Matching and bargaining with deadlines: An experimental study*

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Abstract

We describe an experiment where buyers and sellers, endowed with heterogeneous deadlines, are randomly matched and attempt to reach agreement over the division of a fixed surplus. The theoretical models that provide the background for this experiment have been developed in recent papers by Hurkens and Vulkan. Like those papers we consider both the case where deadlines are private and common information – that is, when a trader can or cannot see the deadline of the person she is matched with.

Observed behaviour in the experiment is largely consistent with the theory: when the deadline of the responder is known, offers made are increasing in the responder's deadline while when the deadline of the responder is unknown, offers made are decreasing in the proposer's deadline. However, in contradiction to the theory, the experimental evidence indicates that individuals reject positive offers and prefer to receive zero payoffs. This supports previous empirical findings of ultimatum game effects in bargaining.

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1. Introduction

A fundamental assumption in economics and finance is that a deal today is worth more than a deal tomorrow. This can be because economic agents are impatient, because there is a chance that negotiations may break down or because negotiation is costly. The standard way of modelling this is through the discount factor δ. Most models of bargaining (eg. Rubinstein (1982) and its many variants) adopt the discount rate as the measure of impatience, hence assuming stationarity of preferences. In a bargaining model with perfect information, stationary preferences imply stationary behaviour which means that the same offers are made over and over again and the same criterion is used for accepting or rejecting an offer.

In this paper, we consider deadlines as an alternative way in which to express impatience or eagerness to reach a deal in a bargaining environment. Assuming no deal can be reached past the deadline clearly violates the stationarity assumption. We are particularly interested in how deadlines influence behaviour when there is a (large) number of buyers and sellers who face heterogeneous deadlines. This builds on the recent papers of Hurkens and Vulkan (2007a,b) (hereafter referred to as H&V); in these models, a continuum of buyers and sellers are each endowed with a deadline, arrive to the market according to an exogenous arrival rate where they are randomly matched. H&Va consider the case of commonly known deadlines whereas H&Vb investigate bargaining behaviour when deadlines are privately known. H&Va show how the possibility of delayed agreements depends on the distribution of deadlines and that traders with longer deadlines are being offered more generous deals and thus obtain higher payoffs than traders with a short deadline. H&Vb show that some traders may actually miss their deadline since the offers made are decreasing in the proposer's deadline and even prospers with an immediately expiring deadline may optimally decide to take the risk of being rejected. The goal of this paper is to test the theoretical predictions in H&V using an experimental approach.

The types of interactions we examine in this paper are quite common and becoming increasingly prevalent as the Internet continues developing into a major facilitator of commerce. A notable example of this is eBay, one of the most prominent bargaining facilities on the internet and one which sets specified deadlines before which all offers need to be received. While eBay started out predominantly as an auction site, it now facilitates bargaining between buyers and sellers for an extremely wide range of products, as well as offering customers the opportunity to "buy it now". In addition, the successful relationship between Skype and eBay has improved the scope for buyers and sellers to bargain directly with each other. A related consideration is that the deadline may in fact be part of the good being purchased (eg airline tickets, Christmas presents, etc). With the proliferation of websites such as eBay, in addition to the offline bargaining environments such as the housing and automobile markets and the sale of goods with inherent deadlines, understanding how these deadlines influence bargaining strategies and outcomes is highly important.

The bargaining decisions investigated in this paper are also found commonly in the finance and housing markets. Duffie, Gârleanu and Pedersen (2005) and Vayanos and Wang (2007) investigate this concept within the realm of financial over-the-counter markets where various forms of bonds and derivatives are traded through bilateral bargaining. Another example lies in the real estate market where both buyers and sellers can break off negotiations with the other parties and find new parties with which to bargain. Merlo and Ortalo-Magné (2004) suggest that deadlines could offer an explanation as to why sellers' list prices of real estate decline over time. No other existing theories can offer an explanation for this empirical observation. Furthermore, the authors find that a substantially large number of sellers who

initially reject offers go on to accept a lower offer. A plausible reason for this behaviour lies in the influence of deadlines; the rationale for these seemingly inconsistent decisions to accept and reject offers forms a central research question in our study.

While a lot of theoretical and experimental research has centred on bargaining, relatively little is known about the effects of personal and heterogeneous deadlines on bargaining behaviour. The use of a laboratory experiment in this paper aims to contribute to this literature by empirically evaluating a portion of the underlying theory, specifically the theoretical predictions in H&V. We find that the experimental evidence is largely (but not entirely) consistent with these theoretical predictions:

1. Average offers made are lower when responders have short deadlines and proposers have long deadlines.
2. When information is complete, higher average offers are made when responders have longer deadlines.
3. When information is incomplete, average offers made are lower when proposers have longer deadlines.
4. Matched subjects with long deadlines reach agreement significantly less often than matched subjects with short deadlines.
5. When information is incomplete, deadlines can be missed with positive probability.

The theory is rather silent on whether delay is more likely in the complete or incomplete environment. We find experimentally in our setting that:

6. Delay occurs significantly more frequently when information is incomplete.

Finally, we find experimentally some results clearly contradicting the theory:

7. Deadlines are missed in the complete information treatment.
8. Positive offers are rejected in both treatments by traders with an expiring deadline.

Hence, our experimental evidence does not support the theoretical prediction that individuals always choose to accept a positive payoff in comparison to no payoff at all. In relation to our experiments, the theory predicts that a subject with a deadline of 1 will accept any positive offer, no matter how small, because this is better, in monetary terms, than the alternative of receiving nothing[1]. We find that responders with deadline 1 refuse positive offers. The acceptance threshold, where offers above this level are accepted significantly more frequently than offers below, is 50 when information is complete and 45 when information is incomplete. Nevertheless, if we accept as given the “ultimatum game effect”, and adopt the theory accordingly, we still find that the theory does well in explaining all the other aspects of bargaining behaviour in this setup. This suggests a way forward in testing bargaining theory – which could bring together behavioural and rational approaches a la Kahneman-Tversky – where certain deviations from rational behaviour which nevertheless persist, can be incorporated into general rational models.

The paper is presented in the following manner: Section 2 highlights some of the existing literature that is relevant to this study. Section 3 goes on to present the theoretical predictions. Section 4 describes the experimental design and Section 5 provides a brief discussion of the experimental implementation. Section 6 presents the main experimental results and Section 7 contains a discussion and conclusion. Finally, the Appendix contains

[1] Once the deadline has passed, the subject can no longer trade and receives a payoff of zero.

the experimental tables and figures, as well as some additional results that are of potential interest.

2. Theoretical and experimental literature on deadlines in bargaining

From a theoretical perspective, the concept of facing time constraints in bargaining is not a new one. Research into this particular area of bargaining theory has grown dramatically since Rubinstein (1982) introduced the alternating offers model of bargaining and formed the basis of many subsequent bargaining analyses. Even prior to this, Ståhl (1972) presents a finite horizon version of the Rubinstein bargaining model and shows that last proposer advantage decreases with the number of bargaining rounds. More recently, Yildiz (2004) shows that when deadlines are fixed, agreements are often made close to the deadline but when deadlines are stochastic, agreement is immediate. O'Donoghue and Rabin (1999) present a principal-agent model and show that, when agents have time inconsistent preferences, principals can use deadlines in an effective manner to overcome the agents' present-time biases.

Ponsati (1995) provides another study into bargaining deadlines but she differs from the previous studies by utilising two outcomes over which the two bargaining parties bargain. The players have different preferences regarding the outcomes and the exact utility that the subjects derive from the outcomes is private information. Essentially, the subjects play a waiting game until one player gives in to the other's preferred outcome. Ponsati (1995) finds that many concessions are made at the deadline and a few are made a long time before the deadline but no concessions are made immediately before the deadline. She also finds evidence that deadlines are missed. Fershtman and Seidmann (1993) use complete information and show that agreements will only be reached at the deadline when the bargaining parties are committed to rejecting a proposal that is worse than a previously rejected proposal. Roth, Murnighan and Schoumaker (1988) show experimentally that in most instances, agreements do occur close to the common deadline and, in some cases, deadlines are even missed.

