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Simone Kohnz:

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Department of Economics
University of Munich

Volkswirtschaftliche Fakultät
Ludwig-Maximilians-Universität München

Self-Serving Biases in Bargaining: Explaining Impasse

Simone Kohnz*

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Abstract

There is strong evidence that in bargaining situations with asymmetric outside options people exhibit self-serving biases concerning their fairness judgements. Moreover psychological literature suggests that this can be a driving force of bargaining impasse. This paper extends the notion of inequity aversion to incorporate self-serving biases due to asymmetric outside options and analyses whether this leads to bargaining breakdown. I distinguish between sophisticated and naive agents, that is, those agents who understand their bias and those who do not. I find that breakdown in ultimatum bargaining results from naiveté of the proposers.

JEL classification: A13, C7, D63

KEYWORDS: fairness perceptions, self-serving bias, inequity aversion, ultimatum bargaining, outside options

There is a large body of experimental literature, both in psychology and economics, that finds self-serving biases in judgements of fairness. This literature suggests that self-serving biases are a driving force of bargaining impasse. It is evident

*Ph.D. student, Munich Graduate School of Economics, Kaulbachstr. 45, 80539 Munich, Germany. Please email to: simone.kohnz@lrz.uni-muenchen.de. I am grateful to Klaus Schmidt for ongoing discussion. I would also like to thank Armin Falk, Alfred Garloff, Steffen Huck, Melanie Lührmann, Natalie Timan and Matthias Weiss for their helpful comments.

that bargaining is important on all levels of social interaction from the small quarrels among friends and family to the big negotiations between states. The costs of its impasse can be substantial, consider for example, the amounts spent privately and publicly on civil litigation or the costs of strike and lockout. Understanding why bargaining fails in some cases is one of the major concerns in social sciences. A self-serving bias settles itself in a notion of fairness that, mostly unconsciously, tends to favour the agent. It is intuitive that in a situation where agents have different notions of fairness and moreover, are not aware of these differences, bargaining might fail. In the economics literature, there has been no attempt, so far, to model self-serving biases theoretically and to explore its impact on bargaining breakdown. This paper tries to do this by extending the notion of inequity aversion in the presence of asymmetric outside options and applying it to ultimatum bargaining games.

For a self-serving bias to occur, the psychological literature suggests that "there needs to be some form of asymmetry in how the negotiation environment is viewed", Babcock and Loewenstein (1997, p. 119). In real life, one hardly finds a perfectly symmetric negotiation environment. In particular, most situations are characterised by asymmetric outside options. These occur, for example, in wage bargaining where the employer might have the choice between several different candidates whereas the employee's outside option is unemployment. Yet similarly, asymmetric outside options are present when countries negotiate emission targets of a global pollutant, those damaging effects vary across countries. Furthermore, there is a close link between outside options and individual wealth levels. Asymmetry in terms of outside options plays a prominent role and is maybe the most natural case triggering self-serving biases. This paper therefore focuses on self-serving biases induced by asymmetric outside options.

Economists usually analyse bargaining games with the neoclassical assumption of purely self-interested agents. However, experimental evidence suggests that a large fraction of agents do not behave as classical economic theory predicts. Simple set-ups such as dictator, ultimatum or investment/ trust games, suggest that subjects compare their payoff with the other participants' payoffs. For an extensive summary on the experimental findings, see chapter 2 in Camerer (2003). There exist various approaches to model the experimental evidence. All of these models embed social comparison processes in preferences, for an overview of the literature see Fehr and Schmidt (2003). Here, I follow the approach of inequity aversion by Fehr and Schmidt (1999) where agents dislike income inequity. Inequity aversion provides a simple and sparse representation of the comparison process that nevertheless captures a lot of the experimental findings. Comparing monetary payoffs, agents base their judgement as to whether an outcome is considered as equitable on a reference allocation. Fehr and Schmidt argue that in a symmetric setting a natural reference outcome is one which attributes the same monetary payoff to all agents (*Equal Split*). With the introduction of asymmetric outside options this reasoning is no longer applicable. The *Equal Split* is just one among many other possible reference allocations like, for example, *Split the Difference* which advocates an equal split of the entire cake minus the sum of outside options. On which of the various reference allocations an agent is likely to base her fairness judgement is an empirical question. Yet, a self-serving bias would imply that with asymmetric outside options agents adopt a fairness perception that favours them in monetary terms.

The extension I propose allows inequity averse agents to base their decision on reference allocations different from the *Equal Split*. I render the reference allocation of the agents linearly dependent on the difference in outside options between two agents. The strength with which this difference influences the reference point can vary across agents. It serves as a measure of the extent to which the fairness perception favours the agent. According to Dahl and Ransom (1999, p. 703), agents that are self-servingly biased "...subconsciously alter their fundamental views about what is fair in a way that benefits their interests". Hence, a self-serving bias is characterised by two features: First, it settles itself in a notion of fairness that tends to favour the agent, i.e. that leaves the agent with a relatively big monetary payoff. Second, agents are not aware of their self-serving biases. I separate the two features of self-serving biases to analyse the influence of each component separately: An agent is *biased*, if she has a reference allocation that attributes a larger allotment to her than the reference allocation of her partner agent. To capture the second feature of a self-serving bias, namely that people are ignorant about the partiality, I distinguish between *sophisticated* agents who understand that their fairness notion favours themselves, and *naive* agents who have no such understanding.

Within this extended framework of inequity aversion, I analyse ultimatum bargaining. This simple bargaining game delivers the ingredients to more sophisticated negotiation environments. It is thus interesting to understand in a first step how self-serving biases work in this simple setting. In an ultimatum game, a proposer and a responder bargain over the division of a fixed pie. The proposer announces a division which the responder can accept or reject. If he accepts, the pie is divided according to the proposed rule. If he rejects, each player gets an outside option, known to both agents. With purely self-interested agents, as well as with standard inequity averse agents, there will be no bargaining breakdown. With the mere introduction of differing evaluations of what allocation is fair, this does not change. As long as the proposer knows the fairness perception of the other agent, she prefers to offer a share that the responder is willing to accept rather than to get her outside option. Accordingly, as long as the biased agents are aware of their bias, agents reach an agreement. If instead the proposer is biased and naive, then there are circumstances where the bargain breaks down. The reasoning is straightforward. The respondent is willing to accept any offer that is above a certain threshold. The threshold level depends on the fairness perception of the respondent. Sophisticated and biased proposers predict the threshold correctly, while some naive and biased proposers underestimate it. Therefore, whenever a naive proposer offers the underestimated threshold level in equilibrium, the bargain fails.

Related to the present paper is Konow (2000). He presents a model that incorporates, in addition to standard material utility, a genuine value of fairness intertwined with an incentive to change beliefs about the fairness concept. He postulates that there is an objective fairness concept from which agents voluntary deviate to favour themselves. In contrast, the present paper takes the belief about the fairness concept as given and analyses how this belief induces bargaining breakdown. Another related paper by Heifetz and Segev (2003) suggests that self-servingly biased agents have entered a tough state of mind vis-a-vis someone else. Heifetz and Segev characterise a class of bargaining mechanisms under which a population evolves that exhibits some moderate degree of toughness. They identify the underlying trade-off that toughness decreases the average probability of a bargain, but improves the terms of trade. In contrast, this paper examines how toughness influences behaviour on each bargaining stage. Finally, Frohlich, Oppenheimer, and Kurki (2004) extend equity aversion in a way similar to our extension. They introduce the concept of "just deserts" in the context of dictator games with preceding production. There, agents suffer when their inputs to the surplus are larger/ smaller than their final shares. The dictator faces a trade-off between material payoffs, equality and just deserts. However, their extension of inequity aversion differs substantially in that they assume that different norms are conflicting with each other. In their model, agents trade-off disutility from inequality with disutility from a deviation to just deserts. Whereas the present model postulates that agents adhere to one norm which depends on the context of the situation.

