experiments 1 and 3, where two-way coalitions produce high synergies. In fact, 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 (Wilcoxon $z = -3.877$; $p = 0.0001$).

As expected, it takes longer to negotiate a three-way coalition than a two-way coalition. In experiments 2 and 6, however, 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 experiment 5). Thus in situations where the *CBV* predicts a delay to merge, we see agreements reached slightly slower.

These results on timing support the *CBV*'s predictions of when takeovers will occur. We can imagine using these predictions in the field as well. For example, whether takeovers create positive or negative externalities is something that can be ex-ante known based on the industry characteristics. The industrial organization literature proposes several factors such as concentration, barriers to entry (Stigler, 1950), product differentiation (Deneckere and Davidson, 1985), and excess capacity (McAfee and Williams, 1992) which create an environment where positive-externality mergers may arise. In those circumstances merging firms increase prices, which indirectly lead to increased profits for rivals. The polar case in which mergers create negative externalities can occur, for example, because of economies of scale and scope (Farrell and Shapiro, 1990), technology shocks, or predatory pricing. In such circumstances merging firms create a stronger competitor producing at lower costs or using aggressive pricing strategies that can reduce the profitability of rival firms.

We have shown theoretically and experimentally that the predictions for the timing of takeovers in these cases are distinct. In the negative-externality case, we see firms rushing to merge and takeovers occurring in multiple steps mirroring the merger wave phenomenon. On the other hand, in the positive-externality case, there are merger delays followed by multiple-firm consolidation (where all firms merge together at once). Future empirical research in this area can test these predictions in the field. This research can also identify which industries are likely to be hit by merger waves and which are not.

6.3. EVENT STUDY IMPLICATIONS

Our theory also predicts when and whether the sequence of events influences the realized values of (non-)participating firms in the first takeover. This theoretical result can 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. Song and Walkling (2000) argue and show empirically that companies staying outside of a first takeover earn abnormal returns. The theoretical predictions of *CBV* provide some clues for why different studies obtain these different results. The results depend on the specific structure of externalities and synergies.

The *CBV* predicts the value that firms will realize for a given sequence of takeovers. In particular, for experiments 1 and 3 in which any two-way takeover creates significant synergies, the firm that is left out of the initial takeover is predicted to earn less. For experiments 4 and 5, in which only one firm's takeovers (experiment 4) or only one specific two-way takeover (experiment 5) creates synergies, there should be no differences in value between firms that were included or left out of the initial takeover.[32]

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 VII). 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 of 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).

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

Table VIII. 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		Experiment 1				Experiment 3			
takeover		*A*	*B*	*C*	All	*A*	*B*	*C*	All
IN		161 (31)	155 (22)	134 (15)	153 (68)	157 (21)	159 (13)	148 (16)	155 (50)
OUT		163 (3)	85 (12)	88 (19)	93 (34)	122 (4)	86 (12)	83 (9)	91 (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		Experiment 4				Experiment 5			
takeover		*A*	*B*	*C*	All	*A*	*B*	*C*	All
IN		141 (15)	130 (11)	122 (12)	132 (38)	132 (10)	139 (11)	85 (1)	133 (11)
OUT		169 (4)	133 (8)	122 (7)	136 (19)	85 (1)	NA	130 (10)	126 (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

The average value, number of observations, and statistical differences are shown in Table VIII.

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, in which any two-way takeover creates significant synergies, 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.[33]

[33] 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 VIII to include the cases when all three firms merge in one step. The results are qualitatively the same and are presented in Table XI in Appendix A.

Thus our research can help to organize contradictory results from the previous empirical (event-study) literature. We can also predict industries and situations where entering early will provide an advantage and those where it will not.

6.4. LIMITATIONS

Designing an experiment allows one to focus on specific research questions while keeping other potentially important influences constant. In this respect, experimental research is closely related to theoretical research. But real world problems are more complex, thus a single experiment cannot provide answers to all possible questions. In this section we mention some limitations of the existing experiment and provide some suggestions of how our experimental methods could be extended to address other important issues in mergers and acquisitions.

An obvious extension is the introduction of uncertainty with respect to synergies. As long as the parameters of the uncertainty are common knowledge, the predicted results should not change dramatically. However, if different parties have different estimates of uncertain synergies then there is substantial room for new results. With asymmetric information about valuations and synergies, situations like those in the model of Shleifer and Vishny (2003) can arise, when participants misvalue other firms. Similarly, Giammarino and Heinkel (1986) show that value-maximizing behavior with asymmetric information about potential synergies can cause overbidding and the initial rejections of bids. In contrast, we did not observe systematic overpayment in our data, most likely because asymmetric information was absent in our design. A new experiment incorporating uncertainty and asymmetric information about synergy size would be an interesting extension.

Bolton et al. (2003) have explored the possibility of secret negotiation or bidding. This is clearly an important element in real world takeover negotiations and would be particularly relevant in situations with asymmetric information, as secret interactions reveal less private information than public interactions. Thus further experiments might combine uncertainty and asymmetric information with secret bidding.

Since we focused on negotiations between owner-managers we eliminated agency problems between managers and shareholders. However, these considerations are present in the real world, as Stulz et al. (1990) or Bange and Mazzeo (2004) demonstrate. Future research could design experiments to include principal-agent problems and empire-building motivations in situations with and without externalities.

