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Bargaining with a residual claimant: An experimental study ☆

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ABSTRACT

Many negotiations involve risks that are resolved ex-post. Often these risks are not incurred equally by the parties involved. We experimentally investigate bargaining situations where a residual claimant faces ex-post risk, whereas a fixed-payoff player does not. Consistent with a benchmark model, we find that residual claimants extract a risk premium, which increases in risk exposure. This premium can be high enough to make it beneficial to bargain over a risky rather than a risk-less pie. Contrary to the model's predictions, we find that the comparatively less risk averse residual claimants benefit the most from risk exposure. This is because fixed-payoff players' adopt weak bargaining strategies when the pie is risky. We find evidence for a behavioural mechanism where asymmetric exposure to risk between the two parties creates a wedge between their fairness ideas, which shifts agreements in favour of residual claimants but also increases bargaining friction.
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1. Introduction

In many bargaining situations the actual surplus at stake is not known when negotiations take place, and agreements need to be reached before it is revealed. Furthermore, exposure to this risk is often asymmetric. A prominent example is labour-firm negotiations where employees generally receive a fixed salary, whereas the firm faces ex-post risk due to uncertainty over factors such as future demand or costs (Riedl and van Winden, 2012).

This is nicely illustrated by the prominent role asymmetric exposure to risk appears to have played in two high-profile labour negotiations between North American sports leagues and their players' unions: In the National Football League (NFL), one article summarized the negotiating stance of the owners and players as follows, "ownership wants the players to 'buy in' to the fact that running an NFL team requires an enormous allocation of risk not currently shared by the players to

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an appropriate level" (Brandt, 2011). This suggests that the owners believe that they should be compensated for their risk exposure. On the other hand, the article continues, "at one bargaining session, NFLPA representatives responded to the 'shared risk' argument with an offer to also share in profits [...] that argument stopped the discussion in its tracks" (Brandt, 2011). Thus, it appears that the players believe that the owners have benefited from the arrangement and that no extra compensation for the owners' risk is justified. Similarly, in the National Hockey League (NHL) it was argued that, "owners bear all of the risk. Players talk about desiring a partnership, but they certainly don't want to share the risk" (Allen, 2012).

These quotations illustrate that asymmetric exposure to risk is used as a negotiating tactic in high-stakes negotiations, and that those exposed to risk believe that they should be compensated for it. Moreover, the NFL example suggests that—from the players' perspective—despite their apparent exposure to risk, it may have been advantageous to the owners.

Outside of labour negotiations, asymmetric exposure to risk is a common feature of wholesale price contracts in supply chains. Depending on the specific contract form, either the buyer or the supplier bears the risk of unsold inventory (Cachon, 2004). Asymmetric exposure to risk is also present in venture capital investing. In particular, a venture capitalist who invests in a start-up makes a substantial investment for an uncertain return. As a result, it is common for venture capitalists to include a "liquidation preference" clause in the contract as a way to ensure that they get paid in the event that the start-up experiences a liquidation event such as a merger, takeover or failure of the venture. Negotiating the terms of such clauses are often highly fraught (Metrick and Yasuda, 2010; Feld and Mendelson, 2019).[1]

Despite its obvious relevance there is no clean empirical evidence on how asymmetric exposure to risk affects bargaining outcomes and how these are related to negotiators' risk preferences and fairness ideas. Using a series of controlled laboratory experiments we provide such evidence. Specifically, we document that the party exposed to risk can actually benefit from this exposure. We also show that under some circumstances residual claimants actively choose to bargain over a riskier distribution, thereby increasing their risk exposure. At first sight this may seem counterintuitive, since adding a mean-preserving risk, *while leaving the agreement otherwise unchanged*, cannot improve the residual claimant's welfare if she is risk averse. However, this neglects the fact that when risk increases, the agreement itself must also change. Indeed, there are theoretical arguments proposing that the asymmetric exposure to risk can alter the agreement in favour of the exposed agent to such an extent that it results in higher overall welfare for the exposed agent (White, 2008). We use her model, assuming constant relative risk aversion, to make benchmark predictions on which types can be expected to benefit from risk exposure.

In addition to the theoretical argument there are also behavioural factors that may have a significant influence on bargaining when there is asymmetric risk exposure. In particular, it could create competing ideas of what constitutes a fair allocation, as seems evident in the NFL and NHL labour negotiations examples. Players not exposed to risk (henceforth, fixed-payoff or FP players) might well view the 50-50 split of the expected pie as fair, whereas residual claimants may deem it fair that they are compensated for their risk exposure. Studies have shown that when there are competing fairness ideas in bargaining, agreements often fall between the two ideas (e.g., Gächter and Riedl, 2005; Bolton and Karagözoğlu, 2016; Karagözoğlu and Riedl, 2015). This suggests that residual claimants will receive some risk premium. However, whether the premium is sufficient to make risk exposure beneficial will depend on how much of the difference between these fairness ideas residual claimants can secure for themselves.

We conduct a series of lab experiments to address the issues discussed and obtain systematic empirical evidence on bargaining behaviour under asymmetric exposure to risk. Specifically, we ask the following questions. First, is the residual claimant able to extract a risk premium for her exposure to risk? Second, how is the risk premium related to the riskiness of the pie? Third, is the risk premium sufficiently large to make residual claimants better off when being exposed to risk? Fourth, what is the role of risk preferences and fairness ideas in bargaining with a residual claimant? Next to bargaining outcomes, we also investigate how the bargaining process is affected by asymmetric risk exposure.[2]

In our bargaining environment, subjects are matched into pairs and are assigned either the role of the residual claimant or the fixed-payoff player. In the main experiments, the pie-distribution is exogenously given and pairs negotiate over a payment to the fixed-payoff player. The residual claimant receives the difference between the realized pie and the agreed payment. Subjects negotiate ten times in randomly rematched pairs, experiencing five different pie-distributions, which are ranked according to second-order stochastic dominance.

Our main results are as follows. In answer to our first two questions: Residual claimants are able to extract a risk premium. On average, fixed-payoff players receive less than half of the expected pie and their payment is decreasing in the riskiness of the distribution. Additionally, being more risk averse worsens a subject's bargaining position, especially for fixed-

[1] Additionally, in procurement projects, asymmetric exposure to risk arises when two parties transact but only one is liable for any cost overruns, damages, defects or delays. For example, Lam et al. (2007) discusses asymmetric risk exposure in the construction industry and Texas Department of Transportation (2014, e.g., Items 8.6 & 9.4) highlights the risks faced by highway construction and repair contractors. Also in the political arena, both uncertainty and asymmetry with regard to risk exposure are prominently present in negotiations. Other important examples include negotiations on curbing greenhouse gas emissions and the foundation of the European Financial Stability Facility.

[2] Other experimental studies have investigated bargaining with one-sided private information on the pie size (see, e.g., Mitzkewitz and Nagel, 1993), an environment notably different from the one we are studying. Somewhat related to our research, Deck and Farmer (2007) study a Nash demand game between two risk neutral parties, with one being a residual claimant. Their focus on arbitration rules differs considerably from our research questions. For a recent survey of the laboratory and field experimental literature on bargaining, see Dickinson (2020).

	Ternary	Binary
Low Risk	(16,20,24	(16,24)
High Risk	(12,20,28)	(12,28)

Fig. 1. Summary of the Pie Distributions with Uncertainty.

payoff players.[3] In answer to the third question, we find that some residual claimants do benefit from bargaining over a risky pie. However, in partial answer to our fourth question, we find that the relatively less risk averse residual claimants benefit in expected utility terms from their exposure to risk, contrary to the predictions of the benchmark model. These results are complemented by an experiment run using an endogenous design in which residual claimants were able to choose, before bargaining commenced, whether the parties would bargain over a relatively less or relatively more risky pie-distribution. We find that residual claimants choose the riskier pie-distribution over 30% of the time. That is, they directly reveal a preference—presumably because they expect to benefit from it—for bargaining over a riskier pie-distribution. Consistent with our results in the exogenous design, we observe that less risk averse residual claimants are more likely to choose to bargain over a riskier pie-distribution when given the choice.

Our analysis of the bargaining process (opening and final offers, concessions and proposals during bargaining) shows that, when the pie is risky, fixed-payoff players (especially those who are relatively more risk averse) adopt a relatively weaker bargaining strategy. That is, they demand less, they make larger concessions as negotiations drag on and they are more likely to accept a standing offer than their residual claimant counterparts. As a result, these players earn a lower payoff to the advantage of (less risk averse) residual claimants. Rounding out our answer to the fourth question, we find that relative to a risk-free bargaining situation asymmetric exposure to risk increases the frequency of disagreements and decreases the prevalence of 50-50 splits. This result can be attributed to competing notions of what constitutes a fair bargaining outcome, which we show diverge across player roles, especially as risk increases.

2. Experimental design

Our experimental design consisted of three parts: (i) a bargaining component; (ii) a fairness elicitation; and (iii) a risk elicitation. We first explain in detail the bargaining component, which was the main part of the experiment.

We implemented a free-form tacit bargaining environment in which pairs of subjects have four minutes to exchange offers and reach an agreement, but have no other channel to communicate beyond their offers/demands. One agent is the residual claimant (RC); the other the fixed-payoff player (FP). At the time of bargaining, agents know the distribution of possible pie sizes but the actual pie size is unknown to them. The object of negotiation is the amount to be paid to the FP player. An agreement is reached if one player accepts the current proposal of the other player before the expiration of bargaining time. In case of agreement, the FP player receives the agreed upon fixed payment, while the residual claimant receives the realized value of the pie less the fixed payment. If the agents do not reach an agreement before bargaining time expires, then both receive zero.[4]

We chose an unstructured bargaining framework because it provides a natural environment in which players can express their bargaining strategy through the continuous back-and-forth nature of proposals and counter-proposals. The unstructured bargaining environment also provides a rich set of bargaining process data, which can be used to provide further insights into the nature of bargaining.