In the next section, I propose an extension of inequity aversion that incorporates heterogeneity in fairness perceptions and self-serving biases. The framework is then applied to ultimatum bargaining games in section 2. Section 3 discusses experimental evidence. Section 4 concludes and suggests further paths of research.

1 An extension of inequity averse preferences

Inequity averse agents compare their monetary payoff with the payoff of members of a specific reference group. Within this reference group they dislike outcomes that they perceive as unequal or unfair, that is they derive negative utility of a deviation from their reference allocation. The reference allocation of an agent with respect to another agent is defined by the pair of payoffs that she considers to be equal or fair. The utility of an agent depends on the reference allocation as well as the reference group. Both these determinants are considered exogenous in the model of Fehr and Schmidt. They argue that in an experiment all participants form the reference group. Furthermore, they postulate that in symmetric situations a natural reference allocation is one in which each agent gets the same payoff, the *Equal Split*. Other consequentialist models like Bolton and Ockenfels (2000) and Charness and Rabin (2002) also postulate the *Equal Split* as reference allocation. Once asymmetry is introduced, there is no reason to believe that the *Equal Split* is a natural reference allocation. The asymmetry may lead to various reference allocations. This can be seen, for example, in an experiment by Messick and Sentis (1979) that asked for the fair payment of different groups. One group was told that they should imagine they had worked 7 hours and were to receive a certain amount of money for that. Subjects of the other group were told to imagine they had worked for 10 hours on the same task. All subjects were asked to state the fair payment for the ones that had worked for 10 hours. There were two prominent concepts of fairness, one that induced the same hourly wage and one that induced the same overall payment.

In simple bargaining situations such as the ultimatum game, the mere allocation of roles introduces asymmetry that can induce a self-serving bias.[1] More powerful sources of asymmetry in bargaining environments, however, are asymmetric payoff

[1] Proposers view themselves in a relatively more powerful role and therefore believe that they deserve more than their opponents. The respondents in contrast think that the distribution of roles should not affect the division of the cake, see Hoffman, McCabe, Shachat, and Smith (1994).

possibilities or differing outside options for the agents. The present paper models self-serving biases due to asymmetric outside options. Different outside options are an important source of asymmetry. They are present, for example, in situations where an employer and a worker bargain over the worker's wage. But there are a lot of other day-to-day examples where people with different outside options have to decide about the distribution of a surplus. Furthermore, there is a resemblance between outside options and individual wealth levels in terms of their impact on fairness judgements. In their fairness statements, agents can be and often are guided by considerations concerning the difference in individual wealth levels. Even though individual wealth levels are not "destroyed" if the parties successfully bargain with each other, relative wealth levels might nevertheless determine the reference allocation in the bargaining situation. In this sense, part of the analysis can be transferred to self-serving biases induced by different wealth levels. Apart from this apparent omnipresence, asymmetric outside options are relatively easy to capture. First, it is an easily observable characteristic of the bargaining situation. Second, it can be measured quantitatively. Last, outside options can be altered in experimental set-ups and thus the predictions of the theory should be testable.

An easy and straightforward way of incorporating outside options into fairness considerations is to render the reference allocation linearly dependent on the difference in outside options. The reference allocation then has to obey

$$x_i - x_j = \gamma_i (\omega_i - \omega_j) \quad \forall i \neq j \tag{1}$$

where x_i represents the monetary payoff of agent i, ω_i her outside option and γ_i measures the extent to which the reference allocation favours the agent. This representation has the property that whenever we consider agents in a symmetric environment, the reference allocation is the *Equal Split*, independent of γ_i. Note that the fairness parameter γ_i can vary across agents.

Suppose two agents i, j can jointly generate a fixed surplus, which I normalise to 1 and which is strictly larger than the sum of the outside options $1 > \omega_i + \omega_j$. The reference allocation of agent i is uniquely determined by equation (1) and the restriction that $x_j = 1 - x_i$. Denote the pair of payoffs that solves these equations by

$$\begin{aligned} & \left(x_i^f\left(\gamma_i\right), x_j^f\left(\gamma_i\right)\right) \\ = & \left(\frac{1+\gamma_i\left(\omega_i-\omega_j\right)}{2}, \frac{1-\gamma_i\left(\omega_i-\omega_j\right)}{2}\right) \end{aligned}$$

where the superscript f stands for fair. There are several outstanding reference allocations. The most prominent being the allocation where both agents receive equal monetary payoffs (*Equal Split*). This would imply a fairness parameter γ_i of zero. A reference allocation that splits the difference between the surplus both agents can jointly generate and the sum of the outside options $\omega_i + \omega_j$ (*Split the Difference*) implies a parameter γ_i of one. Furthermore, a parameter of $\gamma_i = \frac{1}{\omega_i + \omega_j}$ represents a reference allocation that divides the entire cake proportionate to the agents' outside options (*Proportional Split*). Still, one could think of any other value of γ_i constituting a reference allocation. In the case where agent i has the larger outside option, $\omega_i > \omega_j$, the parameter range of γ_i can be reduced to $\left[-\frac{1}{\omega_i - \omega_j}, \frac{1}{\omega_i - \omega_j}\right]$. The upper value signifies a reference point where agents consider it fair that agent i gets the entire pie and the lower value where agent j gets everything.[2]

Incorporating this approach in the representation of inequity aversion yields pref-

[2]Suppose an agent considers it to be fair that she gets the entire surplus. One could ask in which ways this agent is different from an agent who is purely self-interested. Contrary to the pure self-interest agent, the inequity averse agent engages in social comparison processes, regardless of the fact that she considers it fair to receives the entire pie. Thus, she nearly always suffers from disadvantageous inequity aversion. As a consequence, behavioural predictions are different, in general, from the predictions derived for the self-interest agent.

erences of the form

$$
\begin{aligned}
u_i(x_i, x_j) &= x_i - \alpha_i \frac{1}{n-1} \sum_{j \neq i} \max\{x_j - x_i - \gamma_i(\omega_j - \omega_i), 0\} \\
&\quad - \beta_i \frac{1}{n-1} \sum_{j \neq i} \max\{x_i - x_j - \gamma_i(\omega_i - \omega_j), 0\}
\end{aligned}
$$

with $\alpha_i \geq \beta_i \geq 0$ and $\beta_i < 1$. The utility parameters α_i resp. β_i measure the loss for agent i resulting from a deviation to her disadvantage resp. advantage from her reference point.

The reference allocation of a self-servingly biased person attributes a relatively big monetary allotment to herself. Moreover, it is often the case that the person believes her reference allocation to be impartial. I split up the notion of self-serving biasedness into these two components: (i) the bias itself and (ii) the belief about the bias.