Ma and Manove (1993) investigate the notion of delay in more detail. They employ a bargaining model where deadlines are known and proposers can make offers, either immediately or after a delay, but where offers are received with some random delay after having been made. They find that, initially, subjects delay making offers and then, once they do decide to propose something, they make offers that are sometimes rejected. In a similar vein to other studies, Ma and Manove (1993) find that most agreements occur close to the deadline and sometimes the deadlines expire before any agreement is reached.

Gneezy, Haruvy and Roth (2003) experimentally analyse the Ma and Manove (1993) explanation that deadlines are important because they enable a bargaining individual to acquire an advantage by delaying making an offer. The authors establish a new experimental environment, which they call the reverse ultimatum game (RUG), within which to test the theoretical explanations offered in Ma and Manove (1993). Using this environment, Gneezy et al (2003) compare bargaining behaviour both with and without deadlines and show that the subgame perfect equilibrium prediction can shift dramatically with the imposition of a deadline –the proposer is able to wait until the last few seconds of bargaining before making the typical ultimatum game take-it-or-leave-it offer, rather than facing a series of small ultimata as the RUG would allow. The key finding in Gneezy et al (2003) is that, when deadlines are imposed in the RUG, proposers elect to delay agreement until very close to the deadline. This allows the proposers to gain more of the surplus for themselves, although not

to quite the extent of the theoretical predictions[2]. In addition, the authors find that the timing of agreements in the experiment differs significantly from that predicted by the theory – proposers make a number of offers, and responders accept quite a few offers, a long time before the deadline. The authors conclude that "perfect equilibrium predicts the direction of a deadline's effect, but not the magnitude".

One key difference between our paper and that of Gneezy et al (2003) is the use of heterogeneous deadlines. The authors in the latter study use different experiment sessions to investigate two deadline conditions (1-minute and 3-minutes) and find evidence to suggest that the length of the deadline impacts on the division of the surplus. Our paper extends this finding to examine behaviour when the bargaining parties face different deadlines; we explore both complete and incomplete information settings to establish the extent to which the heterogeneous deadlines impact on delay, the magnitude of offers made and the mean final offer accepted.

One other notable paper is Moore (2004) in which experimental subjects show a preference not to reveal their deadlines when information is private, even though such a revelation would lead to improved bargaining outcomes. In addition, Moore (2005) employs an experimental methodology to show that subjects do not realise that their bargaining partners are affected in the same way as themselves by the imposition of time constraints in bilateral bargaining; most subjects believe that the imposition of a time constraint (a strict deadline) worsens their expected bargaining outcome.

A crucially important empirical finding, not restricted to but clearly evident in bargaining environments with deadlines, has been the rejection of the theoretical prediction that subjects will accept any positive offer. Theoretical predictions of the ultimatum game encompass the notion that individuals will accept any positive offer when acting as the responder and will offer an amount of ε, where $\varepsilon>0$ and very small, when acting as the proposer[3]. The experimental evidence, however, does not support this and indicates that individuals may be motivated by notions of fairness and reciprocity rather than pure monetary payoff.

The first key study conducted within this field is Guth et al (1982) where the authors employ experimental techniques and find that positive offers are rejected and there is systematic deviation from the game theoretical predictions of the ultimatum game. They also compare the behaviour of inexperienced subjects with that of more experienced subjects (individuals return one week later to repeat the bargaining game) and find that experience leads to lower offers being made, although the offers do remain substantially above some small amount ε. This paper is in contrast to Binmore, Shaked and Sutton (1985) where the authors illustrate that standard theory can indeed be a good predictor of bargaining behaviour. Furthermore, these authors find that subjects care about the fairness of bargaining outcomes, preferring equal divisions rather than attempting to secure large amounts for themselves.

Guth and Tietz (1988) go on to indicate that experienced subjects do not alter their behaviour to bring offers in line with the predicted equilibrium, but rather the offers appear to converge to an equal division between the proposer and responder. Finally, Roth et al (1991) conduct a simple, one-period bargaining experiment in a number of different countries and find clear deviations in bargaining behaviour from the theoretical ultimatum game predictions.

[2] The authors find that the offers made by the proposer are highest when there is no deadline and the responders receive slightly more than the proposers. With the imposition of a deadline, the mean final offer that is accepted moves in the proposer's favour, more so when the deadline is short.

[3] As mentioned later in the results section, the ultimatum game is a special case of the experimental game in the paper, where the responder and proposer both have a deadline of 1.

In relation to the ultimatum game, one could question whether the total size of the amount being bargained over influences behaviours. More specifically, does the total size of the pie influence the offers made and the frequencies of acceptance and rejection? Hoffman, McCabe and Smith (1996) find that offers are not determined by the overall size of the pie. Cameron (1995) finds that rejection decisions are independent of the size of the pie. Cameron also finds that the larger the overall pie, the closer the offers get to the fair 50-50 spilt. Furthermore, he indicates that when no payment is involved, offers are generally lower and rejection rates are higher.

3. Theoretical predictions

In this section we describe the theoretical H&V models and their predictions. They consider a model with a continuum of sellers and buyers (of mass 1 each) flowing into the market every period. All sellers have one unit of a good they produced at zero cost and all buyers have unitary demands for this good, which they all value at one. The only difference between different traders is their deadline. The deadline of a trader is an integer number from {1,2,...,N} that indicates how many periods are remaining for this trader to conclude a deal. If a trader fails to conclude a deal at the last opportunity he misses his deadline and his utility is zero. That is, a trader with deadline 1 will have to make a deal immediately or his opportunity will be lost. Such a trader, if rational, is willing to accept any deal that gives him a positive utility. On the other hand, traders with a long deadline will be able and willing to reject certain deals and wait for better opportunities in the future.

H&V assume that proportion p(i) of the sellers (buyers) that flow into the market place every period has deadline i. The procedure for closing trades is as follows: in each period $t \in Z$ each buyer is matched with a seller. One trader in each pair is chosen at random and becomes the proposer (with probability one half). This trader makes a proposal which can be accepted or rejected. In the first case trade takes place and traders disappear from the market. In the second case no trade takes place and both traders go back to the market and become matched next period (with different partners), as long as their deadlines have not expired. Of course, their deadline will then be reduced by one. H&V assume that traders discount late trades by some factor $\delta \leq 1$. They show that the role of the discount factor is rather limited because of the deadlines, and in the experiment we do not implement any discounting, so that $\delta=1$.

The theoretical predictions are in terms of the steady state or stationary equilibrium: A stationary equilibrium is an equilibrium where all buyers (sellers) with the same deadline make and accept the same proposals (independent of the time period t) and where the mass of traders in the market place and the distribution of deadlines among the buyers (sellers) (denoted by q) remains constant over time. Such a steady state equilibrium is shown to exist for any number of deadlines and any distribution of deadlines p. There are two different scenarios possible. In the first scenario, which we will refer to as the no delay case, trade occurs in each matching. In this case the stationary distribution q of deadline types is simply given by p. In the second case, which we will refer to as the delay case, there is no trade taking place in some matches. In this case the stationary distribution q will be different from the inflow distribution p.

H&Va assume that traders that are matched know each other's deadline. H&Vb assume that traders only know their own deadlines, and therefore the proposal made by one of the traders may thus depend only on his own deadline.

The main general results of these two papers which will be tested in this paper are:

- When information is private, heterogeneity of deadlines may cause delay and deadlines may be missed altogether. If there is delay, then bargaining parties with longer deadlines receive higher payoffs than bargaining parties with shorter deadlines and make weakly lower offers.
- When information is complete, bargaining parties with long deadlines may choose not to bargain with each other and rather return to the market where they hope to be matched with someone who has a short deadline. Delay therefore may occur frequently. Moreover, conditional on making a proposal that is expected to be accepted, offers should be independent of the proposer's deadline and should be increasing in the responder's deadline. Deadlines will not be missed.