Subjects participated in 10 rounds of bargaining over a risky pie distribution. The distribution of the pie is exogenously varied from round to round. Five different pie-distributions were implemented using a within-subject design. As a benchmark, one distribution had no risk and subjects bargained over a pie size of €20 for sure. For the risky cases, four pie-distributions with a mean of €20 and mean-preserving spreads were used, varying the extremes of the possible outcomes (low risk versus high risk) and the number of possible outcomes (binary lottery versus ternary lottery). In each pie-distribution, every outcome was equally likely. This within-subject variation was chosen to obtain a direct comparison of how well the same residual claimant does under differing risk conditions.

Fig. 1 shows the four risky pie-distributions that were implemented. Fixing the number of possible outcomes (Ternary, Binary), the pie-distribution including the outcomes 12 and 28 is riskier than the one including 16 and 24. Fixing the extremes of the pie-distribution (Low Risk, High Risk), the binary distribution is riskier than the ternary distribution. Finally, it is easy to see that the (16,24) distribution second order stochastically dominates the (12,20,28) distribution. Thus, the ternary-high-risk condition is riskier than the binary-low-risk condition. A further difference between the binary and ternary pie-distributions is that the latter includes the 20 outcome. As a result, with the ternary pie-distributions, it is possible for both agents to earn ex-post the same payoff, should they agree to a 50-50 split of the expected value of the pie. In contrast,

[3] For previous experimental results on bargaining and risk preferences, see Murnighan et al. (1987, 1988) and the references cited therein. These experiments implemented binary and ternary lottery games where the surplus over which subjects are bargaining is in lottery tickets rather than experimental currency units; there is no residual claimant in these environments. Generally, these studies find an effect of risk aversion in the direction predicted by game-theoretic models of bargaining—risk aversion is disadvantageous in bargaining except in situations with agreements that are lotteries with an outcome that is worse than the disagreement outcome—although, they also find large focal point effects.

[4] See Section C of the Supplementary Materials for a complete set of instructions.

with the binary pie-distribution, the 50-50 split of the expected value of the pie necessarily leads to an ex-post unequal outcome. This difference may affect bargaining behaviour and outcomes if subjects have concerns for ex-post fairness (Saito, 2013; Cettolin et al., 2017). Subjects experienced each pie-distribution twice.

2.1. Experimental procedures

We refer to the presented environment for the bargaining component as the *exogenous* design. With this exogenous design, 240 subjects participated in ten sessions across two waves of experiments (two sessions involving 48 subjects were conducted in 2012; eight sessions involving 192 subjects were conducted in 2019, with slightly different procedures as noted below). Each session consisted of 24 subjects split into two matching groups of 12, which were run in parallel on separate z-Tree servers (Fischbacher, 2007), giving 20 matching groups for the exogenous design.[5]

2.1.1. The 2012 sessions with the exogenous design

In these sessions, the aforementioned three parts of the experiment took place in the following order: 10 bargaining rounds (B); incentivized risk elicitation (R); and *unincentivized* fairness elicitation (F). Before bargaining commenced, subjects were randomly assigned either the role of the RC or the FP player, and kept the same role throughout. At the beginning of a bargaining round, subjects were randomly matched within their matching groups into pairs (one RC and one FP) and were informed of the pie-distribution over which they would bargain. During the round, subjects had four minutes to reach an agreement, which was framed as a payment to the FP player.[6] Subjects were free to make as many offers as they wished during this time, and subsequent offers were not required to improve upon one's previous offer. An agreement was reached when one of the two accepted the standing offer of the other player, and subjects received feedback on the size of the pie, their own payoff and that of their match. In case of disagreement both bargaining parties earned nothing. No communication beyond sending and accepting offers was permitted.

During a session, the order of pie-distributions was the same for all subjects in a matching group. However, the order was varied across matching groups, except that in rounds 1 and 10 subjects always bargained over the risk-free pie of €20.[7] In all cases, in the first five rounds all subjects experienced each of the five pie-distributions exactly once. The order in rounds 6 to 9 was the same as in rounds 2 to 5.

Following bargaining, subjects participated in the risk elicitation task. Specifically, we elicited the certainty equivalent for six different binary lotteries using an implementation similar to Cettolin and Tausch (2015) (see also Bruhin et al., 2010).[8] For each subject, the elicited certainty equivalents were used to estimate the ρ parameter assuming a CRRA functional form: $u(x) = ({}^{1}/_{(1-\rho)})(x^{1-\rho} - 1)$.

Finally, our fairness elicitation collected information on subjects' fairness ideas for the different pie-distributions. Subjects were asked to give their judgement of a fair allocation to the FP player, for each of the five pie-distributions. Specifically, they were asked, "what would be, in your opinion, a 'fair' amount to give to the [fixed-payment player] from the vantage point of a **non-involved neutral arbitrator**". This non-incentivized fairness elicitation procedure has been successfully used before (e.g., Babcock et al., 1995; Gächter and Riedl, 2005). It was completed at the end of the experiment as part of a questionnaire that included questions on demographic and study programme characteristics.

2.1.2. The 2019 sessions

The eight sessions in 2019 were all with the exogenous design, where we made a few changes in response to comments from anonymous referees. First, in half the sessions the order was: 10 bargaining rounds (B), *incentivized* fairness elicitation (F) and *expanded* risk elicitation (R), while in the other half, the order was R, F and B.

Second, the risk elicitation was expanded to consist of two additional certainty equivalent elicitations (i.e., 8 in total). Moreover, the interface and instructions for the risk elicitation were slightly modified in order to make more clear the nature of the elicitation to minimize errors due to misunderstanding. In addition, we included five questions designed to identify the higher-order risk preference prudence, using a procedure similar to Noussair et al. (2014) but with the lotteries modified to have similar potential payoffs and risks as the standard risk elicitation. The purpose of the prudence elicitation data is to test whether a key necessary condition for the benchmark theoretical mechanism is met. This bar was easily passed: 90% of subjects made the prudent choice at least a majority of the time.

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5 During the 2012 wave of experiments, a further 192 subjects participated in 8 sessions run with an *endogenous* design, where residual claimants were given some choice over which pie-distribution to bargain over during the last five rounds. These were run as an alternative test of the welfare implications for residual claimants of bargaining with a riskier pie-distribution. Together with the exogenous design this makes 36 matching groups. For expositional ease, we defer discussing the endogenous design until Section 6.

6 Proposals were restricted to ensure that the residual claimant would never go bankrupt.

7 The four orders were: (16,24), (12,28), (16,20,24), (12,20,28); (12,28), (16,24), (12,20,28), (16,20,24); (16,20,24), (12,20,28), (16,24), (12,28); (12,20,28), (16,20,24), (12,28), (16,24). These systematically vary whether the binary lotteries or the ternary lotteries were shown first, and whether the low risk or high risk came first.

8 The six lotteries were: $(15, 1/2; 0, 1/2)$, $(14, 1/2; 6, 1/2)$, $(20, 2/5; 0, 3/5)$, $(18, 1/2; 2, 1/2)$, $(10, 3/4; 0, 1/4)$ and $(12, 2/3; 0, 1/3)$. Lotteries $(14, 1/2; 6, 1/2)$ and $(18, 1/2; 2, 1/2)$ were chosen to provide some gambles similar to those the RC faced in the bargaining task; these are simply the (16,24) and (12,28) pie-distributions minus an FP payment of 10. The other four lotteries were chosen to aid the estimation of CRRA coefficients. Instructions were given via the computer interface after the bargaining task had been completed.

Table 1
Details of the Experimental Sessions.

Year	Order	Sessions	Matching Groups	Subjects	Notes
2012	B, R, F	2	4	48	Fairness not incentivized
2019	B, F, R	4	8	96	Fairness incentivized; enhanced risk elicitation
2019	R, F, B	4	8	96	Fairness incentivized; enhanced risk elicitation
2012	B, R, F	8	16	192	Fairness not incentivized; endogenous design

Note: B stands for Bargaining; R stands for Risk Elicitation; and F stands for Fairness elicitation. The endogenous design is discussed in Section 6.

Third, the fairness elicitation was incentivized using the spectator method (Cappelen et al., 2013; Cettolin and Riedl, 2017). Specifically, for each of the five pie distributions, subjects were placed in the same role as during bargaining—i.e., either as an FP or RC player—and asked to make an allocation that could be implemented for *another* pair of subjects consisting of one FP and one RC player. To mitigate any possible spillover effects between the bargaining parts and the fairness elicitation, subjects were explicitly told that the allocation they would implement, if so determined, would be for a pair of subjects that they would never interact (and have never interacted) with in the other parts of the experiment. This was possible because each session was divided into two matching groups. Hence, the fairness allocations were "across matching groups", while the bargaining part occurred "within matching groups". To avoid any potential for anticipated reciprocity within the fairness elicitation, subjects who had their allocation implemented for two other subjects did not receive an allocation from another subject and vice-versa. Subjects who did not receive an allocation were given €3. Lastly, following these three parts, we also conducted exactly the same, unincentivized fairness elicitation as in the 2012 sessions at the end of the session as part of the final questionnaire. Table 1 summarizes the main aspects of the experimental sessions.

The experiments took place at the BEElab of Maastricht University, and all participants were students at Maastricht University recruited using ORSEE (Greiner, 2015). Sessions took approximately 90 (2012 sessions) or 120 (2019 sessions) minutes. In the 2012 sessions, subjects were paid a show-up fee of €2. They also received payment for one randomly selected bargaining round, and the risk-elicitation was similarly incentivized. In the 2019 sessions, no show-up fee was given, but subjects received payment for one randomly selected bargaining round and one randomly selected decision from the risk/prudence elicitation. Additionally, in the fairness elicitation, if subjects were selected to implement an allocation for others, then they would receive €3, while if they were selected to receive an allocation, then they would receive the allocation from a randomly selected other subject for a randomly chosen pie distribution. On average subjects earned €18.77.