Definition 1 *An agent i is* ***self-servingly biased*** *with respect to another agent j if a higher monetary payoff is attributed to herself by her own reference allocation than by the reference allocation of agent j, i.e. $x_i^f(\gamma_i) > x_i^f(\gamma_j)$.*

This implies that the agent with the relatively high outside option is self-servingly biased if she has a relatively large fairness parameter γ_i. Conversely, an agent with the relatively small outside option is self-servingly biased if she has a relatively low γ_i. Consider for example the two specific reference allocations of *Equal Split* and *Split the Difference*. Agents are self-servingly biased if the agent with the relatively big outside option regards *Split the Difference* as a fair outcome, while the agent with the relatively small outside option considers the *Equal Split* fair. This relativistic view of biasedness might sound unfamiliar. One might argue that whenever an agent considers it to be equitable that she gets the entire surplus herself, she is self-servingly biased. However, biasedness requires a point of comparison. There is no such exogenous "objective" comparison available in the context of bilateral bargaining. Therefore, biasedness is defined here in comparison to the reference allocation of the other agent.

To rule out cases where an agent allocates less to herself than the opponent does, I restrict the parameter range such that

$$\gamma_j \in \left[-\frac{1}{\omega_i - \omega_j}, \gamma_i \right] \text{ for } \omega_i \geq \omega_j.$$

The agent with the relatively small outside option is thus bound to have a smaller fairness parameter than her opponent.

I distinguish between those agents that are aware of differing fairness notions among individuals and those that are not. In analogy to O'Donoghue and Rabin (1999), I call an agent naive who thinks her reference allocation is impartial. A naive agent assumes therefore that the other agent has the same fairness parameter as herself. In contrast, a sophisticated agent knows that her reference allocation differs from the one of her opponents. Moreover, she knows the exact fairness parameter of the other agents.[3] Denote the belief of agent i about the fairness parameter of agent j by $\widehat{\gamma}_{ij}$.

Definition 2 *Agent i is **naive** if she believes that agent j's fairness parameter is the same as hers, that is $\widehat{\gamma}_{ij} = \gamma_i$. Agent i is **sophisticated** if her belief about agent j's fairness parameter is correct, that is $\widehat{\gamma}_{ij} = \gamma_j$.*

In the presence of naive agents the solution concepts of subgame perfection and Bayesian perfection become problematic as beliefs might not be correct in equilibrium. I therefore employ the concept of "perception perfect strategies" introduced by O'Donoghue and Rabin (2001) in the context of hyperbolic discounting. This concept merely requires that agents choose an action that maximises their payoff

[3] If we allow sophisticated agents to be uncertain about the exact value of the fairness parameter of the other agent, we get partial sophistication. The case with perfect sophisticates and perfect naives can be regarded as a benchmark.

according to their beliefs. But it does not require, as the concept of subgame perfection or Bayesian perfection, that agents' beliefs are correct in equilibrium. Denote with $U_i\left(s_i\left(\gamma_i,\widehat{\gamma}_{ij}\right)\right)$ the (expected) utility of agent i resulting from the strategy $s_i \in A_i$ where A_i signifies the strategy space for agent i. I restrict the strategy space to incorporate pure strategies only.

Definition 3 *The strategy* $s_i^{pp}\left(\gamma_i,\widehat{\gamma}_{ij}\right)$ *is perception-perfect for a* $\left(\gamma_i,\widehat{\gamma}_{ij}\right)$*-agent if and only if it is such that* $s_i^{pp}\left(\gamma_i,\widehat{\gamma}_{ij}\right) \in \arg\max_{s_i} U_i\left(s_i\left(\gamma_i,\widehat{\gamma}_{ij}\right)\right)$.

The belief of sophisticated agents is correct. Therefore the perception perfect equilibrium coincides with the subgame perfect equilibrium resp. the Bayesian perfect equilibrium.

In the next sections, I analyse the behaviour of self-servingly biased inequity averse agents in ultimatum bargaining games. In particular, I focus on the behaviour of self-servingly biased agents that are naive.

2 Ultimatum game

In an ultimatum game, a proposer and a responder bargain over the division of a fixed surplus of one.[4] The proposer (P) announces a division of the surplus $(1-s,s)$ where s denotes the share offered to the responder. The responder (R) in turn accepts or rejects the proposal. If he accepts, then the surplus is divided according to the proposed rule. If he rejects, each player gets her or his outside option denoted by $\omega_i \geq 0$ for $i=P,R$. Both agents know the outside options of either player.

In the subgame perfect equilibrium under the assumption of purely self-interested agents, the proposer offers a division of the surplus of $(1-\omega_R,\omega_R)$ which is accepted

[4] In what follows, I denote the first player as female and the second player as male.

by the respondent. Contrary, with inequity averse agents, the equilibrium offer depends upon the characteristics of the utility functions of both players. With complete information concerning the utility parameters α_R and β_R, proposers offer

$$s \begin{cases} = \max\{\underline{s}, \frac{1}{2}\} & if\ \beta_P > \frac{1}{2} \\ \in \left[\underline{s}, \max\{\underline{s}, \frac{1}{2}\}\right] & if\ \beta_P = \frac{1}{2} \\ = \underline{s} & if\ \beta_P < \frac{1}{2} \end{cases}$$

where $\underline{s} = \frac{\alpha_R + \omega_R - \alpha_R \max\{\omega_P - \omega_R, 0\} - \beta_R \max\{\omega_R - \omega_P, 0\}}{1+2\alpha_R}$. An increase in the outside option for the responder increases the minimum share he is willing to accept. However, an increase in the outside option of the proposer might decrease or increase the minimum acceptable share depending on the difference in outside options of the proposer and the responder. With the introduction of asymmetric outside options, it might occur that the minimum offer the responder is willing to accept $\underline{s}$ exceeds the equal share of $\frac{1}{2}$. This occurs if the value of the outside option to the responder exceeds the equal share of a half. In this case, the proposer prefers to offer the minimum offer rather than staying with her outside option, as will be shown in section 2.2.

The focus of this paper is to study the equilibrium, and potential bargaining breakdown in equilibrium, when the reference allocations of agents differ from the *Equal Split*. In particular, I am interested in the impact of heterogeneity in reference allocations and of ignorance concerning this heterogeneity. Before analysing the equilibrium of the general case, I explain the workings of a self-serving bias with the help of a simple example in the next section.

2.1 *An example*

Suppose the proposer has got no outside option and the responder's outside option is positive, $\omega_R > \omega_P = 0$. Consider the two conflicting reference allocations of *Equal*

Split and *Split the Difference.* A biased proposer believes that the *Equal Split* $\left(\frac{1}{2}, \frac{1}{2}\right)$ is fair, while a biased responder adopts *Split the Difference* $\left(\frac{1-\omega_R}{2}, \frac{1+\omega_R}{2}\right)$ as reference allocation. The fairness parameter of the proposer resp. the responder is $\gamma_P = 0$ resp. $\gamma_R = 1$. The mere introduction of a self-serving bias in reference allocations does not result in a breakdown of the bargaining. A sophisticated biased proposer is always willing to divide the pie such that the respondent is at least as well off as with his outside option. The efficiency gain resulting from the bargain is large enough to compensate for deviations from the reference allocation.