H&V is a rather general model with a continuum, of traders and infinite inflow of new traders, which clearly is impractical for experiments. In our experiment we will therefore consider instead a discrete version, using the following parameters: buyers and sellers are assigned either deadline 1 or 4 with equal probabilities. These parameters are chosen because they are reasonably easy to implement in the lab and also because they are consistent with the predictions of the theory which we want to test. Specifically, for this distribution the (discrete version of) the theory predicts that there will be delay in both private and common information setting. Furthermore:

- When information is complete, higher offers should be made when responders have longer deadlines. When matched with a trader with deadline 1 (i.e. who is in his last period) a zero offer should be made.
- When information is incomplete, lower offers should be made when proposers have longer deadlines
- There should be more delay when information is incomplete.
- Expected payoffs in both setting should increase with types.

Appendix 9.1 provides a further discussion of the offers that are predicted by the theory.

4. Experiment design

4.1 Basic experiment design

The experiment is designed for 16 participants; bargaining can only proceed when two subjects are matched with each other and it is therefore necessary that the number of participants is an even number. The experiment is conducted using the z-tree software[4]. All subjects are recruited from an assembled database of individuals who had previously registered their contact details and expressed willingness to participate in research of this nature. Each individual participates voluntarily and is only allowed to participate in one session. Each experimental session lasts approximately 1 hour and subjects receive an average payment of £10 for their participation.

All sessions were conducted at the Said Business School during one day. At the beginning of each session, subjects are invited into the computer laboratory and are asked to sit at one of the computers. Each computer is numbered and all decisions the subject makes are recorded as coming from that computer and not a specific individual (in other words, no

[4] Fischbacher, U. (2006).

names or personal details are linked with the specific computers). All decisions made by the subjects are therefore anonymous and no decisions or actions within the experiment can be traced to specific individuals. The computer records the decisions made and calculates payment at the end of the session, thereby ensuring this anonymity.

Within the experiment, subjects are told they will be asked to make certain decisions and, to do this, they will be paired up with different individuals in the room. Each subject is matched with different subjects throughout the session but they never know exactly who they are matched with. They are told that all their decisions will remain anonymous and that they will only interact via the computers and will therefore never learn the identity of the individuals with whom they bargain.

The key task within the experiment is for the subjects to bargain over the division of a certain item. This item has a value of 100 units and the subjects are required to bargain with the subjects they are paired with to determine how the item should be split between the two of them. The item can be divided into any whole number but only numbers between 0 and 100 are acceptable.

When subjects are matched with other subjects for bargaining, one of the subjects is randomly selected to be the person to make the offer (the “proposer”). The other subject is then the one who decides whether to accept or reject the offer made by the proposer and is called the “responder”. This role allocation is performed by the computer and is randomly assigned in every instance when subjects are matched to bargain with each other.

The way in which the proposer makes the offer is to enter into the computer the amount that he/she wants to give to the other subject; in other words, an offer of 60 means that the proposer is offering 60 to the responder and indicating that he wishes to keep 40 for himself. The computer screen for the responder then displays this offered amount and asks him/her to accept of reject the offer, which is done by clicking the appropriate button on the screen.

In terms of timing, the experiment is made up of periods and rounds. The smallest unit of time is called a “period” and is made up of one player making an offer and the other player either accepting or rejecting that offer. There are four periods like this in each “round”. The bargaining commences by four subjects enter the bargaining in the first round, and then again in each of the following three rounds. By the end of round 4, therefore, all subjects have been brought into the bargaining procedure and no more subjects enter.

At the beginning of every round, the computer tells the individual his/her deadline. This deadline ranges from 1 to 4 and specifies how many periods the subject has in which to reach agreement over the division of the item. A uniform distribution of deadlines with types 1 and 4 is used; each subject therefore has an equally likely chance of having a deadline of 1 or a deadline of 4. If no agreement is reached before the subject’s deadline expires, that subject will receive zero in that round.

Subjects can reach agreement in any period leading up to their deadline but they will only be re-matched with another subject once the deadline has expired. Furthermore, if a subject’s deadline expires before the round he/she is currently in is finished, that subject will have to wait for the beginning of the next round before being matched with another subject. When

this occurs, the computer screen displays a message asking the subject to wait for the bargaining process to continue.[5]

Example: Suppose a subject has a deadline of 4 and is chosen to be the proposer. In the first period of bargaining, the subject makes an offer to the responder. If the responder accepts the offer, the subjects will divide the item in the agreed manner and the proposer will sit out of the bargaining process for the remaining 3 periods of the deadline. If, however, the responder does not agree, the proposer goes forward into the next bargaining period and his deadline reduces to 3. In this period the proposer will be randomly matched with another subject, most likely a different one to the previous period, and one of the subjects will once again be selected as the proposer.

In every period, the computer screen tells each subject his/her own deadline. In the incomplete information treatment, subjects are not told the deadline of the subject with whom they are matched, while in the complete information treatment, subjects are told both their own deadlines as well as those of the subjects with whom they are matched.

During the bargaining process, proposers are allowed a maximum of 20 seconds in which to decide how much to offer. Once the offer has been decided and entered into the computer, the responder has 10 seconds in which to decide whether to accept or reject the offer. When the responder has entered his/her decision, play continues in the next bargaining period. Subjects are always able to keep track of the time as the time remaining is displayed in the top right corner of the computer screen.

Each subject receives payment for taking part in the experiment. This payment is divided into two components. Firstly, each subject receives £4 for taking part in the session – this is guaranteed to the subject and no decisions made or actions undertaken within the experiment can alter this amount. Secondly, each subject can earn, on average, a further £6 from the experiment. This amount depends on the decisions made regarding offers submitted and offers accepted or rejected. Payment only occurs when there is agreement in bargaining and is calculated at a conversion rate of 2p for each point agreed upon. For example, an offer of 60 that is accepted results in the proposer earning 80p and the responder earning £1.20.

Once the experimenter has explained all these instructions, subjects complete a brief quiz in order to confirm they understand the instructions. The experimenter goes through the answers to this quiz with all the subjects and encourages questions in order to ensure understanding[6]. Following the quiz, subjects commence the bargaining rounds, the initial three of which are considered practice rounds. These practice rounds do not count towards payment and are employed to allow subjects time to familiarise themselves with the computer interface and the bargaining mechanism. At the end of the three rounds, the experimenter asks for questions or problems and, if the subjects appear to understand the process, bargaining continues for a further seven rounds, which do count for payment purposes. There are thus ten rounds of bargaining within one experiment session.

Finally, once the bargaining has concluded, subjects are asked to fill in a brief questionnaire. This questionnaire asks for the subjects' feedback regarding the experiment – whether

[5] It is possible that occasionally subjects need to remain out of the bargaining process for one further period. This is because an even number of subjects is always required and it may occur that to maintain an even number, a subject needs to sit out for one additional period. This should only happen very rarely, but the subjects are informed of the possibility of this occurring.

[6] A copy of this quiz is included in the Appendices (Appendix 9.5)

everything was clear and what they thought the experiment was designed to investigate. A copy of this questionnaire is included as Appendix 9.6.

4.2 Treatments

Two main treatments are used in this experiment; the length of the deadline and the extent of information available to the subjects. These treatments are designed to test a number of theoretical predictions surrounding the bargaining behaviour of subjects when faced with deadlines. Specifically, do subjects with short deadlines behaviour differently than subjects facing long deadlines? And, does a subject behave differently when he only knows the deadline constraints placed on himself rather than also knowing the deadline constraints of the subject with whom he is matched?

The first treatment concerns the length of the deadline and this is investigated by randomly allocating deadlines of 1 and 4 to subjects according to a uniform distribution. As mentioned in the basic design, this means that each subject has an equal probability of being a type 1 (having a deadline of 1) or a type 4 (having a deadline of 4). The behaviour of the different types can therefore be analysed to determine how offers differ when deadlines differ as well as how the frequency and pattern of delay and missed deadlines change when the deadline of the subject changes.