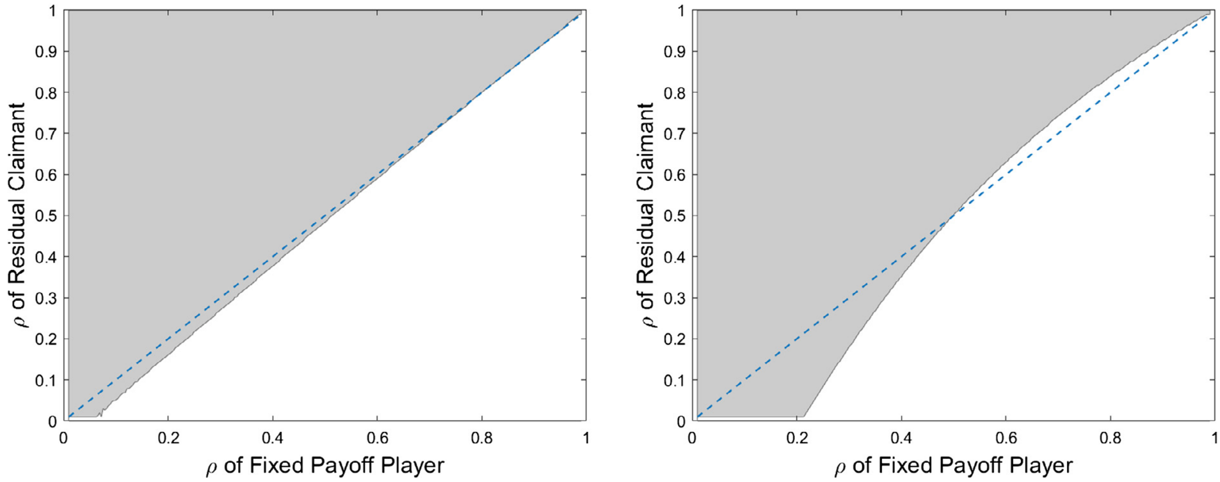
3. Theoretical background and hypotheses

The theoretical background is provided by White (2006, 2008). Assuming common knowledge of risk preferences, the author provides mild conditions under which the expected receipts of the residual claimant increase with her exposure to risk, and analyzes when this increase is large enough to result in higher welfare. The driving force behind her results is the effect of prudence in bargaining. In both alternating-offers bargaining (Rubinstein, 1982) and cooperative Nash bargaining (Nash, 1950), the curvature of an agent's utility function is a key determinant of the allocation an agent will receive. All else equal, a more risk averse agent values an additional dollar less than the previous dollar. Therefore, in the alternating-offers setting, she is less willing to hold out to make a more advantageous counteroffer. In the Nash bargaining solution, which maximizes the Nash product, as risk aversion increases, the share allocated to the agent decreases because the marginal impact on the Nash product of an additional dollar gets smaller.

To illustrate that exposure to risk could be beneficial for an agent, consider adding a mean-preserving spread to a risk averse agent's payment. Under the assumption of decreasing absolute risk aversion, marginal utility is a convex function. Consequently, holding the original agreement fixed, the expected marginal utility of the agent exposed to risk has increased relative to the risk-free case. Thus, the new agreement must shift away from the risk-free agreement in favour of the agent exposed to risk. Whether she ultimately benefits in utility terms from exposure to ex-post risk will also depend on the preferences of the fixed-payoff player since his marginal utility may increase as the agreement moves in favour of the residual claimant.[9]

Since we implement free-form bargaining in our experiments, we apply the Nash bargaining solution to provide a theoretical benchmark. In what follows, we give the specific predictions for the implemented environment with common knowledge of preferences. The Nash bargaining solution is found by maximizing the product of the expected utilities of the FP and RC players. In our setting, given that the amount to divide is a random variable, π, the solution is a payment to the FP player, y, that maximizes the Nash product: $u_{FP}(y) \cdot \mathbb{E}_{\pi}[u_{RC}(\pi - y)]$. For a fixed distribution, since disagreement represents the worst outcome, the solution will have the usual comparative statics with respect to the players' utility func-

[9] The intuition is reminiscent of a result from the precautionary savings literature. Kimball (1990) showed that, with additive risk, a decision maker exhibiting decreasing absolute risk aversion (DARA) will *increase* her savings when her future income becomes risky. That is, the introduction of risk effectively makes the decision maker more patient.



(a) $(16, 20, 24)$ **(b)** $(12, 28)$

Note: In the grey region RC players are predicted to do better in expected utility terms. The broken 45-degree line indicates the locus for which the RC and FP players have identical risk preferences. These figures are drawn under the assumption that players have, commonly known, CRRA utility functions. The parameter ρ represents the CRRA risk parameter, where $\rho = 0$ implies risk neutrality.

Fig. 2. Region of players' risk parameters over which exposure to risk is advantageous for RC players.

tions: for either player, greater concavity in their utility function will result in a lower share of the bargaining surplus (see, for example, Roth and Rothblum, 1982).

Fixing the preferences of the players, Proposition 6 of White (2006) states that a residual claimant's expected share of the pie will increase with the addition of a small additive risk, compared to the no risk case. That is, the fixed payment to the FP player will decrease as risk increases.[10] However, a decreasing payment to the FP player does not always imply increasing welfare for the RC player. Proposition 7 of White (2006) provides a necessary and sufficient condition for the RC's welfare to improve with a small additive risk, compared to the no risk case. Under CRRA risk preferences, this will be true whenever the residual claimant is *more* risk averse than the FP player.[11,12]

In our experiment, the risks the RC player is exposed to are not small and White's Proposition 7 will not hold exactly. Indeed, numerical calculations show that the residual claimant being more risk averse than the FP player is neither necessary nor sufficient for the RC's welfare to improve when exposed to the risks in our experiment. However, it is still a useful approximation as can be seen in Fig. 2. This figure plots in grey the region of risk preference parameter values over which RCs are predicted to do better in expected utility terms when moving from the riskless pie (€20) to one of the two risky pie distributions implemented in the experiment. Panel (a) depicts the region for the $(16, 20, 24)$ pie-distribution, which is the least risky of the uncertain pie-distributions, while panel (b) depicts the region for the $(12, 28)$ pie-distribution, which is the most risky. The 45 degree line indicates the locus for which the RC and FP players have identical risk preferences.

The above discussion leads us to the following set of hypotheses:[13]

Hypothesis 1 *(White, 2006, 2008).* The amount allocated to the fixed-payoff player declines as the riskiness of the pie-distribution increases.

Hypothesis 2 *(Roth and Rothblum, 1982).* Holding the pie-distribution constant, the amount allocated to the fixed-payoff player is decreasing in own risk aversion and increasing in the residual claimant's risk aversion. This holds for all pie-distributions, provided that the residual claimant is risk averse.

Hypothesis 3 *(White, 2006, 2008).* (A) Residual claimants can benefit in welfare terms from adding a mean-preserving risk to their receipts. (B) To a first approximation, whenever the residual claimant is **more** risk averse than the fixed-payoff player,

[10] This holds under a mild condition that is always satisfied under both constant relative risk aversion (CRRA) and constant absolute risk aversion (CARA).

[11] Simple calculations show that this condition can never be satisfied under CARA risk preferences. Holt and Laury (2002) find evidence for increasing relative risk aversion but decreasing absolute risk aversion. However, both Harrison and Rutström (2008) and Wilcox (2008) highlight that the finding of increasing relative risk aversion is highly dependent on the estimation procedure, and argue that constant relative risk aversion cannot be rejected.

[12] Identification of the result relies on subjects taking a narrow frame to the risks displayed in the experiment—that is, they display small-stakes risk aversion, which we capture by assuming CRRA utility over the payoffs from the experiment. Cox and Sadiraj (2006) argue that this small-stakes risk aversion need not generate absurd behaviour over larger stakes as in the Rabin (2000) critique. Indeed, a recent experiment by Harrison et al. (2017) finds evidence that one of the main premises underlying this critique did not hold for a large sample of undergraduate students.

[13] See Section B.1 of the Supplementary Materials for a graphical illustration of Hypotheses 1–3.

the residual claimant's welfare will be higher when faced with a risky pie-distribution than when faced with a riskless pie-distribution.

In addition to the above, the following hypothesis regarding disagreements is a direct consequence of the Pareto optimality axiom built into the Nash bargaining solution concept:

Hypothesis 4 *(Nash, 1950).* Across all pie-distributions, the frequency of agreements is 100%.

Our free-form bargaining environment allows us to not only analyze bargaining outcomes, but also the bargaining process. Although the theoretical benchmark model is silent about that aspect, we can use an idea of Zeuthen (1930) to shine some light on it. He suggested a behavioural model of the bargaining process based on his concession principle, which states that the next concession must come from the player with the least willingness to face the risk of a conflict. Harsanyi (1977) extended this idea and demonstrated its close connection to the Nash bargaining solution. The idea is that a player's willingness to face the risk of conflict is measured by their risk limit, which is defined as the ratio of their utility gain from getting their offer rather than the other's and their utility gain of getting their offer rather than disagreement. As shown in Harsanyi (1977), comparing players' risk limits for a given set of offers is equivalent to comparing the Nash product of the offers. Based on this argument the following benchmark hypothesis for the concession process can be formulated.

Hypothesis 5. Given open but incompatible offers from the FP and RC players, the player who has the lower risk limit will be the one who is more likely to make the next concession.

Of course, there may be factors at play not considered by the benchmark model. Most prominently, fairness-driven bargaining behaviour or private information of risk preferences could have a significant influence on bargaining, especially with the addition of asymmetric exposure to risk. We discuss how these might impact our benchmark hypotheses below.