To see this, I compute the maximum share the proposer is willing to offer (MTO - *Maximum Tolerable Offer,* denoted by $\overline{s}$) and the minimum share the responder is willing to accept (MAO - *Minimum Acceptable Offer,* denoted by $\underline{s}$). These shares render the proposer resp. the responder indifferent between their outside option and the division of the pie. In our example, the value of the outside option to the responder is $u_R(0, \omega_R) = \omega_R$ and a division $(1-s, s)$ of the cake which is disadvantageous to him, i.e. $s \leq \frac{1+\omega_R}{2}$, results in a value of $u_R(1-s, s) = s - \alpha_R(1 - 2s + \omega_R)$. The responder's MAO is thus

$$\underline{s}_{\gamma_R=1} = \frac{(1+\alpha_R)\,\omega_R + \alpha_R}{1+2\alpha_R}.$$

The proposer values the outside option with $u_P(0, \omega_R) = -\alpha_P \omega_R$. She derives a utility of $u_P(1-s, s) = 1 - s - \alpha_P(2s-1)$ of a disadvantageous division $(1-s, s)$ of the pie, with $s \geq \frac{1}{2}$. Hence she is better off with a division of the pie as long as the share for the respondent does not exceed the MTO of

$$\overline{s}_{\gamma_P=0} = \frac{1 + \alpha_P(1+\omega_R)}{1+2\alpha_P}.$$

The MTO $\overline{s}_{\gamma_P=0}$ is strictly bigger than the MAO $\underline{s}_{\gamma_R=1}$. The bargain therefore never fails to take place. The reason being that agents also dislike inequity when they stay with their outside options. The proposer thus suffers from inequity aversion in case of the breakdown of the bargain. This increases the share she is maximally willing to give to the responder. In section 2.2, I show that this holds in general.

If, however, the proposer is biased and naive about the bias, then the bargain is likely to fail. The naive and biased proposer thinks that the responder shares the same reference allocation with $\gamma_P = 0$. She employs this fairness parameter to compute the MAO. Hence, she believes the MAO to be the same as in the standard case with simple inequity aversion

$$\underline{s}_{\widehat{\gamma}_{PR}=0} = \frac{(1-\beta_R)\,\omega_R + \alpha_R}{1+2\alpha_R}.$$

This level is strictly smaller than the actual MAO, i.e. $\underline{s}_{\gamma_R=1} > \underline{s}_{\widehat{\gamma}_{PR}=0}$. If the proposer's sufferance from advantageous inequity is sufficiently small, i.e. $\beta_P < \frac{1}{2}$, then, in equilibrium, the proposer is going to propose the smallest share to the responder. Therefore, she proposes a share that is below the minimum share the responder is willing to accept and the bargain fails.

The next section extends this result to more general notions of fairness and derives the equilibrium for the case of incomplete information concerning the utility parameters α_R and β_R.

2.2 *General case*

The introduction of asymmetric outside options has several implication for the equilibrium of the ultimatum game with inequity averse agents. On the one hand, asymmetry in outside options can increase the MAO such that it exceeds the fair share of the pie. On the other hand, the asymmetry might lead to a self-serving bias.

In the framework of Fehr and Schmidt, we have already seen that in some cases, namely when the utility of the outside option to the responder is larger than the utility of the fair share, the MAO exceeds the fair share. In these cases, the proposer simply offers the MAO regardless of her level of sufferance due to advantageous inequity aversion. For the general case of heterogenous reference allocations, Lemma 1 shows that the responder's MAO is larger than the share the proposer considers to be fair for the responder if and only if the utility the responder receives from his outside option is larger than the utility derived from the fair share. With a self-serving bias the number of cases, where the MAO exceeds the fair share $s^f(\gamma_P)$, increases compared to the case where both agents share the same reference allocation. Denote the fair allocation of agent i depending on the fairness parameter γ_i by $\left(1 - s^f(\gamma_i), s^f(\gamma_i)\right) = \left(\frac{1+\gamma_i(\omega_P - \omega_R)}{2}, \frac{1-\gamma_i(\omega_P - \omega_R)}{2}\right)$ and the MAO depending on the fairness parameter γ_R by $\underline{s}(\gamma_R)$.

Lemma 1 *The MAO of the responder is larger than the fair share of the proposer,* $\underline{s}(\gamma_R) > s^f(\gamma_P)$*, if and only if* $u_R(\omega_R, \omega_P) > u_R\left(s^f(\gamma_P), 1 - s^f(\gamma_P)\right)$.

Proof. The MAO $\underline{s}(\gamma_R)$ is a disadvantageous share for the responder such that he is indifferent between the outside option and that share. It is thus determined by $u_R(\omega_R, \omega_P) = u_R(\underline{s}(\gamma_R), 1 - \underline{s}(\gamma_R))$. The responder's utility of a share s that is to his disadvantage is given by $u_R(s, 1-s) = s - \alpha_R(1 - 2s - \gamma_R(\omega_P - \omega_R))$, which is strictly increasing in the share s. The fair share $s^f(\gamma_P)$ that the proposer attributes to the responder is weakly disadvantageous to the responder. If proposer and responder share the same reference allocation, then the fair share is not disadvantageous. Otherwise, if agents are biased, the fair share of the proposer by definition attributes less to the responder than the fair share of the responder, hence it is disadvantageous. Therefore,

$$
\begin{aligned}
& u_R(\omega_R, \omega_P) - u_R\left(s^f(\gamma_P), 1 - s^f(\gamma_P)\right) > 0 \\
\leftrightarrow \quad & \left(\underline{s}(\gamma_R) - s^f(\gamma_P)\right)(1 + 2\alpha_R) > 0 \\
\leftrightarrow \quad & \underline{s}(\gamma_R) > s^f(\gamma_P).
\end{aligned}
$$

■

In case the MAO is larger than the fair share, we have to ensure that the proposer wants to offer more than her fair share to the responder. The efficiency gain from a bargain has to be sufficiently large as to compensate the proposer for the loss resulting from the disadvantageous deviation from her reference allocation. Lemma 2 establishes that the proposer is better off if she offers the MAO to the responder than if she is left with her outside option. In case the MAO exceeds the fair share, the proposer therefore prefers to offer the MAO, than to be left with her outside option.

Lemma 2 *The MAO* $\underline{s}(\gamma_R)$ *of the responder is smaller than the MTO* $\overline{s}(\gamma_P)$ *of the proposer.*

Proof. Suppose agents are biased such that $\gamma_i \geq 1$, $\gamma_j \leq 1$ for $\omega_i > \omega_j$. This includes the case where each agent considers it fair that she or he gets the entire surplus. The MTO and the MAO can then be calculated as

$$\begin{aligned} u_P(1-\overline{s},\overline{s}) &= 1-\overline{s}-\alpha_P(2\overline{s}-1-\gamma_P(\omega_R-\omega_P)) \\ &= \omega_P-\alpha_P(1-\gamma_P)(\omega_R-\omega_P)=u_P(\omega_P,\omega_R) \end{aligned}$$

$$\overline{s}=\frac{\alpha_P+1-\omega_P-\alpha_P(\omega_P-\omega_R)}{1+2\alpha_P}, \tag{2}$$

and

$$\begin{aligned} u_R(\underline{s},1-\underline{s}) &= \underline{s}-\alpha_R(1-2\underline{s}-\gamma_R(\omega_P-\omega_R)) \\ &= \omega_R-\alpha_R(1-\gamma_R)(\omega_P-\omega_R)=u_R(\omega_R,\omega_P) \end{aligned}$$

$$\underline{s}=\frac{\alpha_R+\omega_R+\alpha_R(\omega_R-\omega_P)}{1+2\alpha_R}. \tag{3}$$

Algebraic transformations show that the MAO is smaller than the MTO if the sum of the outside options is smaller than the entire pie:

$$\underline{s} \leq \overline{s} \leftrightarrow \omega_R + \omega_P \leq 1,$$

see Appendix 4 for further detail.