Another related topic not incorporated into our experiment is the effect of ownership and financing structure.[34] For example, Kale and Noe (1997) study the effect of unconditional and conditional tender offers and their effects on shareholders' behavior. They find, despite the presence of free riding, takeovers succeed

[34] Billett et al. (2004) analyze how bond holders of target firms profit from takeovers. For example, they show that target bondholders gain if the acquirer has a higher bond rating.

at premiums that are less than the post-takeover value. 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. A closely related topic is the effect of toeholds. For example, Singh (1998) and Burkart (1995) demonstrate how the bidder's initial stake (toeholds) leads to overpaying. A first experimental analysis is provided by Hamaguchi et al. (2002) who study the free-rider problem of shareholder tendering with and without toeholds.

Highlighting these limitations reinforces our impression that the questions around takeovers are far from being answered. So far, only certain aspects of the process have been studied either theoretically, empirically or experimentally, but the complexity of the takeover process requires more exploratory research that combines them. Experiments are especially useful here because the environment can be tailored to address specific questions.

7. Conclusion

Firms appear willing to consider a merger or acquisition as soon as (potential) synergies are identified – as soon as the new company can enjoy additional value. The question remains, however, how these synergies are shared between the firms. We model this decision as a bargaining game between owner-managers. In experiments 1 and 2 of this paper we test existing solution concepts' predictions of how synergies will be shared. We describe a new solution concept, the *CBV*, which accurately selects between competing equilibrium concepts of the Shapley value and the Nucleolus in predicting synergy sharing.

Next we extend these games to capture conditions of externalities, i.e., the merger of two firms affects the stand-alone value of the third firm. In experiments 3–6 we find that the *CBV* performs well in predicting how synergies will be shared in situations with externalities. In these settings, the *CBV* outperformed its nearest competitor, the Myerson-Shapley value, in predicting how synergies would be shared.

Our third question involves the *dynamics* of takeovers. For example, the emergence of GlaxoSmithKline out of two previous two-way mergers may be attributed to the available takeover options and the synergies associated with these options at sequential points in the lives of the involved firms. Our results formalize the conditions under which we would expect to see three-way mergers instead of a series of two-way mergers. In Section 6.1 we find that the *CBV*'s predictions of the order in which takeovers would occur were observed in over 75% of the rounds.

These dynamics predictions carry with them other predictions about the earnings of firms in and out of the first takeover. In settings where high synergies are created by a two-way merger, for example, the *CBV* predicts that firms who first participate and then later merge with the remaining firm will earn more than those who are left out of the first takeover. In contrast, when one firm or two-way takeover dominates, the order of takeovers will not affect the value received by each of the firms. Our experimental outcomes are again consistent with these predictions.

We use experiments to investigate these questions because field methods using market valuations to measure synergies face challenges. Tests using field data are really tests of the joint hypotheses of theories of how synergies are shared and of efficient markets. The actual synergies and externalities created from the takeover remain unknown to the researcher. In our experimental approach, in contrast, we can control exactly the synergies and externalities created from takeovers, and then examine competing theories of how they will be shared.

In addition to validating the equilibrium concepts, our research has a number of empirical implications, discussed in Section 6. In general, the synergies created from takeovers and the resulting externalities will have strong implications for which takeovers will be observed, when and at what prices. The theory provides a framework to identify industries in which takeovers will occur, makes predictions about the order in which they will occur, the likely speed of those takeovers (merger waves) and identifies firms who are likely to participate in early takeovers and those who are likely to wait for later ones. To make these predictions the researcher would like to have an estimate of the synergies and externalities that would result from all potential takeovers (even those which are not observed). This information is known by industry participants, but rarely collected. Our research suggests that such a data collection exercise would significantly improve our ability to explain and predict takeover activity. Alternately, cross-industry comparative static predictions can be made and tested with significantly lower information requirements.

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. Synergies are known and all alternatives are well-defined, thus our results shed light on aspects of the process of mergers and acquisitions that cannot be observed by using empirical stock market data. This experimental setting allows us to test competing predictions in a way that could not be done in the field. 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 more accurate predictions and a better understanding of when takeovers will occur, at what prices and in what order.

Appendix A. Additional Tables

Table IX. 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 X. *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 $\bar{V}_{BC} \leq \frac{1}{3}V$

Table XI. 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 VIII in the main text, this table includes one-step, three-way mergers in which all players are included in the first takeover.

First		Experiment 1				Experiment 3			
takeover		*A*	*B*	*C*	All	*A*	*B*	*C*	All
IN		160 (32)	154 (23)	134 (16)	152 (71)	158 (22)	152 (14)	149 (17)	153 (53)
OUT		163 (3)	85 (12)	88 (19)	93 (34)	122 (4)	86 (12)	83 (9)	90 (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		Experiment 4				Experiment 5			
takeover		*A*	*B*	*C*	All	*A*	*B*	*C*	All
IN		139 (31)	134 (27)	125 (28)	133 (86)	135 (37)	137 (38)	127 (28)	133 (103)
OUT		169 (4)	133 (8)	122 (7)	136 (19)	170 (1)	NA	130 (10)	133 (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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