3.1. Fairness-driven bargaining behaviour

We expect that asymmetric exposure to risk will create competing beliefs for what constitutes a fair allocation. For example, the fixed-payoff players may think that the 50-50 split of the expected pie is a fair allocation, whereas residual claimants may deem it fair that they are compensated for their exposure to risk and, thus, may feel entitled to more than half of the expected pie. Prior bargaining studies have shown that when there are competing fairness ideas, agreements often fall between allocations reflecting these ideas (see, e.g., Gächter and Riedl, 2005; Karagözoğlu and Riedl, 2015; Bolton and Karagözoğlu, 2016).

To provide more structure to how such fairness ideas might impact our benchmark hypotheses, we follow the approach taken in Bolton and Karagözoğlu (2016), who consider a social preference modification of the Nash bargaining solution (NBS) in an environment with two competing fairness ideas, with one advantageous to player 1 and the other advantageous to player 2. The main idea is that, to avoid disagreement a player could always concede to the fairness idea that is advantageous to the other player. The result is a *fairness-adjusted* NBS, where each player's disagreement utility is given by the amount they would receive under the other player's perceived fair allocation. In our setting, it is natural to think that there are two prevalent self-serving fairness ideas (e.g., Babcock et al., 1995): The FP player may try to argue that the players should ignore risk and just divide the expected pie evenly, whereas the RC player may argue that some compensation for risk is fair.

Without risk it is reasonable to expect the fairness ideas to be symmetric and split the surplus 50-50. In which case, the fairness-adjusted NBS would predict a prevalence of 50-50 splits irrespective of each players' risk preferences, since there is no surplus over which to negotiate beyond satisfying each other's fairness-driven bargaining positions. With the introduction of ex-post risk, the perceived fair payment to the FP player from the perspective of the residual claimant is likely to be decreasing in the riskiness of the pie-distribution to compensate risk averse residual claimants for being exposed to the risk (i.e. the residual claimant should get more compensation for risk when there is greater risk).[14] This divergence in self-serving fairness ideas opens a new channel through which exposure to risk affects bargaining outcomes, over and above the prudence mechanism identified in White (2008). Furthermore, the fixed payoff players find themselves in a more difficult bargaining position as their associated fairness idea does not change with ex-post risk, while that of the residual claimants is moving in a way that can only reduce the FP player's likely payment. Now it is the less risk averse residual claimants that are likely to benefit from the introduction of risk, since the less risk averse they are the more they can pull

[14] Unlike Bolton and Karagözoğlu (2016), where the competing fairness ideas are clear, there is more ambiguity about the fairness idea for the residual claimant in our setting. For our purposes, we only need: (i) that both parties perceive a 50-50 split of the surplus as fair in the absence of risk in the pie-distribution; and, (ii) that the perceived fair payment to the FP player from the perspective of the residual claimant is decreasing in the riskiness of the pie-distribution, while a 50-50 split of the expected surplus remains the perceived fair outcome for fixed payoff players. For simplicity, we do not consider fairness ideas that are specific to the risk attitude of the residual claimant.

the agreement towards their own fairness idea, extracting a greater proportion of the surplus that remains between the two fairness-adjusted disagreement points.[15]

These arguments suggest that the residual claimant will generally receive a premium for their exposure to risk, and that being more risk averse is, other things being equal, a disadvantage in bargaining, at least in the cases with risky pie-distributions. Consequently, the introduction of fairness-driven bargaining behaviour does not alter Hypotheses 1 and 2. Furthermore, the opening up of a wedge between the self-serving fairness ideas for residual claimants and fixed payoff players, along with the prudence mechanism, also leads to the prediction that residual claimants can benefit in welfare terms from their exposure as in Hypothesis 3(A). However, the likely effect of risk preferences is the opposite of the one stated in Hypothesis 3(B). We, therefore, formulate the following alternative hypothesis.

Hypothesis 3 *(B ALT).* The less risk averse RC players are more likely to benefit in welfare terms when faced with a risky pie-distribution compared with a risk-less pie-distribution.

It is an axiom for the Nash bargaining solution that agents would always reach a Pareto-improving agreement. However, in real bargaining disagreements are frequently observed. Recent literature suggests that under risk there may be a conflict between ex-ante and ex-post fair outcomes (Fudenberg and Levine, 2012; Brock et al., 2013; Cettolin and Riedl, 2017), which may generate disagreements even if agents would otherwise agree in situations without risk. Birkeland and Tungodden (2014) propose a theoretical model which explicitly incorporates conflicting fairness ideas in a bargaining model. They show that disagreement may arise when players' fairness ideas diverge too much. In our case, such divergence is likely because each player type can easily adopt a self-serving fairness idea. Moreover, as the RC's desired compensation for bearing risk is predicted to increase with the riskiness of the pie-distribution, so may the tension between self-servingly biased fairness ideas. The fairness-adjusted model of Bolton and Karagözoğlu (2016) includes a small probability of a player being non-compromising; that is, they would rather disagree than accept an allocation that gives them less than *their own* perceived fair allocation. In their model, in the risk-free case, no disagreement is predicted irrespective of player types because fairness ideas (i.e., equal-split) are compatible. However, divergent fairness ideas and the possibility that two non-compromisers meet implies that bargaining with a risky pie-distribution could result in disagreement.[16] Together, these theoretical arguments suggest the following alternative hypothesis regarding the frequency of agreements:

Hypothesis 4 *(ALT).* Disagreements are more likely to occur for risky pie-distributions than for the risk-less one. The frequency of disagreements increases with the riskiness of the pie-distributions.

Regarding concession behaviour, Bolton and Karagözoğlu (2016) established a bargaining process analogous to the Harsanyi-Zeuthen process introduced above and established an equivalence result for their fairness-adjusted Nash bargaining solution. Using their arguments, we can formulate the following alternative hypotheses concerning concession behaviour, when fairness ideas play a role in bargaining.[17]

Hypothesis 5 *(ALT).* When bargaining over risky pie-distributions, given incompatible open offers from the FP and RC players, which lie between their fairness ideas, the player who has the lower fairness-adjusted risk limit will be one who is more likely to make the next concession.

3.2. Incomplete information

In both the benchmark model and the fairness-adjusted behavioural alternative, players are assumed to have common knowledge of all the important parameters of the environment. This implies that bargaining parties should know each other's preferences and, for the behavioural alternative, additionally, each other's fairness ideas.

Extensions of the cooperative Nash bargaining solution concept to the case of incomplete information typically involve parties negotiating over more complex objects than offers and counter-offers. Since offers over divisions of the surplus can reveal valuable private information, in such extensions, parties bargain over whole mechanisms, which are then implemented once an agreement has been reached (see Myerson, 1991, chapter 10). It is beyond the scope of this paper to provide a formal treatment of the incomplete information case. However, Section B.4 of the Supplementary Materials provides a numerical analysis of several possible specifications for the extension of the Nash bargaining solution suggested by Myerson (1979).

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[15] See Section B.2 of the Supplementary Materials for explicit details of the fairness-adjusted NBS set-up and predictions. In particular, Figure B.3 provides an analogy to Fig. 2, showing the region of players' risk parameters over which risk is advantageous for residual claimants.

[16] Non-compromisers are included in Bolton and Karagözoğlu (2016) to make the fairness ideas credible. The simple formulation of a fixed probability of players being a compromiser or non-compromiser means that the probability of disagreement is the same irrespective of the degree of divergence in fairness-ideas. The authors consider using the probability of meeting a non-compromiser as a way of modelling the credibility of a fairness-idea, something that would be needed to generate the prediction of increasing disagreement rates when the risky pie-distribution gets riskier or when comparing between two risky pie-distributions.

[17] See Section B.3 of the Supplementary Materials for details.

Table 2
Bargaining Outcomes and Fairness Ideas in the Exogenous Design.

Distribution of Pie	Final FP Earnings (€)		Agreed FP Payments (€)		Disagreements (%)		Remaining Time (sec)		Fairness Ideas (€ to FP)			
									FP		RC	
(20)	9.67	(2.06)	10.05	(0.79)	3.8	(19)	169	(82)	10.34	(1.44)	9.89	(1.86)
(16, 20, 24)	8.86	(3.16)	9.76	(1.50)	9.2	(29)	87	(88)	10.62	(1.72)	9.57	(1.11)
(16, 24)	8.87	(3.02)	9.64	(1.59)	7.9	(27)	75	(82)	10.58	(1.52)	9.47	(1.44)
(12, 20, 28)	8.24	(3.20)	9.29	(1.36)	11.3	(32)	61	(79)	10.05	(1.28)	8.47	(1.83)
(12, 28)	8.04	(3.02)	8.86	(1.69)	9.2	(29)	71	(87)	9.79	(1.33)	8.18	(1.64)

Notes: Standard deviations are reported in parentheses. 'Final FP Earnings' averages include the disagreement payment of zero when players fail to reach an agreement; 'Agreed FP Payments' averages do not. 'Remaining time' is the average time left when an agreement was reached (and as such is conditional on an agreement). The columns 'Fairness Ideas (€ to FP)' report the judgements of a fair allocation to the FP player. The first of these is the average allocation reported by those assigned the FP role; the second, the average reported by those assigned the RC role.

This analysis finds that residual claimants can benefit from their exposure to risk, in line with Hypothesis 3(A). However, whether more or less risk averse residual claimants are most likely to benefit from ex-post risk depends on the details of the type-space. Our numerical analysis suggests that it is more likely to be the *less* risk averse type who benefits, as long as risk aversion is not too pronounced for the least risk averse type. Finally, when risk preferences are private information, disagreement may occur as part of the solution. Interestingly, the numerical analysis shows that the frequency of disagreement may actually *decrease* when the riskiness of the pie-distribution increases.

3.3. Overall summary

All of the models discussed generally agree that FP players earnings should decrease as risk increases. Moreover, there is also agreement that *some* residual claimants may actually benefit in welfare terms from bargaining over a risky pie-distribution (relative to the risk-free case). However, there is less agreement on *which* residual claimants can be expected to benefit from risk exposure. In the results section we will, among other things, test those predictions about which the models agree and report insights about actual behaviour where the models disagree.