If agents become less partial as either γ_i decreases or γ_j increases (with $\gamma_i \geq \gamma_j$), the MTO weakly increases or the MAO weakly decreases, see Appendix 4 for further detail. ■

To get some intuition, consider the following example. Let the outside option of the proposer be half the pie, $\omega_P = \frac{1}{2}$, while the responder has no positive outside option, $\omega_R = 0$. Further assume that the proposer's reference allocation is such that she gets the entire pie and the reference allocation of the responder is the *Equal Split*. Now, if the proposer suffers a lot from disadvantageous inequity, i.e. α_P is very large, one might think that he is not willing to deviate much from his reference allocation and is willing to give only a very small amount to the responder, ε. The responder with a high α_R might prefer to stay with the outside option constellation $\left(\frac{1}{2}, 0\right)$ rather than accept the division $(1-\varepsilon, \varepsilon)$ as he suffers less from inequity aversion under the outside options. Why is this reasoning not correct? The proposer does not only suffer from inequity aversion when the bargain takes place and she gets less than the entire pie, but also when both agents get their outside options. In both situations, proposers with a very high α_P suffer a lot. Hence to avoid the suffering in the outside option constellation, she is willing to propose an offer that is substantially smaller than she thinks to be fair.

The result is robust to the following modification of the model. Suppose a participation decision precedes the game. Participation implying that agents forego the possibility to earn their outside option. In this version of the game, agents receive nothing in case they do not agree on a division of the surplus, just as in the standard case. However, the decision to pass on the outside option might still influence their perception of the fair allocation. If it influences the reference allocation whenever the bargain takes place as well as when it breaks down, the above result stays valid. The MAO could only exceed the MTO if the fair allocation depends on the difference in outside options in case the bargain takes place, but not when it breaks down. Hence, only when agents have different reference allocations in these two cases, the proposer might not be willing to offer the MAO.

The following proposition characterises the equilibrium of the ultimatum bargaining with sophisticated proposers, that is proposers who understand that they are biased.

Proposition 1 *In perception perfect equilibrium, if* $u_R(\omega_R, \omega_P) \leq u_R\left(s^f(\gamma_P), 1 - s^f(\gamma_P)\right)$, *a sophisticated proposer offers a share*

$$s^* \begin{cases} = s^f(\gamma_P) & \beta_P > \frac{1}{2} \\ \in \left[\underline{s}(\gamma_R), s^f(\gamma_P)\right] & \beta_P = \frac{1}{2} \\ = \underline{s}(\gamma_R) & \beta_P < \frac{1}{2} \end{cases} .$$

Otherwise, she proposes $s^* = \underline{s}(\gamma_R)$. *The responder accepts the offer.*

Proof. If $u_R(\omega_R, \omega_P) \leq u_R\left(s^f(\gamma_P), 1 - s^f(\gamma_P)\right)$, the MAO $\underline{s}(\gamma_R)$ is smaller than the fair share $s^f(\gamma_P)$. The rest of the proof is analogous to the proof of proposition 1 in Fehr and Schmidt (1999).

If instead $u_R(\omega_R, \omega_P) > u_R\left(s^f(\gamma_P), 1 - s^f(\gamma_P)\right)$, the MAO $\underline{s}(\gamma_R)$ exceeds the fair share $s^f(\gamma_P)$. The proposer's utility of an offer above the fair share $s \geq s^f(\gamma_P)$ is given by $u_P(s) = 1 - s - \alpha_P(2s - 1 - \gamma_P(\omega_R - \omega_P))$ which is strictly decreasing in s. The proposer therefore never offers a share bigger than the MAO. By definition, the responder only accepts offers above the MAO. Lemma 2 shows that the proposer always prefers to offer the MAO than to get her outside option. Therefore, in equilibrium the proposer offers exactly the MAO. ■

Proposition 1 implies that a self-serving bias as such does not generate a bargaining breakdown. The proposer is always willing to render the responder at least indifferent between his outside option and the proposed share.[5] Note that the beliefs of sophisticated agents are correct and the perception perfect equilibrium coincides with the subgame perfect equilibrium.

To what extent do the results change if the proposer is biased and naive? Naive agents believe that other agents share the reference allocation with them. In the example, we have already seen that naiveté about the self-serving bias can lead to an offer that is not acceptable for the responder. The naive proposer underestimates the MAO. If she comes to propose the underestimated MAO in perception perfect equilibrium, the responder rejects the offer and the bargain breaks down.

Lemma 3 states the conditions under which naive and biased proposers predict the MAO to be strictly smaller than the actual MAO. Whether the naive proposer accurately predicts the MAO depends crucially on whether her fairness parameter is bigger or smaller than one. A fairness parameter of one implies the reference allocation of *Split the Difference*. With *Split the Difference*, the agent does not suffer from inequity in the outside option constellation. For illustrational purposes assume that the outside option of the responder is larger than of the proposer. As soon as the fairness parameter of the responder exceeds one, the responder suffers from disadvantageous inequity in the outside option constellation. The responder thus suffers in the same way from disadvantageous inequity, both, in the outside option constellation and when he gets his MAO. Therefore his MAO is independent of the fairness parameter as can be seen in (3). Contrary, if the fairness parameter of the responder is below the threshold of one, the responder suffers from advantageous inequity in the outside option constellation and from disadvantageous inequity when

[5] Babcock and Loewenstein (1997) propose the self-serving bias as source of bargaining impasse. They hypothese that a self-serving bias might eliminate the contract zone, that is the set of agreements that both sides prefer to their reservation value. The above argument shows that, within the framework of extended inequity aversion, a self-serving bias does not eliminate the contract zone in an ultimatum game.

he gets his MAO. Therefore the MAO depends on the fairness parameter. A naive proposer thinks that her fairness perception is impartial. Therefore, the predicted MAO is independent of the fairness parameter if her fairness parameter exceeds one, $\gamma_P \geq 1$. Otherwise the prediction depends upon the particular fairness parameter of the proposer. A wrong prediction can only occur when the proposer predicts that the MAO depends on the fairness parameter. In case she predicts the MAO to be independent of the parameter, we know her fairness parameter is above one. The partiality of the agents implies that the parameter of the responder is even bigger and therefore also bigger than one. Hence, the MAO is correctly predicted. However, if the proposer predicts the MAO to be dependent on the fairness parameter, the partiality implies that she underestimates the actual MAO. The following lemma generalises this argument.