The second treatment variable investigates the effect of different degrees of information on behaviour. In the incomplete information treatment, a subject is told his own deadline but does not know the deadline of the subject with whom he is matched. This opposing subject may have a longer or shorter deadline than the subject or he may have exactly the same deadline – but the subject will never find out this information. In contrast, subjects in the complete information treatment know both their own deadlines as well as the deadlines of the subjects with whom they are matched. This allows the subjects to know how many bargaining periods both they and their opposing subjects have remaining in which to reach agreement.

Theory predicts that subject behaviour will differ significantly when the level of information they are privy to changes. These theoretical predictions are investigated in through the hypotheses discussed in the previous section.

5. Experimental implementation

Prior to the implementation of this experiment, a pilot session was conducted. This pilot session was performed in accordance with the game design and lasted approximately one hour. No major problems were identified in this pilot study, although the way in which the computer programme recorded the data was not ideal for analysis purposes. This was therefore altered for the subsequent experiment sessions. While the experiment itself ran according to plan, the difficulties with data capture resulted in the data being very difficult to analyse and therefore this data is not currently included in the analysis.

A total of six experimental sessions were conducted during the course of one day, resulting in a total sample size of 88 individuals. Four of the six sessions were conducted with 16 participants, while the remaining two sessions were conducted using 12 participants. This was due to some subjects not showing up for the session. This did not affect the experimental implementation in any way as the software used could simply be modified to accommodate 12 rather that 16 subjects.

Three sessions were conducted using the complete information treatment while the other three sessions employed the incomplete information treatment. The six sessions were identical in every respect expect the use of these treatment variables.

All sessions took place in a computer laboratory at the Saïd Business School and all sessions were randomly composed; subjects were free to register for any available session that suited them. All participants were recruited from a group of individuals who registered their names on the OxLab experimental website in order to express their willingness to partake in research of this nature[7]. Approximately 70% of the subjects were students while the remaining 30% comprised individuals either in employment, retirement or who are currently unemployed. There was also a fairly even representation of the two gender groups, with 56% female and 44% male.

When implementing the experimental game, most aspects of the experimental design went according to plan. In terms of the timing of bargaining, subjects had been told they had 20 seconds in which to make offers and then 10 seconds in which to accept or reject these offers. In implementation, however, the computer package did not cut subjects off if they failed to act within these time constraints, and results indicate that most subjects did take longer than the allocated times. This does not appear to be a material flaw and, in each session, the experimenter verbally amended the instructions so that subjects knew they would not be cut off but subjects were strongly encouraged to make their decisions within the allotted time.

Finally, subjects received payment according to their bargaining within the experiment. For ease of payment, all subject earnings were raised to the nearest 50p and this formed the amount that the subjects received.

While the majority of subjects were matched exactly according to the game design, a slight error with the software did result in some subjects being brought into the bargaining process in periods in which they were supposed to be inactive[8]. When compiling the experimental results, we performed data analysis both including and excluding the observations relating to these matchings. None of the results are significantly altered by excluding these matchings[9]. All observations have, therefore, been included in the analysis and we do not believe the results to be compromised in any way.

The experimental implementation, therefore, was in accordance with the experiment design, except for the minor differences mentioned above. The data collected captures the decisions made in the appropriate manner and has allowed a detailed analysis into the effect of deadlines and information provision on bargaining decisions.

6. Results

Before delving into the main results of this study, a brief investigation into the average offers made allows an informative overview of the bargaining behaviour observed. Focusing specifically on the treatment when information is complete, it is interesting to explore how the

[7] The address of this website is: https://oxlab.oii.ox.ac.uk

[8] This occurred for 11.7% of the matches in the perfect information treatment and 9.5% of the matches in the imperfect information treatment.

[9] Furthermore, individual behaviour prior to these erroneous deadline allocations does not appear to differ significantly from the observed individual behaviour after these events.

average offers made by a proposer depend on both the proposer's own deadline and the deadline of the responder. In this regard, the following result emerges from the data:

Result 1: Average offers made are lower when responders have short deadlines and proposers have long deadlines.

Table 1: Average offers made as a function of both own and opponent's deadline (no. of observations in brackets) (complete information)

Proposer deadline	Responder deadline	
	short	**long**
short	38.49 (75)	48.36 (72)
long	30.04 (72)	38.91 (80)

A short deadline is defined as a deadline of 1 or 2 and a long deadline as a deadline of 3 or 4. As Table 1 indicates, a proposer with a short deadline offers a notably lower amount to a responder with a short deadline compared to a responder with a long deadline (an average of 38.49 compared to an average of 48.36, when the proposer has a short deadline, and an average of 30.04 compared to an average of 38.91 when the proposer has a long deadline). A two sample t-test indicates that this difference is indeed highly significant (t=4.7046, p=0.0000)[10]. In addition, the average offer made by a proposer appears substantially larger when the proposer has a short deadline compared to when the proposer has a long deadline; this is presumably because proposers with long deadlines feel they have more time in which to reach agreement and can therefore attempt to obtain a larger share at the initial stage of bargaining. Again, this difference has a high statistical significance (t=-4.5264, p=0.0000). This is interesting as it goes against what the theory would predict – that the proposer's own deadline does not influence the offer he/she makes when information is complete.

This preliminary analysis of the bargaining behaviour facilitates a progression into more specific and probing research questions. The theoretical predictions mentioned earlier suggest that offers made when information is complete depend on the deadline of the responder while offers made when information is incomplete depend on the deadline of the proposer. The experimental data produces the following two key results:

Result 2: When information is complete, the offers made by the proposer are increasing with the type of the responder.

Result 3: When information is incomplete, the offers made by a proposer are weakly decreasing in the proposer's own type.

These results indicate that the empirical data gathered through the experiment supports the underlying bargaining theory. The evidence to support these two results is contained in Tables 2 and 3.

[10] The repeated nature of the individual choices within the experiment gives rise to independence concerns. For this reason, we verified all our statistical results through the use of clustering techniques – specifically clustering the data according to the bargaining period (7 periods in each session). Adopting this approach did not affect the significance of any of the results and we have therefore retained the initial unclustered results. The results using clustering techniques can be obtained from the authors should they be desired.

Table 2: Average offers made by proposer as a function of responder's deadline (complete information)

	Ave. offer	Std dev.	No. of obs
Responder is type 1:	31.65	16.14367	109
Responder is type 2:	41.74	11.95416	38
Responder is type 3:	43.42	15.32626	69
Responder is type 4:	43.48	17.77801	83

Table 3: Average offers made by proposer as a function of his/her own deadline (incomplete information)

	Ave. offer	Std dev.	No. of obs
Proposer is type 1:	46.29	11.44778	103
Proposer is type 2:	40.95	11.64237	65
Proposer is type 3:	34.13	11.15431	86
Proposer is type 4:	32.77	12.05866	100

Table 2 displays the average offers made by a proposer when information is complete. The offers in this table clearly appear to increase as the responder's deadline increases, with the average offer made to a type 1 being 31.78 and the average offer made to a type 4 being 43.48. The standard deviation and number of observations are highest for types 1 and 4, as is to be expected. A two-sample t-test shows that the observed difference in average offers is statistically significant (t=4.8143, p=0.0000). We can therefore conclude that when information is complete, the offers made by a proposer are increasing in the deadline of the responder (Result 2).

Table 3 displays the average offers made when information is incomplete. This table clearly shows that average offers made by the proposer are decreasing in the proposer's own deadline – the average offer made by a proposer with deadline 1 is 46.29 while the average offer made by a proposer with deadline 4 which is 32.77. This difference is again highly significant (t=-8.1951, p=0.0000) and we conclude that the average offers made by a proposer are decreasing with the proposer's own deadline (Result 3).