4. Results

We begin our analysis by focusing on outcomes to understand how asymmetric exposure to risk affects bargaining outcomes in the residual claimant environment (Hypotheses 1 and 2). We then address the questions of whether there is any evidence that residual claimants might benefit, or expect to benefit, in welfare terms from their exposure to risk, and if so which risk preference types of residual claimant benefit (Hypothesis 3). Throughout, statistical significance is established using a regression-based approach (two-sided test of the relevant regression coefficient) with cluster-robust standard errors that allow for arbitrary correlation between observations within a matching group. Non-parametric tests on matching-group averages were run as a robustness check.[18]

4.1. Bargaining outcomes in the exogenous design

Table 2 presents a summary of the bargaining outcomes. As can be seen from the second column, the FP players' final earnings are, on average, less than half of the expected pie for each pie-distribution (ordered from risk-free to riskiest in the table; $p = 0.011$ for the risk free pie-distribution, and $p < 0.001$ for each of the risky pie-distributions). This average, however, includes the disagreement payment of zero when the players fail to reach an agreement. Focusing on agreements, which is the primary concern of the benchmark model, in all risky pie-distributions the average agreed FP payment is less than half the equal split of the expected value ($p = 0.019$, $p = 0.003$, $p < 0.001$ and $p < 0.001$, in order of increasing risk), and decreasing in the riskiness of the pie-distribution (see third column).[19]

Disagreement rates range from 3.8% to 11.3% and are somewhat lower than in other studies using free-form bargaining—see, e.g., Roth et al. (1988) and Gächter and Riedl (2005) who report disagreement rates of approximately 23% and 16%, respectively. As can be seen, there is a stark difference in bargaining duration between riskless and risky pie distributions, but for the latter the average time remaining does not appear to be sensitive to the amount of risk. Fairness ideas, shown in the last two columns, diverge as the riskiness of the pie-distribution increases. FP players generally view at least the 50-50

[18] These robustness checks are reported in Appendix A (Tables A.2 and A.3). There are no substantive differences between the two sets of tests. Appendix A.1 also contains tests for differences in risk preferences (noted in the text), key outcome variables and fairness ideas between the different session types (broken down by pie-distribution in Table A.1). There are only minor differences in measured risk and fairness preferences between 2012 and 2019, and behaviour is also not noticeably affected by the order in which tasks were conducted in the different sessions.

[19] Agreements in the risk-free pie-distribution do not differ significantly from 10 ($p = 0.324$). In Appendix A, the top two panels of Tables A.2 and A.3 show that most of these pairwise comparisons are statistically significant for final FP earnings and agreed FP payments (17 out of 20). The latter result is also shown in the regression analysis reported in Table 3.

Table 3
Linear Random-Effects Regression of Agreed Payments to the FP Player.

	Agreed FP Payments							
	(1)		(2)		(3)		(4)	
$\mathbf{1}[(16, 20, 24)]$	−0.28**	(0.110)						
$\mathbf{1}[(16, 24)]$	−0.39***	(0.112)						
$\mathbf{1}[(12, 20, 28)]$	−0.71***	(0.153)						
$\mathbf{1}[(12, 28)]$	−1.14***	(0.152)						
Variance			−1.06***	(0.142)	−1.06***	(0.143)	−1.00***	(0.188)
ρ_{FP}					−0.71***	(0.275)	−0.71***	(0.275)
ρ_{RC}					0.31	(0.214)	0.41*	(0.234)
$\rho_{RC}\times$ Var.							−0.24	(0.314)
Constant	10.02***	(0.047)	9.96***	(0.052)	10.03***	(0.095)	10.00***	(0.097)
R^2	0.07		0.07		0.09		0.09	
Observations	1002		1002		1002		1002	

Note: Data include only observations for which $|\rho_i| < 1$ for both RC and FP players. ***1%, **5%, *10% significance using standard errors clustered at the matching group level.

division as fair, while many residual claimants report a fair allocation that compensates them for their risk.[20] Note that, for all pie-distributions with risk, average agreed payments are between the (self-serving) fairness perceptions of the RC and the FP players. Looking at individual bargaining pairs, we see that for 68.1% of all agreements, the agreed payment to the FP player lies between the fairness perceptions of the two players. This is significantly different from 50% at $p < 0.001$ according to a two-sided sign-rank test on matching group averages and the 95% confidence interval is (65.2%, 72.0%).

The regression results reported in Table 3 investigate Hypotheses 1 and 2 directly. The dependent variable in these random-effects regressions is the agreed payment to the FP player (that is, payments conditional on agreements). The indicator variables $\mathbf{1}[(\cdot)]$ take value 1 for the indicated pie-distribution and 0 otherwise. The risk-free pie-distribution is the reference category. The first specification confirms that, in comparison to the risk-free pie-distribution, risky pie-distributions significantly reduce the agreed payment to FP players for all risky pie-distributions. The second specification uses the variance of the risky pie-distributions, normalized so that the variance of the riskiest pie-distribution is one, as a single measure of riskiness and shows that this also captures the effect of this treatment variation. This supports Hypothesis 1.

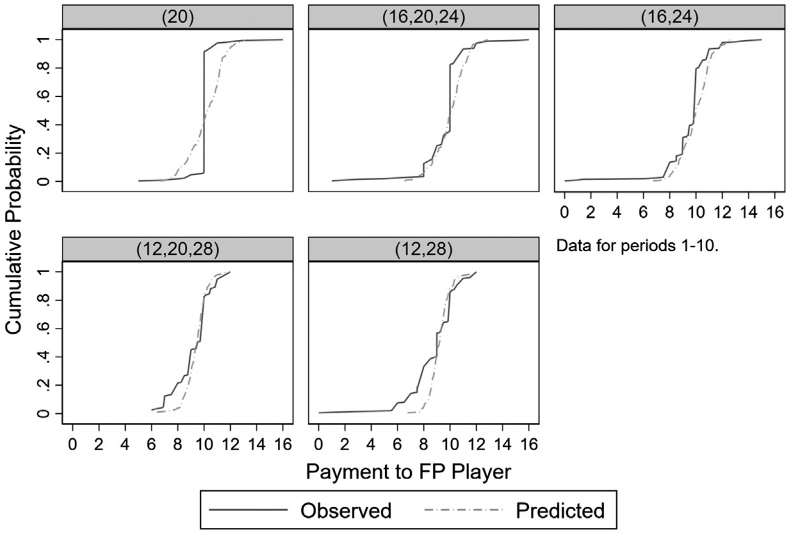
Building upon specification (2), the last two columns include estimates of the risk aversion parameter of the FP (ρ_{FP}) and RC (ρ_{RC}) players as explanatory variables. These specifications test Hypothesis 2. The coefficient on ρ_{FP} is significantly negative, while for ρ_{RC} it is positive but not significant. That is, fixing the pie-distribution, being more risk averse does not improve RC players' bargaining position, while strictly worsening it for FP players. The role of risk aversion is clearly muted for RC players, having a marginally significant effect only after controlling for the interaction between ρ_{RC} and risk in specification (4)—i.e., only after controlling for the moderating role risk has for the RC player. Overall, risk preferences affect the agreed FP payment in the direction predicted by the benchmark model; while for fixed risk preferences of the FP and RC, increasing the risk of the pie-distribution improves the bargaining position of the latter.[21]

While the regressions reported in Table 3 show that agreed payments vary with risk preferences largely in line with Hypothesis 2, a stronger test would be to examine the relationship between the agreed payment predicted by the Nash bargaining solution, given the elicited risk preferences of the bargaining pair. Fig. 3(a) plots the cumulative distribution of agreed and predicted payments. This figure provides a number of insights. First, when there is no risk (panel (20)), nearly all agreements are a 50-50 division of the pie. That is, differences in preferences lose salience and the fairness idea of equal division dominates. This is consistent with the Bolton and Karagözoğlu (2016) model. Second, for the risky pie-distributions, there is a correspondence between the observed and predicted division of payoffs. However, agreed FP payments are, on average, smaller than predicted by the theoretical model, as can be seen in Fig. 3(b). This table reports the results of a linear-random effects regression where the dependent variable is the agreed FP Payment and as explanatory variables we include the predicted Nash bargaining solution (NBS), indicator variables for the risky pie-distributions, and their interaction. The positive coefficients on the NBS interactions show that the NBS does have some predictive power for the agreements, while the negative coefficients on the indicators show that, when there is risk, FP players receive, uniformly, less. We summarize the above discussion in the following result.

Primary Result 1 *(Bargaining Outcomes).* (A) Asymmetric exposure to risk decreases average agreed payments to the fixed-payoff player as the pie-distribution becomes more risky. (B) Fairness ideas are associated with bargaining outcomes: with

[20] The fairness assessments of the RC players are below those of the FP players when there is risk, as a regression-based test with standard errors clustered at the matching-group level shows. Going in order of increasing riskiness, the p-values are 0.041, < 0.001, < 0.001, < 0.001 and < 0.001, respectively.

[21] For convenience, here we keep the focus on the riskiness of the pie distribution and risk preferences. In subsequent analysis, we will consider the role of fairness and other factors.



(a) Comparing Predicted vs Empirical CDF

$\mathbf{1}[(16,20,24)]$	−2.39**	(1.064)
$\mathbf{1}[(16,24)]$	−2.37**	(0.989)
$\mathbf{1}[(12,20,28)]$	−2.02*	(1.170)
$\mathbf{1}[(12,28)]$	−4.12***	(1.223)
Nash Bargaining Solution (NBS)	0.05	(0.063)
$\mathbf{1}[(16,20,24)]\times$ NBS	0.21*	(0.108)
$\mathbf{1}[(16,24)]\times$ NBS	0.20**	(0.094)
$\mathbf{1}[(12,20,28)]\times$ NBS	0.14	(0.123)
$\mathbf{1}[(12,28)]\times$ NBS	0.33**	(0.132)
Constant	9.49***	(0.625)
R^2	0.10	
Observations	2004	

(b) Linear Random-Effects Regression of Agreed FP Payment on Predicted NBS Payment

Note: Data include only observations for which $|\rho_i| < 1$ for both RC and FP players. ***1%, **5%, *10% significance using standard errors clustered at the matching group level.