Lemma 3 *A naive and biased proposer believes the MAO to be smaller than the actual MAO,* $\underline{s}(\gamma_P) < \underline{s}(\gamma_R)$ *if and only if*

1) $\omega_P < \omega_R$ *and* $\gamma_P < 1$, *or*

2) $\omega_P > \omega_R$ *and* $\gamma_P > 1$.

The proof of Lemma 3 is relegated to Appendix 4.

Given the conditions of Lemma 3, a naive and biased proposer underestimates the MAO, i.e. $\underline{s}(\gamma_P) < \underline{s}(\gamma_R)$. Therefore, if she offers the predicted MAO in perception perfect equilibrium, her offer is too low and is rejected by the responder. The following proposition summarises the conditions for bargaining breakdown.

Proposition 2 *Under the conditions of Lemma 3, a naive and biased proposer causes a breakdown (with positive probability) if*

1) $u_R(\omega_R, \omega_P) > u_R\left(s^f(\gamma_P), 1 - s^f(\gamma_P)\right)$ *or*

2) $u_R(\omega_R, \omega_P) \leq u_R\left(s^f(\gamma_P), 1 - s^f(\gamma_P)\right)$ *and* $\beta_P < \frac{1}{2}$ $(\beta_P = \frac{1}{2})$.

Proof. In equilibrium, the respondent accepts any offer above the true MAO $\underline{s}(\gamma_R)$. Under the conditions of Lemma 3, a naive and biased proposer predicts the MAO to be too small, that is $\underline{s}(\gamma_P) < \underline{s}(\gamma_R)$. If the utility of the outside option of the responder is larger than the utility of the fair share, $u_R(\omega_R, \omega_P) > u_R\left(s^f(\gamma_P), 1 - s^f(\gamma_P)\right)$, the MAO $\underline{s}(\gamma_R)$ is larger than the fair share of the proposer $s^f(\gamma_P)$. In perception perfect equilibrium, the maximally offered share is given by $\max\left\{s^f(\gamma_P), \underline{s}(\gamma_P)\right\}$, see Proposition 1. This is smaller than the actual MAO $\underline{s}(\gamma_R)$ and the bargain breaks down.

Otherwise, if the utility of the outside option of the responder is smaller than the utility of the fair share, $u_R(\omega_R, \omega_P) < u_R\left(s^f(\gamma_P), 1 - s^f(\gamma_P)\right)$, the MAO is smaller than the fair share the proposer attributes to the responder, $\underline{s}(\gamma_R) \leq s^f(\gamma_P)$. The proposer offers a share $s^* \begin{cases} = s^f(\gamma_P) & if\ \beta_P > \frac{1}{2} \\ \in \left[\underline{s}(\gamma_P), s^f(\gamma_P)\right] & if\ \beta_P = \frac{1}{2} \\ = \underline{s}(\gamma_P) & if\ \beta_P < \frac{1}{2} \end{cases}$ in perception perfect equilibrium. Therefore, if the parameter of advantageous inequity is smaller than $\frac{1}{2}$, the equilibrium share is smaller than the minimal share and the bargain breaks down. With a parameter $\beta_P = \frac{1}{2}$, the bargain breaks down with positive probability.

■

Proposition 2 characterises the circumstances under which there is bargaining breakdown with complete information concerning the parameters of the responder's utility function α_R and β_R. The analysis stresses that both characteristics of a self-serving bias are crucial for breakdown, namely, the bias as well as the ignorance of it.

On the one hand, the introduction of asymmetric outside options can increase the MAO such that it exceeds the fair share of the pie, on the other, the asymmetry might lead to a self-serving bias. There is no built-in mechanism that makes a self-serving bias more likely if the difference in outside options becomes more pronounced. The conditions of Lemma 3 do not get more or less restrictive if the difference in outside options increases. We therefore do not expect more bargaining breakdown because of self-serving biases when the difference in outside options increase. However, the increase in the difference of outside options might increase the likelihood of the case where the MAO exceeds the fair share and through this channel the likelihood of a bargaining breakdown. However, the influence of an increase in the difference of outside options is indeterminate and depends on the parameters of the utility function.

So far, I analysed the perception perfect equilibrium given that the proposer knows the willingness of the responder to deviate from his reference allocation. Now, suppose the proposer does not know the parameters of the responder's utility, but believes that the parameter of disadvantageous α_R and advantageous β_R inequity are distributed according to the joint cumulative distribution functions $F_{\alpha,\beta}(\alpha_R, \beta_R)$ on the support $[\underline{\alpha}, \overline{\alpha}] \times [\underline{\beta}, \overline{\beta}]$. Denote $\underline{s}(\widehat{\gamma}_{PR})^{\max} = \max_{\alpha_R,\beta_R} \underline{s}(\alpha_R, \beta_R | \widehat{\gamma}_{PR})$ and $\underline{s}(\widehat{\gamma}_{PR})^{\min} = \min_{\alpha_R,\beta_R} \underline{s}(\alpha_R, \beta_R | \widehat{\gamma}_{PR})$.

Proposition 3 *With $(\alpha_R, \beta_R) \sim F_{\alpha,\beta}[\underline{\alpha}, \overline{\alpha}] \times [\underline{\beta}, \overline{\beta}]$, the proposer offers*

$$s^*(\beta_P) \in \begin{cases} \left[s^f(\gamma_P), \max\left\{s^f(\gamma_P), \underline{s}(\widehat{\gamma}_{PR})^{\max}\right\}\right] & \text{if } \beta_P > \frac{1}{2} \\ \left[\min\left\{\underline{s}(\widehat{\gamma}_{PR})^{\max}, s^f(\gamma_P)\right\}, \max\left\{\underline{s}(\widehat{\gamma}_{PR})^{\max}, s^f(\gamma_P)\right\}\right] & \text{if } \beta_P = \frac{1}{2} \\ \left[\underline{s}(\widehat{\gamma}_{PR})^{\min}, \underline{s}(\widehat{\gamma}_{PR})^{\max}\right] & \text{if } \beta_P < \frac{1}{2} \end{cases}$$

in the perception perfect equilibrium.

Proof. This follows from Propositions 1, 2 and the proof of Proposition 1 in Fehr and Schmidt (1999). ■

The perception perfect equilibrium differs for sophisticated and naive proposers in essentially two features. First, the offered shares and second, the resulting propensity of bargaining breakdown. The share sophisticated proposers offer is weakly bigger than the share offered by a naive agent. Proposers face a trade-off between costs and the probability of acceptance. With increasing shares, the probability of acceptance increases as well as the associated costs to the proposer. Naive proposers assess the reference allocation of the responder wrongly. They believe the responder shares the reference allocation with themselves. We have seen that, under the conditions of Lemma 3, this leads to a wrong prediction of the MAO in the complete information case. For a given parameter pair (α_R, β_R), the prediction of the MAO is smaller than the true MAO. This implies that the assessment of the probability of acceptance of a share s is bigger than the actual probability. Thus, naive proposers offer less than sophisticated proposers in perception perfect equilibrium. Given that the share a sophisticated proposer offers exceeds the share of a naive proposer, the probability of bargaining breakdown increases for a naive proposer. The following proposition summarises these two characteristics of the perception perfect equilibrium with incomplete information.