The two-sample t-test used above as a test for significance assumes that the samples are drawn from approximately normal distributions[11]. In contrast, a non-parametric, ranksum test (such as the Mann-Whitney or Kruskal Wallis) does not require this assumption to be made. Both of these non-parametric tests are conducted here to establish whether the two samples are drawn from identical populations or whether the populations from which the samples are drawn actually have different median values. The Mann-Whitney test indicates that the median offer made to responders with deadline 1 is very different to the median offer made to responders with deadline 4 (z=4.606, p=0). Similarly the median offer made by a proposer with deadline 1 is different to the median offer made by a proposer with deadline 4 (z=-7.29, p=0). The Kruskal Wallis tests support these findings and the non-parametric results therefore combine to uphold Results 2 and 3.

Apart from the offers made by a proposer, the theory predicts a number of other results when bargaining is conducted within the confines of personal deadlines. Moreover, whether

[11] The large sample size suggests that this assumption is a realistic one. Figures 1 and 2 in Appendix 9.2 plot the offers made by the proposer for the complete and incomplete information treatments respectively. As these figures indicate, the distribution of offers appears approximately normal in both treatments.

information is complete or incomplete impacts both the bargaining process and outcome. A key prediction of the theory is supported by the experimental data and the result can be expressed as follows:

<u>*Result 4 (delay):*</u>
- *There is more delay when information is incomplete than when information is complete*
- *A type1-type1 matching reaches agreement with a higher probability than a type4-type4 matching*

Delay occurs as a result of the offers made and received as well as of the deadlines of the proposer and responder.

We conduct a significance test of the experimental data to establish whether the occurrence of delay differs significantly between the two information treatments. The results indicate that delay occurs significantly more often when information is incomplete (t=3.1417).

The second part of Result 4 investigates the impact of deadline pairings on the frequency with which agreement is reached. This rate of agreement is likely to fluctuate since all subjects are assigned different deadlines and are then matched into bargaining pairs according to a random process. If any pair is more likely to reach agreement more or less often than another pair, one would expect that difference to be maximised for the extreme pairs. The key result that emerges from the experimental data is that when both the proposer and responder have short deadlines, there is a significantly higher likelihood of agreement being reached than when the proposer and responder both have long deadlines.

Table 4 looks at offers from the proposer's perspective and displays the frequency with which offers, in the complete information treatment, are accepted. As expected, a type1-type1 matching reaches agreement much more frequently than when proposers and responders with deadline 4 are matched. Accordingly, the frequency with which agreement is reached also appears to increase from the type4-type4 cell in the bottom right of the table to the type1-type1 cell in the top left of the table, thereby suggesting that the deadlines of the subjects play a significant role in their willingness to reach agreement.

Table 4: % of agreements reached between proposer and responder (complete information)

Proposer deadline	**Responder deadline**			
	1	**2**	**3**	**4**
1	87.88	76.47	66.67	68.97
2	83.33	100	63.64	36.36
3	73.91	55.56	52.63	57.89
4	71.43	40	22.22	29.17

The observed differences in agreement rates are highly significant (t=-5.5757) and illustrate that a type1-type1 matching reaches agreement with higher probability than a type4-type4 matching. In other words, delay does occurs significantly more frequently when both subjects have a deadline of 4 compared to when both subjects have a deadline of 1.

These experimental results indicate that delay does indeed occur. Consequently, it is important to investigate whether this delay induces bargaining deadlines to be missed. Deadlines are considered to be missed when a subject receives a payoff of zero as a result

of not reaching agreement before his/her deadline expires. The frequency with which deadlines are missed is therefore calculated as the number of instances when deadlines are missed as a percentage of the sum of the number of instances when agreement is reached prior to the subject's deadline expiring and the number of instances when deadlines are missed.

The theory predicts that deadlines should only be missed when information is incomplete. Experimental findings, however, show that deadlines are missed with very similar frequency in both the complete and incomplete information treatments. Specifically, the experimental data reveals that the overall percentage of deadlines missed is 8.37% when information is complete and 8.01% when information is incomplete. The following result therefore emerges from the data:

Result 5: The frequency with which deadlines are missed when information is complete is almost exactly the same as the frequency when information is incomplete.

There are two reasons why deadlines might be missed when information is incomplete. Firstly, proposers with deadline 1 may make offers that are rejected. Secondly, responders with deadline 1 may reject offers received from proposers. While the first explanation is consistent with rational behaviour, the second is not. This occurrence of responders with deadline 1 rejecting positive offers is often observed in experimental implementations of the ultimatum game.[12] The relevant theory here predicts that the responder should accept any offer greater than zero. However, as is shown in the experimental results, subjects often reject positive offers, ostensibly because rejecting low, "unfair" offers is the only means they have at their disposal to punish selfish proposers.

An investigation into these concerns, using the experimental data, yields the following result:

Result 6: Responders with deadlines of 1 refuse positive offers. Moreover, responders are no more likely to refuse offers made by proposers with short deadlines (1 or 2) than by proposers with long deadlines (3 or 4).

Analysis of the data reveals that there are 16 instances[13] under complete information and 11 instances[14] under incomplete information where subjects with deadlines of 1 refuse positive offers. Tables 5 and 6 go on to analyse the magnitude of the average offers rejected by type 1s. Both these tables indicate that type 1s are willing to accept lower offers than responders with longer deadlines, although they still refuse average offers of 16.5 and 22 in the complete and incomplete information treatments respectively.

Table 5: Average offers accepted and rejected (complete information)

Own deadline	Ave offer accepted	Ave offer refused
1	33.21	16.5
2	47	37.2
3	57.07	34.75
4	57.03	35.7

[12] While the game used in this study is not an ultimatum game, the specific case of a proposer and responder both having deadline 1 does constitute an ultimatum game.
[13] 22.2% of offers received by a subject with deadline of 1
[14] 15.3% of offers received by a subject with deadline of 1

Table 6: Average offers accepted and rejected (incomplete information)

Own deadline	Ave offer accepted	Ave offer refused
1	39.43	22
2	45.08	35.18
3	50.26	37.67
4	49	33.72

The fact that responders reject positive offers supports the claim that an ultimatum effect is present. Further evidence for the ultimatum effect is gathered by investigating whether offers are rejected simply because the responders view the amounts offered as too low, or do responders reject offers as a way to punish selfish proposers? If the former holds true, and responders adhere to an acceptance threshold below which they will refuse all offers, then the rejection rate should depend exclusively on the amount offered and not on the deadline of the proposer. However, if the latter explanation of punishment holds true, responders should reject offers with higher probability when they are made by proposers with short deadlines (1 or 2) rather than by proposers with long deadlines (3 or 4), since this would punish the short deadline proposers more severely.

We conduct probit regression analysis to investigate, under complete information, the relationship between a responder's decision to accept or reject an offer and the proposer's deadline. Our results show that the responder's acceptance decision is indeed significantly influenced by the proposer's deadline as well as the offer being made ($z=-2.83$, $p=0.005$). We then investigate this decision while limiting attention to responders with deadline 1 and find that, while the size of the offer remains significant, the proposer's deadline does not significantly influence the responder's acceptance decision ($z=-1.32$, $p=0.186$).

The key result that emerges from the data is that rejection rates are highly dependent on the amount offered but independent of the type of the proposer. Results 5 and 6 therefore combine to support the theoretical predictions – once the ultimatum effect is accounted for, the behaviour identified in the bargaining experiment concurs with the theory surrounding bargaining with deadlines.

7. Discussion and Conclusion

This paper has focused specifically on how individuals bargain under the constraint of heterogeneous deadlines. These deadlines provide a means by which to express an individual's time preference for reaching agreement, much in the same manner as a common discount factor. Indeed, deadlines are a particularly interesting phenomenon as they offer a much simpler way for individuals to identify their own time preferences – few individuals will stop to think explicitly about what the value of their discount factor is, whereas many individuals are faced with deadlines when bargaining for houses, cars, etc.