Fig. 3. Observed Versus Predicted Agreed Payments to the FP Player.

no pie-distribution risk the equal split of the pie is both the predominant agreement and fairness idea, while agreements lie between the two players' fairness ideas when the pie-distributions are risky.

4.2. Residual claimant welfare

Hypothesis 3 concerns the question of whether the welfare of a residual claimant could be increased by bargaining over a risky pie-distribution rather than a risk-free pie distribution. That is, is the observed reduction in FP payments when bargaining over a risky pie-distribution sufficient to compensate RC players for the disutility of bearing risk? In Table 4 we consider two different approaches to answer this question. The first is more indirect but uses the full sample of agreements, while the second is more direct but only uses a subset of the data—in particular, those instances in which the same two subjects (one FP player and one RC player) bargained in two periods, once when the pie-distribution was riskless and once when it was risky. In both cases, we take the agreed FP payment and calculate the certainty equivalent of the RC player using the RC player's estimated risk parameter.

Column (1) of Table 4(a) reports the results of the former, more indirect, analysis. If Hypothesis 3(B) were correct—so that residual claimants benefit from exposure to risk when they are more risk averse than the FP player—then the coefficient $\mathbf{1}[\text{Var} > 0] \times \mathbf{1}[\rho_{RC} > \rho_{FP}]$ should be positive, as should the sum of this coefficient and the coefficients for $\mathbf{1}[\text{Var.} > 0]$ and $\mathbf{1}[\rho_{RC} > \rho_{FP}]$. As can be seen from the table, neither of these are true. Therefore, while we find evidence of residual claimants benefiting in welfare terms from their exposure to risk in line with part (A) of Hypothesis 3, it is actually those residual claimants who are *less* risk averse than their fixed-payoff counterparts who are the ones benefiting, contrary to part (B) of the hypothesis. Indeed column (2) of Table 4(a)—which replaces the indicator variable for the RC player being more risk averse than the FP player with an indicator for whether the RC player has an estimated ρ_{RC} greater than the median estimated risk parameter in our sample—suggests that it is the less risk averse RC players more generally that benefit, in line with our behavioural alternative, Hypothesis 3(B ALT).

Table 4
An Analysis of Certainty Equivalents.

(a) Linear Random-Effects Regression of the Certainty Equivalent of Agreements for RC Players

	(1)		(2)	
Constant	9.81***	(0.067)	10.01***	(0.046)
$\mathbf{1}[\text{Var.} > 0]$	0.80***	(0.144)	0.64***	(0.129)
$\mathbf{1}[\rho_{RC} > \rho_{FP}]$	0.28**	(0.128)		
$\mathbf{1}[\rho_{RC} > \rho_{RC}^{median}]$			−0.06	(0.121)
$\mathbf{1}[\text{Var.} > 0] \times \mathbf{1}[\rho_{RC} > \rho_{FP}]$	−1.12***	(0.185)		
$\mathbf{1}[\text{Var.} > 0] \times \mathbf{1}[\rho_{RC} > \rho_{RC}^{median}]$			−1.00***	(0.188)
R^2	0.08		0.08	
Observations	1002		1002	

(b) An Analysis of Matched-Pair Outcomes: Higher vs. Lower Risk

	(1)		(2)	
$\mathbf{1}[CE_{hr}^p - CE_{lr}^p > 0]$	0.15	(0.380)		
$CE_{hr}^p - CE_{lr}^p$			−1.13	(0.832)
ρ_{FP}	1.44**	(0.649)	0.65*	(0.369)
ρ_{RC}	−2.30***	(0.588)	−1.18***	(0.205)
$\rho_{FP} \times \rho_{RC}$	−1.96	(1.728)	−1.60**	(0.795)
Constant	0.14	(0.334)	0.37***	(0.076)
Log-Like/R^2	-357.17		0.073	
Observations	596		596	
Dependent Variable	RC Benefits in Riskier; i.e., $\mathbf{1}[CE_{hr}^a - CE_{lr}^a > 0]$		$CE_{hr}^a - CE_{lr}^a$	

Note 1. In both panels, data includes only observations for which $|\rho_i| < 1$ for both RC and FP players. ***1%, **5%, *10% significance using standard errors clustered at the matching group level. Note 2. Panel (a) linear random-effects regression; panel (b) random effects models; (1) estimates logit model, (2) linear model. Note 3. $\rho_{RC}^{median} = 0.305$ is the median value of elicited risk coefficients for the residual claimants. Note 4. In Panel (b), CE_y^x, where $x \in \{a, p\}$ and $y \in \{lr, hr\}$, stands for the predicted (p) or actual (a) certainty equivalent for the lower risk (lr) or higher risk (hr) pie-distribution.

Panel (b) focuses on the subset of the data in which the same pairs of FP and RC players bargained once with a relatively less risky (lr) pie-distribution and once with a relatively more risky (hr) pie-distribution. The first panel considers a random-effects logistic regression where the dependent variable takes value 1 if the residual claimant had a higher certainty equivalent under the relatively riskier distribution (i.e., $CE_{hr}^a - CE_{lr}^a > 0$). The explanatory variables include an indicator for the predicted difference being positive (i.e., $CE_{hr}^a - CE_{lr}^a > 0$), as well as our measures of risk preferences for both player types. Observe that if the subjects behave as in the theoretical model, then only the indicator variable should matter. However, as can be seen, this variable is small in magnitude and not significant. Instead, consistent with our earlier results, risk preferences matter. The residual claimant is significantly more likely to benefit when bargaining over the riskier distribution the *more* risk averse is the FP player and the *less* risk averse she, herself, is. The second column takes a linear regression and uses the actual and predicted differences in certainty equivalents as the dependent and explanatory variables, respectively. The results are comparable. The predicted difference in certainty equivalents has no explanatory power, while risk preferences do matter and in the direction suggested by the alternative behavioural Hypothesis 3(B ALT). We summarize the above discussion in our next result.

Primary Result 2 *(*Residual Claimant Welfare*).* (A) Residual claimants can benefit in welfare terms from their exposure to risk. (B) It is the relatively less risk averse residual claimants that are likely to be the ones to benefit from risk exposure.

4.3. Bargaining frictions

The disagreements and time remaining columns of Table 2 show that the presence of risk also increases bargaining frictions. Contrary to the benchmark model (Hypothesis 4), but consistent with the behavioural alternative (Hypothesis 4(ALT)), disagreements are significantly more frequent when bargaining over a risky pie-distribution than when bargaining over a riskless pie-distribution (regression-based test; $p < 0.001$). Furthermore, when an agreement is reached, it occurs with significantly less time remaining until the deadline when the pie-distribution is risky than when it is not (regression-based test; $p < 0.001$).[22]

[22] For the associated pairwise comparisons, see Table A.2 in Appendix A. See Section E.1 of the supplementary materials for details.

Table 5
Opening and Final Offers to FP Players by Player Type.

Distribution of Pie	Opening Offers		Final Offers		Fairness Ideas (€ to FP)	
	FP	RC	FP	RC	FP	RC
(20)	12.03	8.43	10.80	9.36	10.34	9.89
(16,20,24)	12.76	7.41	10.58	9.11	10.62	9.57
(16,24)	12.37	7.39	10.55	8.93	10.58	9.47
(12,20,28)	11.09	6.55	9.85	8.29	10.05	8.47
(12,28)	10.88	6.28	9.45	7.79	9.79	8.18

Notes: The lightly (darkly) shaded cells are significantly different from offers for the (20) pie-distribution at the 1% (5%) level. Comparing both opening and final offers between FP and RC player, the differences are always statistically significant at the 1% level. For all tests we use Wilcoxon signed rank tests using the matching group average (for the particular type or pie-distribution) as the unit of independent observation. We have 20 matching groups overall.

Additional Result 1 *(Bargaining Frictions).* Disagreements are significantly more frequent and bargaining duration is longer when the pie-distribution is risky than when it is not.

5. Bargaining process

Thus far the analysis has focused on bargaining outcomes, for which the benchmark and alternative models make predictions. We now explore other aspects of the bargaining process data on which these models are mostly silent. The overall picture that emerges from this analysis is that the presence of risk creates a wedge between the fairness ideas of both parties, leading to different bargaining postures by the FP and RC players, as well as greater conflict. Furthermore, risk attitudes play an important role, particularly for FP players, with relatively more risk averse FP players adopting weaker bargaining strategies.

5.1. First and final offers

Table 5 examines the opening offers, final offers (offers outstanding either at the time of agreement or the expiry of bargaining time) and the fairness ideas of both player types for each pie-distribution. Unsurprisingly, opening offers of the RC players are always significantly lower than those of the FP player (Wilcoxon signed-rank tests; $p < 0.01$). Consistent with Bolton and Karagözoğlu (2016), opening offers are more extreme than subjects' reported fairness ideas. In their opening offers, RC players always demand a risk premium whenever they are exposed to risk, and this premium is increasing in pie-distribution risk. While FP players tend to demand less as risk increases, their opening offers are consistently above half the expected pie size.

The two middle columns of Table 5 show a similar pattern for final offers. Both the RC and FP players concede ground from their opening positions. While the final offer of RCs is still significantly lower than that of the FP players, the average difference is now only €1.56, as compared to €4.66 for opening offers. Relative to the certain pie-distribution, RC players still demand a risk premium for all the risky pie-distributions, and it is statistically significant for all but the least risky (non-degenerate) pie-distribution. The FP players concede a statistically significant risk premium to the RC player for the two riskiest pie-distributions, while for the others they still demand more than half the pie, on average. We also see that for all risky pie-distributions, the final offers of FP players are approximately equal to or even below their fairness idea, which means that, on average, they tend to concede even more than they think is fair. In contrast, for RC players, their final proposals are less than their fairness idea, which means that their last offer is unfair in a way that benefits them.