Proposition 4 *With incomplete information, a naive proposer offers (weakly) less and the probability of bargaining breakdown is (weakly) higher than with a sophisticated proposer.*

Proof. The maximisation problem of the proposer is characterised by $\arg\max_s \left(u_P(1-s,s) - u_P(\omega_P,\omega_R)\right) prob\left(s \geq \underline{s}\left(\widehat{\gamma}_{PR}\right)\right) + u_P(\omega_P,\omega_R)$. Note that the probability is the estimated probability of acceptance of the share s. Lemma 2 tells us that the proposer is always better off proposing the MAO than with her outside option. The difference between the utility of the bargain with share s and the outside option is thus always positive, $u_P(1-s,s) - u_P(\omega_P,\omega_R) \geq 0$ and weakly decreasing in s on the interval of the equilibrium share s^*.

The maximisation problem is characterised by the trade-off between a higher probability of acceptance and the associated costs. If the conditions of Lemma 3 are met, the naive proposer underestimates the MAO. Thus she believes the probability of acceptance of share s to be too high. The maximisation calculus thus results in a lower share for these proposers.

As shown above the share of a sophisticated proposer is weakly bigger than the share of a naive, $s_s \geq s_n$, where the subscripts s, n denote sophisticated and naive. The probability of bargaining breakdown equals the probability of acceptance of a share. Thus the probability of breakdown is smaller with a sophisticated proposer, $prob\,(s \geq s_n) \geq prob\,(s \geq s_s)$. ■

The probability of a bargaining breakdown is higher if the proposer is naive than if she is sophisticated. The intuition for this result is straightforward. Naive and sophisticated proposers face uncertainty concerning the parameters that determine the loss resulting from a deviation from the responder's reference allocation. The decision how much of the pie to offer to the responder is thus based on expectations. In some cases, the proposed share is going to be too low for the responder to accept it. This is one source of bargaining breakdown which is identical for a naive and a sophisticated proposer. If the naive proposers share the belief about the responder's reference allocation with the sophisticated, they face the same propensity of bargaining breakdown out of uncertainty. However, generally the naive proposers do not share beliefs with sophisticated. Their belief about the responder's reference allocation is based on their own assessment of fairness. We have seen that this can lead to an offer that is below the actual MAO in the complete information case and a generally smaller offer than the offer of a sophisticated agent in the incomplete information case. This is an additional source of bargaining breakdown. Consequently, the probability of acceptance and therefore the probability of bargaining breakdown is larger with naive than with sophisticated proposers.

The model predicts that asymmetry compared to symmetry in outside options increases the probability of rejection. This contrasts with the predictions of the theory of inequity aversion by Fehr and Schmidt (1999), where agents, by assumption, share the same reference allocation of *Equal Split* and thus cannot fall prey to a self-serving bias. Fehr and Schmidt predict no difference in rejection rates across ultimatum games with symmetric and asymmetric outside options. This difference in predictions provides a test that discriminates between the theory of Fehr and Schmidt that does not allow for a self-serving bias and the enriched version presented in this model.

3 Evidence

There are some experiments on ultimatum bargaining that introduce asymmetry in outside options. In an experiment by Knez and Camerer (1995), proposer and responder have positive and asymmetric outside option. The proposer's outside option amounts to 30% of a $10-pie, while the respondents are divided into two groups. The first half of the responders (R1) gets a smaller outside option than the proposers, namely 20% of the pie, and the second half of the responders (R2) gets a higher option of 40%. Offers to the responder with the small outside option are significantly lower than to the responder with the high outside option. Moreover, MAO of the R1 responder are significantly lower than of the R2 responder. This impact of the outside options on offers and MAO can be explained with inequity averse agents. Furthermore, Knez and Camerer (1995) find that rejection rates are around 45%-48%. This is much higher than the rejection rates found for two player ultimatum games with no outside options which are around 20%, see tables on pages 53-55 in Camerer (2003). A likely cause for the increase in the rejection rate is the introduction of asymmetric outside options. The remaining experimental set-up is identical to other ultimatum bargaining experiments in western countries. If agents are inequity averse with symmetric reference allocations as postulated in Fehr and Schmidt (1999), then rejection rates should not be influenced by the introduction of asymmetric outside options. However, the existence of self-servingly biased agents can account for part of the additional inefficiencies. As we have seen, naive proposers underestimate the MAO and are thus likely to propose a share that is not acceptable for the responder. Hence, the bargain breaks down more often than in the case where agents are sophisticated about their bias or where they are not biased at all.

The increase in rejection rates in Knez and Camerer could also stem from the fact that positive outside options have been introduced rather than the attached asymmetry. However, similarly high rejection rates are found in the ultimatum experiments by Buchan, Croson, and Johnson (2004) and Schmitt (2004). In these studies solely one of the two players is endowed with a positive outside option. Both studies find that offers and MAO decrease with a higher outside option of the proposer. Schmitt finds that rejection rates are 50% in the treatments where proposer have the positive outside option and around 30-40% in the treatments with positive outside options for the responders. The experiment by Buchan, Croson, and Johnson is run in the US and Japan. For the US, the rejection rate in the condition with a positive outside option for the proposer is significantly larger than in the condition with no positive outside option for either player, whereas there is no significant difference in Japan.[6]

Falk, Fehr, and Fischbacher (2001) present an experiment on a reduced ultimatum game with a positive outside option for the respondent. There the proposer can choose between a split which gives herself 8 and the responder 12 and a split where she gets 5 and the proposer gets 15. Whenever the responder rejects the offer, the proposer goes home with nothing and the responder gets his outside option of 10. They argue that: "Since both offers give the responder a higher payoff than the proposer they cannot be viewed as unfair from the responder respectively. Thus resistance to unfairness cannot explain rejections in this game." Using the strategy method, they observe that 24% of the responders reject the 8/12 offer, while only 4% reject the 5/15 offer with the difference being significant at a 1%-level. They take this result as a case for the presence of spitefulness which they define as the willingness to sanction in order to increase the payoff difference between two agents. However, the evidence from this experiment can also be explained by self-serving biases in the perception of the fair allocation. If the proposer thinks that both sub-

[6]Buchan, Croson, and Johnson do not report rejection rates. We thus compute these for each of their treatments using their original data set.

jects unanimously believe that the 8/12 split is the closest to a fair outcome, she proposes this split. But she could be coupled with a responder that is convinced that splitting the difference between the pie and his outside option is fair and is therefore going to reject the inequitable share of 8/12. This provides another explanation to why the rejection of the 8/12 offer is significantly higher than the 5/15 offer. Which of these explanations suits the case better is yet to be determined.

4 Conclusion

There is strong empirical evidence that in bargaining situations with asymmetric outside options people exhibit self-serving biases concerning their fairness judgements and that these self-serving biases are a driving force of bargaining impasse. This paper provides a theoretical framework for analysing the behaviour of self-servingly biased agents in simple bargaining situations. I build on the notion of inequity aversion and extend it to incorporate self-serving biases due to asymmetric outside options. I distinguish between sophisticated and naive agents, that is, those agents who understand their partiality and those who do not. I then apply the framework to analyse the behaviour of naive and sophisticated biased agents in ultimatum games. For ultimatum bargaining with complete information, I find that bargaining can only break down, if biased proposers are not aware of their self-serving bias. In the incomplete information case, the propensity of bargaining breakdown is higher with naive than with sophisticated agents.