It is often easier for a person to determine a date by which agreement needs to be reached rather than to quantify exactly how much he/she values agreement today compared to agreement tomorrow. This becomes especially important when the buyer and/or seller employs the services of an agent. In this situation, the agents need to be told, or programmed with, a deadline in order to ensure that bargaining does indeed reach a conclusion at the desired time. Jennings et al. (1996) detail the application of ADEPT

(Advanced Decision Environment for Process Tasks) agents in British Telecom's customer quote business process. Chavez and Maes (1996) consider MIT's Kasbah experiment (where agents bought and sold goods on behalf of people). In both cases deadlines were central to the design of the bargaining agents. Sandholm and Vulkan (2000) also provide a general discussion of the role of deadlines in e-commerce applications using software agents. The ubiquitous nature of deadlines, together with the rapidly increasing platform for bargaining presented by the internet, provide great motivation for further research into how individuals make bargaining decisions in response to heterogeneous deadlines.

In this paper we have employed an experimental methodology to investigate how deadlines affect bargaining behaviour. We have analysed how individuals bargain in relation to their own deadlines as well as to the deadlines of their opponents. In this regard, we find that whether or not the proposer knows the deadline of the responder has a noticeable effect on the offers made and the frequency of delay in reaching agreement. Specifically, average offers made to a responder with a short deadline will be lower when the proposer knows the responder only has 1 bargaining period remaining compared to when he has no knowledge of the responder's deadline and may want to make a higher offer to increase the likelihood of reaching agreement. Furthermore, delay occurs significantly more frequently when information is incomplete.

In general, the experimental evidence highlights interesting findings within each information treatment. First, when information is complete, we find that higher offers are made when responders have longer deadlines. Second, when information is incomplete, we find that the average offers made are lower when proposers have longer deadlines. Both these findings are in line with the theoretical predictions, although the actual average offers observed do not coincide perfectly with the offers predicted in section 3.

Third, the finding that heterogeneous deadlines cause delay has been highlighted in previous experimental studies (Roth et al, 1988) and in studies that investigate online auction behaviour (Roth and Ockenfels, 2002). As mentioned above, our experimental evidence indicates that delay occurs significantly more often when information is incomplete, although delay does also occur in the complete information treatment.

Finally, deadlines are missed with a very similar frequency across the information treatments. Again, the theory is not clear on whether deadlines should be missed at all. Strictly speaking, responders should accept any positive offer and deadlines should therefore only be missed if responders are offered zero and reject the offer (in this case, the responder would be indifferent between acceptance and rejection as both actions yield a payoff of zero). However, the experimental data provides substantial evidence of non-ultimatum game behaviour; responders do reject positive offers, even if this will lead to their deadlines expiring and them receiving zero. In addition, the theory predicts that proposers will offer very low amounts to responders with short deadlines. However, the experimental evidence once again contradicts this, illustrating, as in Guth et al (1982), that proposers realise responders will reject low offers and therefore increase their offers in an attempt to reach agreement.

Many reasons might exist for responders rejecting positive offers and there is a large literature that discusses possible fairness concerns and feelings of spite as motivating factors behind the decision to reject positive offers. What we would like to highlight with our evidence is that responders appear willing to reject fairly large offers and receive zero. We calculate an acceptance threshold that depicts the offer above which acceptance occurs significantly more frequently than below. These thresholds are very high – 50 when information is complete and 45 when information is incomplete. Presumably, responders consider the

proposed offers very unfair and therefore express a high willingness to pay to show their distaste for such offers. One key conclusion, however, is that, if we accept this ultimatum game effect as given, our results indicate that the theory provides a good explanation for the bargaining behaviour elicited in this experiment.

We conclude with a few suggestions for future related work. First, this paper assumes that proposers and responders are bargaining over a fixed surplus. In this respect, we have followed Rubinstein and Wolinsky (1985) and Binmore and Herrero (1988). Instead, we could have decided to allow buyers with a range of valuations and sellers with a range of costs, which is possibly a more realistic scenario. Papers that adopt this approach include Gale (2000), Mortensen and Wright (2002) and Satterthwaite and Shneyerov (2007), although these authors focus primarily on convergence to equilibria and not on bargaining behaviour in relation to heterogeneous deadlines. Future work might then consider employing this approach within an experimental design similar to the one used in this paper.

Second, this paper adopts the design of single take-it-or-leave-it bargaining outcomes, primarily because this is simple to implement and allows a clear analysis of the impact of deadlines. However, a different approach could be to assume a Rubinstein type of model with frequently alternating offers.

Finally, we suggest including some measure of risk aversion in the game design. The experiment employed in this paper did not take into consideration the varying degrees of risk aversion held by each bargaining party. This may well have an influence on when individuals decide to reach agreement and how large or small they make their offers. A simple risk aversion task (for example, the task used in Harrison et al (2005)) could be incorporated at the beginning of the experiment and this would enable the analysis of results to control for individual levels of risk aversion.

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9. Appendix

9.1 Theoretical predictions

The following table lists the amounts offered as a function of own and other's deadline in case of complete information. The symbol X denotes that disagreement is preferred, which means that a low offer will be made that is expected to be rejected. Note that in the original models of H&Vab responders with deadline 1 must accept a zero offer. However, in the discrete version (where offers are integers) such responders cannot be forced to accept such extreme offers and we will assume that they will only accept proposals of at least 1 unit.
:

Deadline responder -> deadline proposer	1	2	3	4
1	1	34	50	60
2	1	34	50	60
3	1	34	50	**X**
4	1	34	**X**	**X**

:
The table clearly illustrates the results that hold in the general model. The deadlines of both traders will determine whether disagreement occurs. In particular, disagreement occurs when both traders have a long deadline. It should be noted that when two traders with deadline 3 meet they are almost indifferent between agreement and disagreement as the expected payoff to a trader with deadline 2 is between 49 and 50. When offers are expected to be accepted, offers made are increasing in the deadline of the responder but do not depend on the deadline of the proposer. Responders with deadline 1 are always offered 1, the smallest amount that yields a positive utility.

The following table lists the amounts offered in the case of incomplete information. Obviously, in this case the offer can only depend on the deadline of the proposer.

Deadline proposer	offer
1	62
2	1
3	1
4	1

The offer of 62 should be accepted by any type of responder. The offer of 1 should only be accepted by responders with deadline 1. This means that disagreement and delay should occur whenever none of the traders in the match has deadline 1. Deadlines should not be missed. It should be noted, however, that proposers with deadline 1 are almost indifferent between offering 62 and offering 1. Hence, deadlines being missed because of proposers with deadline 1 making the greedy proposal are not completely implausible.

The reader may believe that these results depend crucially on the fact that proposers with deadline 1 will accept very extreme proposals, while it is known from ultimatum bargaining games low offers are in fact often rejected. If we assume that such responders only accept offers of at least 25 out of 100, the theoretical predictions change slightly with respect to the exact offers to be made, but do not alter the predictions with respect to whether agreement should occur or not. Specifically, in the case of complete information acceptable offers made to traders with deadlines 1, 2, 3, and 4 are, respectively, 25, 33, 50, and 60. In the case of incomplete information, proposers with deadline 1 should offer 56, while the others should offer 25.