Table 6 reports the results of a more detailed regression analysis of offers. The first two columns show that opening offers are, surprisingly, not significantly influenced by agents' risk preferences. However, we do see that fairness ideas significantly (positively) affect first offers for both FP and RC players.[23] The third and fourth columns show that fairness ideas also affect the payment, conditional on an agreement, to the FP player, as well as the likelihood of disagreement. Specifically, RC players who think FP players deserve more make agreements which, in fact, give more to the FP player, while FP players who think that they deserve more are more likely to see bargaining end in disagreement. The fact that risk preferences do not affect the likelihood of impasse whereas (at least the FP player's) fairness ideas do affect the likelihood of impasse resonates with results from other studies. For example, Dickinson (2009) observes that overly optimistic beliefs about potential outcomes can be more important determinants of bargaining outcomes than the bargainers' risk preferences, and we note that a similar effect may also hold for fairness ideas. In that respect, it is important to note that risk preferences and fairness ideas are uncorrelated ($p = 0.349$ when regressing fairness ideas on risk preferences while controlling for the riskiness of the pie distribution and player type).

[23] The same regressions as for opening offers, but for final offers, show fairness ideas matter throughout the bargaining process. For FP players, the coefficient is 0.11 ($p < 0.01$), while for RC players, the coefficient is 0.15 ($p = 0.015$).

Table 6
Linear Random-Effects Regressions of the Role of Risk Preferences and Offers.

	Opening Offer				Agreed FP Payments		Disagreements	
	FP		RC					
$\mathbf{1}[(16,20,24)]$	0.75***	(0.242)	−0.90***	(0.269)	−0.25*	(0.142)	0.03	(0.031)
$\mathbf{1}[(16,24)]$	0.46	(0.287)	−1.00***	(0.222)	−0.38**	(0.158)	0.01	(0.030)
$\mathbf{1}[(12,20,28)]$	−0.86***	(0.221)	−1.50***	(0.243)	−0.38**	(0.166)	0.05*	(0.028)
$\mathbf{1}[(12,28)]$	−1.02***	(0.273)	−1.68***	(0.228)	−0.73***	(0.202)	0.02	(0.025)
ρ_{FP}	−0.26	(0.470)			−0.42**	(0.205)	−0.01	(0.042)
ρ_{RC}			0.07	(0.472)	0.48**	(0.190)	−0.02	(0.038)
Fairness Idea (FP)	0.16*	(0.087)			0.01	(0.038)	0.02***	(0.007)
Fairness Idea (RC)			0.23***	(0.059)	0.12**	(0.060)	−0.01	(0.008)
Opening offer FP					0.09***	(0.031)	0.01	(0.005)
Opening offer RC					0.12***	(0.039)	−0.01	(0.006)
(Time 1st offer FP)/100					1.02***	(0.236)	0.13**	(0.062)
(Time 1st offer RC)/100					−0.11	(0.191)	0.02	(0.055)
Δ(Time 1st − 2nd offer FP)/100					0.38**	(0.168)	0.09	(0.057)
Δ(Time 1st − 2nd offer RC)/100					−0.22	(0.178)	−0.03	(0.041)
Constant	10.38***	(0.897)	6.07***	(0.529)	6.52***	(0.790)	−0.13	(0.093)
R^2	0.14		0.14		0.20		0.04	
Observations	1034		1003		1440		1608	

Notes: Data includes only observations for which $|\rho_i| < 1$ for both RC and FP players. ***1%, **5%, *10% significance using standard errors clustered at the matching group level.

The third column of the table also shows that opening offers are not cheap talk. Specifically, consistent with Galinsky and Mussweiler (2001), Bolton and Karagözoğlu (2016) and others, we see that final agreements are *anchored* on the opening offers of both players. There is a significantly positive relationship between the opening offer of both the FP and RC players and the agreed payment to the FP player. Therefore, an FP player who initially demands more, or an RC player who initially offers less, are likely to end up with a more favourable outcome, assuming an agreement can be reached. Although risk preferences do not seem to affect opening offers (first and second columns), consistent with Primary Result 1, they do affect final outcomes (third column) in a manner consistent with the benchmark model: holding the pie-distribution constant, increased risk aversion weakens one's bargaining position.

Finally, the third and fourth columns of Table 6 also control for the time at which players made their first offer and the amount of time that they waited between making their first and second offer. These two variables are meant to capture aspects of a player's bargaining posture. For example, someone who makes an opening offer but then never amends it may be trying to "stick to his guns". The results show that the FP player can earn more by delaying making a first offer and also by delaying making his/her first concession (third column); however, the strategy is risky as delaying making an offer also significantly increases the chance of disagreement (fourth column).

Primary Result 3 *(*Initial and Final Offers*).* (A) Fairness ideas are positively associated with opening and final offers. (B) Players adopt adversarial initial positions relative to these fairness ideas but the bargaining process brings final offers closer to the fairness ideas. (C) For the riskiest pie-distributions, average final offers acknowledge that the RC player should be compensated for exposure to risk.

Additional Result 2 *(*Risk Attitudes Influence Bargaining*).* Whereas opening offers are uncorrelated with estimated risk coefficients, risk attitudes are strongly associated with the subsequent bargaining process. With risk, FP players concede down to or below their fairness ideas, while RC players do not concede up to their fairness idea.

5.2. Concessions and proposals during bargaining

The Harsanyi-Zeuthen concession principle generates explicit predictions for the identity of the player making the next concession for both the benchmark and fairness-adjusted NBS models. Table 7 presents a regression analysis testing these predictions.[24] The dependent variable is an indicator of whether the residual claimant was the one to concede. The prediction is that the RC player concedes if their risk limit (RL_{RC}) is lower than the risk limit of the FP player (RL_{FP}). In the table, the first two columns use the standard NBS concept, and its associated risk limit, to build an indicator for when the residual claimant is predicted to concede. The third and fourth columns use an adjusted risk limit associated with the fairness-adjusted NBS. The two risk limits can differ due to differing disagreement utilities.

[24] Section D of the Supplementary Materials reports details of this analysis. The Harsanyi-Zeuthen concession principle makes predictions about the identity of the player making a subsequent concession, rather than whether there is a standoff and whether the subsequent standoff ends with a concession. Consequently, the analysis focuses on episodes where there are open and incompatible offers from both parties (i.e., a standoff) and one party subsequently

Table 7
Linear Regression of RC Concession: Benchmark versus Fairness Adjusted Predictions.

	Benchmark		Fairness-Adjusted		Horse Race	
	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbf{1}[RL_{RC} \le RL_{FP}]$	0.17***	0.29***			0.08***	0.17***
	(0.000)	(0.000)			(0.002)	(0.000)
$\mathbf{1}[RL^{adj}_{RC} \le RL^{adj}_{FP}]$			0.30***	0.41***	0.26***	0.36***
			(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.43***	0.51***	0.35***	0.37***	0.33***	0.37***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	4241	4241	2455	2455	2455	2455
Clusters	20	20	20	20	20	20
R^2	0.03	0.10	0.09	0.19	0.09	0.19
Average predicted probability of concession by the RC when:						
$\mathbf{1}[RL_{RC} > RL_{FP}]$	0.43	0.36			0.50	0.45
$\mathbf{1}[RL_{RC} \le RL_{FP}]$	0.59	0.64			0.58	0.61
$\mathbf{1}[RL^{adj}_{RC} > RL^{adj}_{FP}]$			0.35	0.29	0.38	0.32
$\mathbf{1}[RL^{adj}_{RC} \le RL^{adj}_{FP}]$			0.66	0.70	0.64	0.68
$\mathbf{1}[RL_{RC} > RL_{FP}] \times \mathbf{1}[RL^{adj}_{RC} > RL^{adj}_{FP}]$					0.33	0.22
$\mathbf{1}[RL_{RC} \le RL_{FP}] \times \mathbf{1}[RL^{adj}_{RC} > RL^{adj}_{FP}]$					0.41	0.39
$\mathbf{1}[RL_{RC} > RL_{FP}] \times \mathbf{1}[RL^{adj}_{RC} \le RL^{adj}_{FP}]$					0.60	0.58
$\mathbf{1}[RL_{RC} \le RL_{FP}] \times \mathbf{1}[RL^{adj}_{RC} \le RL^{adj}_{FP}]$					0.67	0.74

Notes: RL^{adj} denotes the fairness-adjusted calculation of risk limit. Data includes only observations with $|\rho_i| < 1$ for both RC and FP players. ***1%, **5%, *10% significance using standard errors clustered at the matching group level. Models (1) and (3) are simple linear regressions; models (2) and (4) include subject level fixed effects (see Table D.3 of the Supplementary Materials for details on modelling unobserved heterogeneity); in all cases, adding controls for unobserved heterogeneity at the subject or group level increases size and significance of the risk limit variables.

As can be seen in columns (1)–(4), both the benchmark NBS and fairness-adjusted NBS models result in risk limit comparisons that are significantly associated with the identity of the party making the next concession. In all cases, an RC player is more likely to be the one to concede when their risk limit is less than the FP player's, while the opposite holds if the risk limit is larger. This is consistent with both Hypotheses 5 and 5 (ALT). The last two columns consider a horse-race specification that includes both the benchmark and fairness adjusted predictions. Both models appear informative.[25] Overall, the two measures of risk limit are strongly associated with the identity of the person making the next concession. If the residual claimant has both risk limits lower, the predicted probability that they will concede is over two-thirds; when both are higher, this probability halves to below one-third. The Harsanyi-Zeuthen concession principle, however, does not make predictions for the content of proposals or the size of concessions.