So far, the framework only incorporates one prominent form of asymmetry, due to outside options. One path of further research could be to think of incorporating other forms of asymmetries in bargaining games that might bias the perception of fairness, such as asymmetric payoff possibilities. Kagel, Kim, and Moser (1996) have run ultimatum experiments with asymmetric payoff possibilities. Players bargain over the distribution of chips with different exchange rates and different information concerning these rates. If both players are fully informed and proposers have higher exchange rates, conflicting fairness norms seem to develop. This is reflected in unusually high rejection rates.

Appendix

Details to the proof of Lemma 2 Lemma 2 states that the amount the proposer is maximally willing to give (MTO) exceeds the acceptance threshold of the responder (MAO). To prove this, we have to show that even in case of the most extreme biasedness, i.e. $\gamma_i \geq 1$, $\gamma_j \leq 1$ for $\omega_i > \omega_j$, the MAO is smaller than MTO. Suppose $\gamma_i \geq 1$, $\gamma_j \leq 1$ for $\omega_i > \omega_j$. Then the MTO and MAO are given by (2) and (3). The following calculations show that the MAO is smaller than the MTO:

$$\begin{aligned}
\underline{s} &= \frac{\omega_R + \alpha_R - \alpha_R\left(\omega_P - \omega_R\right)}{\left(1+2\alpha_R\right)} \leq \frac{1+\alpha_P - \omega_P + \alpha_P\left(\omega_R - \omega_P\right)}{\left(1+2\alpha_P\right)} = \overline{s} \\
&\leftrightarrow \omega_R\left(1+2\alpha_P\right) + \alpha_R\left(1+2\alpha_P\right) - \alpha_R\left(1+2\alpha_P\right)\left(\omega_P - \omega_R\right) \\
&\leq 1+2\alpha_R + \alpha_P\left(1+2\alpha_R\right) - \omega_P\left(1+2\alpha_R\right) + \alpha_P\left(1+2\alpha_R\right)\left(\omega_R - \omega_P\right) \\
&\leftrightarrow \left(\omega_R + \omega_P\right)\left(1+\alpha_R+\alpha_P\right) \leq 1+\alpha_R+\alpha_P.
\end{aligned}$$

Next, I show that the MTO given by (2) is the smallest MTO and that the MAO given by (3) is the largest MAO. Generally, the MTO is computed as $\overline{s} = \frac{\alpha_P+1-\omega_P}{1+2\alpha_P} + \frac{\alpha_P\gamma_P(\omega_R-\omega_P)}{1+2\alpha_P} + \frac{\alpha_P\max\{(1-\gamma_P)(\omega_R-\omega_P),0\}}{1+2\alpha_P} + \frac{\beta_P\max\{-(1-\gamma_P)(\omega_R-\omega_P),0\}}{(1+2\alpha_P)}$. The minimum of the MTO occurs at $\overline{s}^{\min} = \left\{\begin{array}{ll} \overline{s}\left(\gamma_P \geq 1\right) & if\ \omega_P > \omega_R \\ \overline{s}\left(\gamma_P \leq 1\right) & else \end{array}\right\} = \frac{\alpha_P+1-\omega_P+\alpha_P(\omega_R-\omega_P)}{1+2\alpha_P}$. Similarly, the MAO can be expressed as $\underline{s} = \frac{\omega_R+\alpha_R-\alpha_R\gamma_R(\omega_P-\omega_R)}{1+2\alpha_R} - \frac{\alpha_R\max\{(1-\gamma_R)(\omega_P-\omega_R),0\}}{1+2\alpha_R} - \frac{\beta_R\max\{(1-\gamma_R)(\omega_R-\omega_P),0\}}{1+2\alpha_R}$. The maximum of the MAO occurs at $\underline{s}^{\max} = \left\{\begin{array}{ll} \underline{s}\left(\gamma_R \leq 1\right) & if\ \omega_P > \omega_R \\ \underline{s}\left(\gamma_R \geq 1\right) & else \end{array}\right\} = \frac{\alpha_R+\omega_R+\alpha_R(\omega_R-\omega_P)}{1+2\alpha_R}$.
Thus MTO exceeds the MAO. ■

Proof of Lemma 3 Lemma 3 establishes the conditions under which a biased and naive proposer underestimates the MAO. The belief of the naive proposer concerning the MAO is given by

$$\underline{s}(\gamma_P) = \begin{cases} \frac{\alpha_R+\omega_R+\alpha_R(\omega_R-\omega_P)}{1+2\alpha_R} & \begin{array}{c}\text{if } \omega_R > \omega_P \ \& \ \gamma_P \geq 1 \\ \text{or } \omega_R < \omega_P \ \& \ \gamma_P \leq 1\end{array} \\ \frac{\alpha_R+\omega_R+((\alpha_R+\beta_R)\gamma_P-\beta_R)(\omega_R-\omega_P)}{1+2\alpha_R} & \text{else} \end{cases}.$$

1) Suppose $\underline{s}(\gamma_P) < \underline{s}(\gamma_R)$ and neither condition 1) nor 2) are satisfied. Then, if $\omega_R > \omega_P$ ($\omega_R < \omega_P$) the fairness parameter of the proposer is $\gamma_P \geq 1$ ($\gamma_P \leq 1$). As the proposer is biased, the true fairness parameter of the responder is larger (smaller) than the parameter of the proposer, $\gamma_R > \gamma_P \geq 1$ ($\gamma_R < \gamma_P \leq 1$). Thus both the true MAO and the belief of the proposer about the MAO are independent of the fairness parameter, $\underline{s}(\gamma_i) = \frac{\alpha_R+\omega_R+\alpha_R(\omega_R-\omega_P)}{1+2\alpha_R}$ for $i = P, R$. Hence the assumption of $\underline{s}(\gamma_P) < \underline{s}(\gamma_R)$ is violated.

2) Now, suppose condition 1) (or 2)) is satisfied, $\omega_R > \omega_P$ and $\gamma_P < 1$ (or $\omega_R < \omega_P$ and $\gamma_P < 1$). Then the belief of the proposer is $\underline{s}(\gamma_P) = \frac{\alpha_R+\omega_R+((\alpha_R+\beta_R)\gamma_P-\beta_R)(\omega_R-\omega_P)}{1+2\alpha_R}$ and we have to show that this is smaller than the true MAO, $\underline{s}(\gamma_R)$. As the proposer is biased, $\gamma_R > \gamma_P$ (resp. $\gamma_R < \gamma_P$). If the true MAO is $\underline{s}(\gamma_R) = \frac{\alpha_R+\omega_R+((\alpha_R+\beta_R)\gamma_R-\beta_R)(\omega_R-\omega_P)}{1+2\alpha_R}$, then $\underline{s}(\gamma_R) > \underline{s}(\gamma_P)$ as the MAO is increasing (decreasing) in the fairness parameter. If the true MAO is $\underline{s}(\gamma_R) = \frac{\alpha_R+\omega_R+\alpha_R(\omega_R-\omega_P)}{1+2\alpha_R}$, then $\underline{s}(\gamma_R) > \underline{s}(\gamma_P)$ as $\gamma_P(\omega_R-\omega_P) < (\omega_R-\omega_P)$. ∎

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