9.2 Figures

Figure 1: The distribution of offers made by a proposer under complete information

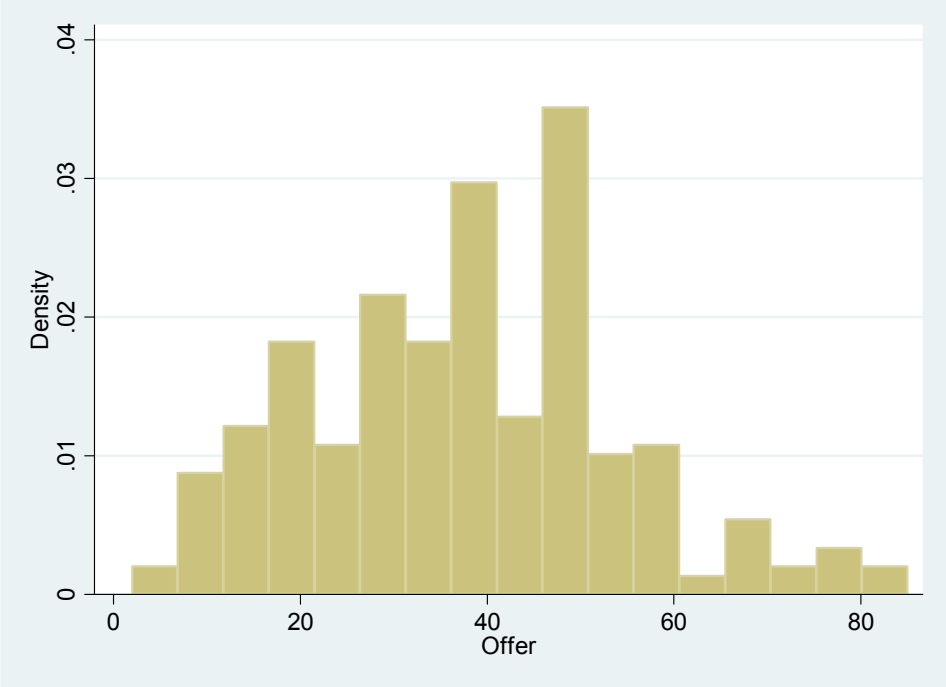
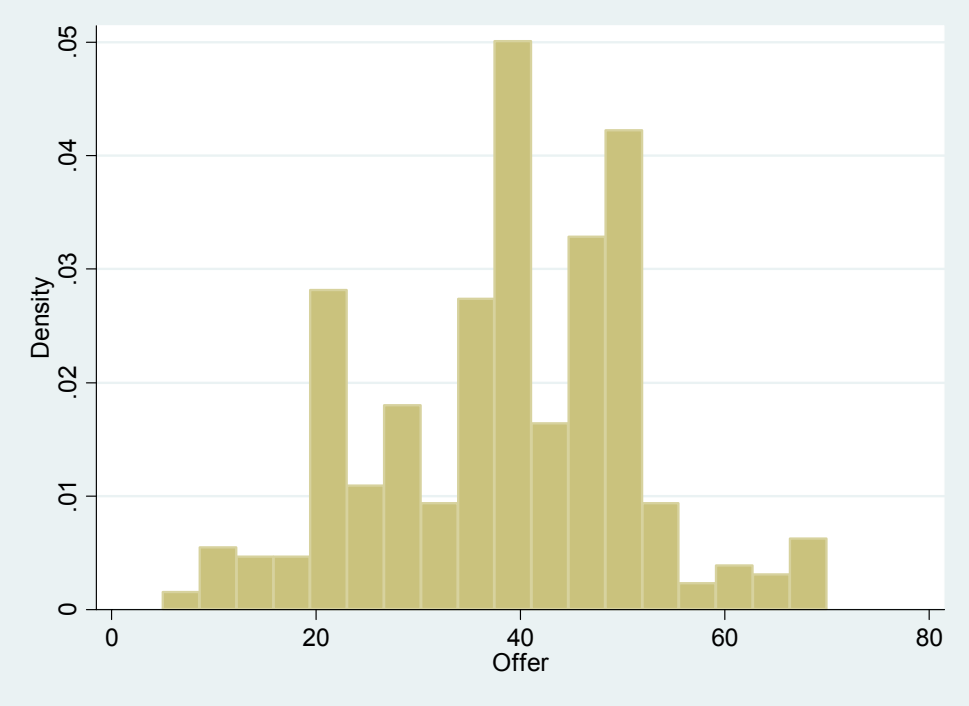


Figure 2: The distribution of offers made by a proposer under incomplete information



9.3 Additional results

Although not central to this particular study, the relationship between expected payoffs and individual deadlines is a very interesting one. Specifically, the result we find is the following:

Result 7: When information is incomplete, expected payoffs increase with types.

Table 16 displays the average payoffs for the subjects born as type 1s and the subjects born as type 4s[15]. The average payoffs for subjects born as type 4s are clearly higher in each of the first 4 columns, which illustrate average payoffs that are both accepted and rejected. However, when considering rejection as resulting in a payoff of zero, the overall average payoffs for the subjects are those displayed in the final column. It appears that subjects born with deadlines of 4 actually have lower expected payoffs than those born with deadlines of 1 (this is significant at the 1% level; t=3.1944, p=0.0015). The primary reason for this is most likely due to the higher frequency with which offers are rejected when the subject has a deadline of 4.

In terms of delay, the earlier results focused on the impact of the information treatments and individual deadlines. An extension to this discussion is to compare delay over time and between the experimental sessions. Within each session, there are seven rounds of bargaining and one would expect the frequency of delay to decrease as subjects become accustomed to the bargaining procedure during the course of the rounds. On the other hand, each experiment session was constructed identically to the others and we therefore do not expect any significant difference in behaviour between sessions.

Tables 17 to 20 display the relevant descriptive results from the experimental data. Tables 17 and 18 indicate that delay seems to decrease over time, as one might expect. This trend appears to be more noticeable for the incomplete information treatment. One possible explanation for this is that when deadlines of opponents are not known, subjects cannot learn how different types of opponents behave and therefore they prefer to reach agreement sooner rather than later. In contrast, when subjects have knowledge of opponents' deadlines, they may learn how certain opponents behave and tailor their decisions accordingly.

Tables 19 and 20 go on to indicate that there do appear to be differences between the sessions. This is not expected as all sessions were conducted in a similar manner and therefore one might expect behaviour to be similar across sessions. An interesting investigation into these session differences is once more to look at the thresholds below which responders' acceptance/rejection decisions are significantly influenced by the size of the offer received. In the complete information treatment, session 2 mimics the overall sample and displays a threshold at 50, while sessions 4 and 5 do not produce any threshold offer that significantly affects the acceptance rate. In contrast, for the incomplete information treatment, session 6 displays a significant threshold at 34 while session 1 has no threshold offer of significance and session 3 has a weakly significant threshold at 32. These different significant thresholds, as well as the different sample sizes in the session, offer some explanation for the differences in delay across sessions.

In terms of expiration of deadlines, the previous results section did not delve into the key motivations which lead to deadlines being missed; while the overall number of deadlines

[15] Payoffs are calculated as the offers received when the subject in question is the responder and the residual of the offers made (ie, 100-offer) when the subject is the proposer.

missed is important, a deeper exploration into the reasons for these occurrences is valuable. Specifically, it is interesting to determine whether more deadlines are missed because subjects with deadlines of 1 make offers that are rejected or rather because subjects with deadlines of 1 reject offers made to them. The following result is obtained from analysis of the data:

Result 8: When information is incomplete, the main reason that deadlines are missed is because type 1s make offers that are rejected.

Table 21 details the percentage of deadlines that are missed as a result of type 1s making offers that are rejected. 74% of missed deadlines occur for this reason, a substantially larger percentage than missed deadlines occurring due to type 1s rejecting offers made to them.

It is interesting to compare this result with that of the complete information scenario. Table 22 presents the relevant percentages when information is complete and it is clear, once again, that the majority of deadlines are missed due to type 1s making offers that are rejected. The difference in percentages, however, is notably smaller than in the incomplete information case, where a stark difference between the two reasons for missed deadlines appears. This finding corresponds to what the theory predicts as, when information is complete, type 1s will know the deadline of their opponents who make the offers and they will therefore make offers that are more likely to be accepted.

Finally, Result 6 discussed in the body of the paper highlights that subjects refuse positive offers. As an extension to this result, it is appropriate to consider whether the acceptance rate of responders is significantly influenced by the size of the offer received[16]. Restricting attention to offers received by a subject with deadline 1, and initially to the complete information treatment, analysis of the data reveals that offers greater than or equal to 50 lead to significantly higher rates of acceptance than offers below 50. Specifically, all offers below 50 similarly form significant thresholds for the rates of acceptance[17]. However, offers greater than or equal to 51 are not accepted significantly more than offers below 51.

In contrast, the data for the incomplete information treatment indicates that offers greater than 45 are associated with significantly higher acceptance rates than offers below 45. However, offers greater than or equal to 46 do not correspond to significantly higher acceptance rates than offers below 45. Thus, a threshold offer of 45 appears to exist when information is incomplete; a slightly lower threshold than that of 50 for the complete information treatment.

A further diversion of interest here is a comparison of the frequency with which type 1s reject offers when information is complete and when information is incomplete; Table 23 indicates results of this investigation. As can be seen from the table, a slightly higher proportion of offers are rejected when information is complete. Statistical analysis, however, finds that this difference is insignificant ($t=1.0643$, $p=0.2890$) and we can therefore conclude that whether information is complete or incomplete does not materially affect the frequency with which type 1s reject offers.

[16] Significance is tested at the 5% level.

[17] In other words, for any offer s (where s lies between 0 and 50) offers greater than or equal to s lead to significantly higher acceptance rates than offers below s.

9.4 Additional tables

Table 16: Average payoffs of subjects born as type 1s and type 4s (incomplete information)

	ave proposed payoff received and rejected	ave proposed payoff received and accepted	ave payoff proposed and rejected	ave payoff proposed and accepted	average payoff*
type 1	22 (11)	39.55 (53)	60.43 (21)	48.16 (62)	34.57
type 4	33.72 (39)	49 (22)	66.17 (54)	63.72 (46)	24.9

* calculated using 0 when no agreement reached and payoff received when agreement reached

Table 17: Delay per round of bargaining (incomplete information)

	1	2	3	4	5	6	7
No.	39	50	42	36	30	31	32
%	56.52	58.14	63.64	45	42.86	40.26	38.1

Table 18: Delay per round of bargaining (complete information)

	1	2	3	4	5	6	7
No.	27	36	15	27	36	26	14
%	44.26	42.86	22.39	36.99	50	35.14	25

Table 19: Delay per session (incomplete information)

	1	3	6
No.	58	108	94
%	39.19	49.09	50

Table 20: Delay per session (complete information)

	2	4	5
No.	78	49	54
%	44.83	29.34	36.99

Table 21: Breakdown of deadlines missed (incomplete information)

	%	No.
type 1 rejecting offer[18]	26%	11
type 1 making offer that is rejected[19]	74%	32
Total number of deadlines missed:		43

Table 22: Breakdown of missed deadlines (complete information)

	%	No.
type 1 rejecting offer[20]	40%	16
type 1 making offer that is rejected[21]	60%	24
Total number of deadlines missed:		40

[18] Includes two instances where type 1 matched with type 1
[19] Includes no instances where type 1 matched with type 1
[20] Includes four instances where type 1 matched with type 1
[21] Includes four instances where type 1 matched with type 1

Table 23: Frequency with which type 1s reject offers

	No. of offers rejected	No. of offers received	% rejected
Complete	16	72	22.22%
Incomplete	11	72	15.28%

9.5 Instructions (received by subjects in the complete information treatment)

Thank you for agreeing to participate in this experiment. Please could you turn off your mobile phone, if you have not already done so, and please listen carefully to the instructions that are given. If you have any questions, please raise your hand and one of us will come to assist you. The session will take approximately 1 hour, at the end of which you will receive payment for your participation and will be free to leave.

The main task for this experiment is for you to bargain with another player over the division of a certain item with value 100. The item can be divided into any unit that is a whole number (eg 33, 75, 89, 60, and so on) but the number always has to be between 0 and 100.

Proposers (make the offers) and responders (either accept or reject offers) are randomly selected by the computers. Each of you will be matched into pairs where one player is the proposer and the other player is the responder. All interaction is conducted via the computer screens. Everything you do in this session will remain anonymous. You will be matched with different people throughout the session but no-one will ever learn your decisions.

In terms of timing, a "period" is the smallest unit of time and is made up of one player making an offer and the other player either accepting or rejecting that offer. There will be 4 periods like this in every round, and there will be 10 rounds in total. At the beginning of each round, the computer will allocate you a deadline for that round of bargaining. Each player is allocated his/her own deadline, which ranges between 1 and 4 periods. If you do not reach agreement before your deadline expires then you will receive 0 for that round.

You will be matched with a different player in each period. In each period the computer randomly matches two players in this room who will then bargain together.

Example:
You have a deadline of 4 and are selected to be the proposer. In the first period, you then make an offer to the player you are matched with. That player then decides whether to accept or reject your offer. If he/she accepts your offer, you will divide the item in the agreed manner and then you will sit out of the bargaining process for the remaining 3 periods of your deadline, until the end of that round. If you do not agree, then you go forward into the next period and your deadline reduces to 3, as there are three more periods in which you are able to bargain before your deadline expires. In this second period, you are randomly matched with a different player and once again you will bargain over the item. As before, one of you will be selected to be the proposer and one will be the responder. This role is allocated every period and so even if you were the proposer in the first period, this does not mean you will be the proposer in the next period.

In each period, the computer screen will tell you what your deadline is as well as the deadline of the player you are matched with.

In terms of the bargaining, you can decide on whatever division of the item you like. To make an offer, the proposer writes down the amount that he wishes to give to the other player. For example, the proposer offers 60 to the other player – this means that the proposer would keep 40 for himself/herself if the offer is accepted.

You are allowed a maximum of 20 seconds in which to decide how to make your offer and you are allowed 10 seconds in which to either accept or reject the offer. If you finish bargaining before your deadline has expired, you will need to wait until the remainder of your time elapses before being allocated a new deadline and re-entering the bargaining process. In other words, if you have a deadline of 4 and you agree after 2 periods, you will need to wait for another 2 periods before being re-allocated a deadline.

In terms of payment, each of you will receive £4 for showing up to this session and can earn a further £6 from the experiment, based on the decisions you make regarding the offers you submit and the offers you accept or reject. There is a conversion of 2p for each point you agree on. For example, if you offer 40 to the other player and the other player accepts this, you will then have 60 points which is £1.20. In the next round, someone could offer you 50 and you accept – you then have 50 points from accepting this offer, which is worth £1. Your total over these two rounds is then £2.20.

There are going to be 10 rounds of bargaining, the first 3 of which are practice rounds and the following 7 are the actual rounds that will count for money. Before starting the bargaining, there is a short quiz for you to answer. The quiz and the 3 practice rounds will not count towards payment but once they are complete, we will move on to the actual rounds where you will start earning money.

Quiz

1) You are selected as the proposer and have a deadline of 3. Write down an offer you might be willing to make. Also indicate how much you will get and how much the other person will get if your offer is accepted.

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2) You are selected to be the proposer. What is the amount you will receive if you make an offer of 30?

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3) You are selected as the proposer and your deadline is 1. If you had to choose between making an offer of 10 and 40, which would you choose? Why?

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   _____
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4) You are selected as the responder and your deadline is 1. Would you accept an offer of 20? Why?

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   _____

5) You start off with a deadline of 4. You disagree in your first bargaining period and again in your second bargaining period. In your third bargaining period you reach agreement. When will you start bargaining again?

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Thank you for completing the quiz. We will go through the answers together once everyone has finished.

Because it is very important that you understand the way everything works, you are now going to do three practice rounds of bargaining on the computers. If there are any problems with the computers or anything is unclear, now is the time to ask.

9.6 Questionnaire (completed at the end of the experiment)

1) Were the instructions for the experiment clear? If not, please could you specify how these instructions could be improved.

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2) Did the players you were matched with behave in the ways you expected? Please explain.

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3) Do you think you would have acted differently if you did not know the deadlines of the players you were matched with? If so, how would your decisions have changed?

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4) What do you think this experiment was designed to investigate?

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