Table 8 reports an analysis of the proposals made during bargaining in Panel (a) and on whether the residual claimant accepts in Panel (b). Consider first the proposals models. The dependent variable is the player's current proposal (i.e., the amount proposed to the FP player). As explanatory variables, we include the player's elicited risk parameter and either the time the offer was made (columns (1) and (3)) or the proposal number (columns (2) and (4)), as well as an interaction between the risk parameter and, respectively, proposal number and proposal time. Lastly, the specification also includes indicator variables for the pie-distribution.

Consistent with Table 6, which looked at first offers, RC players offer less and FP players claim less as the riskiness of the pie-distribution increases. Moreover, as would be expected from a gradual concession process, FP players' claims are decreasing over time and proposal number, while RC players' offers are increasing with these variables. Also consistent with Table 6, there is little direct effect of risk preferences. However, for FP players, there is an interaction effect which suggests that more risk averse FP players concede more over time and number of offers. In contrast, for RC players, more risk averse RC players actually concede modestly less across offers.

The main message from Table 6 and Table 8(a) is that FP players take weaker initial positions as the riskiness of the pie-distribution increases. Furthermore, risk aversion negatively impacts FP players throughout the concession process, with more risk averse players conceding significantly more over time and number of proposals. In contrast, residual claimants take stronger initial positions and their concession process is less influenced by risk preferences, as risk increases.

concedes to the other (See Tables D.1 and D.2 for a breakdown of the category of observations across pie-distributions). A concession can take the form of an acceptance of the other's offer or a new offer with terms more favourable to the other player but still incompatible with their current demand.

[25] The fairness-adjusted model has a larger estimated contribution, although note that the benchmark and fairness-adjusted predictions are correlated (correlation coefficient of 0.51). More detailed analysis of the role of the pie-distribution risk shows that, while the benchmark model is equally informative across the pie-distributions, the fairness-adjusted model makes better predictions in the risk-less and less risky distributions (see Table D.4 of Section D of the Supplementary Materials). An important element that the fairness-adjusted model brings over and above the benchmark model is the prediction that, when just one player makes an offer inconsistent with the fairness ideas it is this player that is likely to concede; this happens less often in the riskier pie-distributions (see Figure D.1).

Table 8
Linear Random-Effects Regression on Proposal Behaviour and Acceptances.

(a) Proposals

	FP Player				RC Player			
	(1)		(2)		(3)		(4)	
(Own) ρ	−0.14	(0.560)	−0.14	(0.463)	0.38	(0.611)	0.76	(0.488)
Time	−0.75***	(0.080)			0.88***	(0.173)		
(Own) $\rho \times$ Time	−0.39**	(0.196)			0.05	(0.299)		
Offer Number			−0.05***	(0.010)			0.04***	(0.009)
(Own) $\rho \times$ Offer Num.			−0.06***	(0.018)			−0.05*	(0.027)
$\mathbf{1}[(16, 20, 24)]$	−0.14	(0.258)	−0.26	(0.264)	−0.95***	(0.299)	−0.79***	(0.293)
$\mathbf{1}[(16, 24)]$	−0.41	(0.274)	−0.56*	(0.297)	−1.06***	(0.237)	−0.90***	(0.222)
$\mathbf{1}[(12, 20, 28)]$	−1.51***	(0.305)	−1.59***	(0.294)	−1.74***	(0.237)	−1.54***	(0.223)
$\mathbf{1}[(12, 28)]$	−1.72***	(0.339)	−1.86***	(0.356)	−2.14***	(0.259)	−1.94***	(0.245)
Constant	12.56***	(0.344)	12.24***	(0.317)	8.01***	(0.330)	8.49***	(0.264)
R^2	0.20		0.15		0.07		0.04	
Observations	7441		7441		7697		7697	

(b) Residual Claimant Accepts

	RC Accepts	
$\mathbf{1}[\text{Var.} > 0]$	−0.08*	(0.041)
ρ_{FP}	−0.19***	(0.065)
ρ_{RC}	0.08	(0.060)
Final Offer RC	−0.05***	(0.009)
Final Offer FP	−0.06***	(0.011)
Constant	1.64***	(0.116)
R^2	0.09	
Observations	855	

Notes: FP = Fixed-payoff player; RC = Residual claimant. In panel (b), "Final Offer *x*" is the last proposal made by player type *x* before the end of bargaining for that period. Data includes only observations for which $|\rho_i| < 1$ for both RC and FP players. ***1%, **5%, *10% significance using standard errors clustered at the matching group level.

Table 8(b) analyzes acceptance behaviour of RC players. The dependent variable is an indicator that takes value 1 if the RC player was the one who accepted. As can be seen, RC players are somewhat less likely to accept when the pie is risky. Moreover, we also see that coefficient on the risk parameter of the FP player is negative and significant. That is, the more risk averse the FP player, the more likely they are to be the one ultimately accepting, again suggesting that more risk averse FP players are in a relatively weaker bargaining position than less risk averse ones. Finally, we also observe the intuitive result that RC players are the less likely to accept, the more advantageous to the FP player the final offer on table is, irrespective of who made the final offer.

Primary Result 4 *(Concessions and Proposals).* Both standard and fairness-adjusted risk limit measures help predict which player will make the next concession. More risk averse FP players make larger concessions as negotiations continue and are more likely to accept the RC's offer than are less risk averse FP players.

6. Discussion

Our results show that risk-exposed residual claimants are generally able to extract a risk premium from the fixed-payoff player and this premium is increasing in the riskiness of the pie-distribution. Furthermore, the premium can be large enough to make it beneficial (in expected utility terms) for residual claimants to bargain with some ex-post risk. However, one possible criticism of this result is that it was inferred from bargaining outcomes using elicited risk preferences, which may be subject to measurement error. It may be more convincing if residual claimants directly *revealed a preference* to bargain over a riskier pie. That is, when given the choice between distributions, would a residual claimant choose into the one with more ex-post risk and, therefore, reveal that they expect to benefit from bargaining over a risky pie?

We sought to address this question directly via a set of sessions run using an endogenous design, which we briefly discuss below. The results from these sessions are strongly consistent with those from the exogenous design sessions: residual claimants can benefit sufficiently from asymmetric exposure to risk to choose into bargaining with the exposure, and it is the less risk averse residual claimants that are more likely to do so. This latter point is contrary to the prudence-based mechanism analyzed in White (2008).

In addition to this, we also discuss alternative explanations for our mixed results with regard to the benchmark model. We highlight the evidence for an additional channel through which asymmetric exposure to risk can have substantive impacts on bargained agreements: the wedge asymmetric exposure to risk creates between the fairness ideas of the two bargaining parties, and the impact of fairness ideas on bargaining.

Table 9
Linear Random-Effects Regression of Choice of Pie-Distribution (Periods 6-10).

	Riskier Pie-Distribution Chosen					
	(1)		(2)		(3)	
1[Certain versus Binary]	−0.20***	(0.068)				
1[Ternary versus Binary]	−0.26***	(0.050)				
1[(16,20,24) versus (12,20,28)]	−0.29***	(0.050)				
1[(16,24) versus (12,28)]	−0.29***	(0.058)				
Difference in Variance			0.05	(0.075)		
1[Certain versus Ternary]			0.26***	(0.039)	0.26***	(0.039)
ρ_{RC}					−0.21***	(0.076)
Constant	0.54***	(0.041)	0.25***	(0.036)	0.34***	(0.035)
R^2	0.05		0.05		0.06	
Observations	455		455		455	

Notes: Data includes only observations for which $|\rho_{RC}| < 1$. ***1%, **5%, *10% significance using standard errors clustered at the matching group level. In (1), Certain versus Ternary is the baseline category. Variables **1**[·] are indicator variables assuming value 1 for the respective alternative and 0 otherwise. Difference in Variance variable normalized so that the largest difference (Certain versus (12,28)) is equal to one.

6.1. Endogenous choice of pie-distribution risk

The sessions involving endogenous choice of risk consisted of ten rounds, split into an exogenous and an endogenous part. Rounds 1–5 were the same as in the exogenous design, which has been our focus until now. During rounds 6–10, in contrast, the residual claimant was asked which of two pie-distributions they would prefer to bargain over. The choice was always between two pie-distributions where one was a mean-preserving spread of the other.[26] Overall, about one-third of residual claimants choices were to bargain over the riskier of the two pie-distributions and there were notably more risky choices when the choice was between a certain pie (i.e., €20) and a ternary pie-distribution (i.e., either $(16, 20, 24)$ or $(12, 20, 28)$; note that the ternary pie-distributions are the only risky distributions that allow for an equal split ex-post). In these cases, just over 50% of RC players chose the riskier ternary pie-distribution. The statistical significance of this result is established in specification (1) of the regression analysis reported in Table 9, where the certain versus ternary alternative is the baseline. The regression shows that, in comparison to certain versus ternary, there is a significantly lower rate of riskier pie-distribution choice for any other alternative.[27] These regression results suggest that residual claimants were most likely to prefer bargaining over a risky pie-distribution, rather than the expected value for sure, when there is the possibility of an ex-post equal split.

Specification (3) of Table 9 addresses the second part of Hypothesis 3(B), stating that when the residual claimant is more risk averse than the fixed-payoff player then she can benefit from exposure to a riskier pie-distribution. However, the analysis shows that the likelihood of choosing the riskier pie-distribution is decreasing in the risk aversion of the RC player, which goes against the prediction of the benchmark model, but is entirely consistent with the results from the exogenous design. Recall that we found that it was the relatively less risk averse RC players that appeared to benefit from bargaining over a risky pie-distribution.

6.2. Alternative explanations

There are several reasons why the benchmark model prediction about which risk preferences types benefit from risk exposure are not borne out in the data. First, the results show that risk leads to a divergence in what players consider to be fair: residual claimants believe that fairness demands compensation for risk, while FP players believe fairness means an equal split of the expected value of the pie. Second, initial and final proposals by FP players are positively correlated with their ideas about what constitutes a fair division. Third, disagreement rates were higher with risk. Thus, fairness ideas matter in bargaining, and the addition of risk appears to place a wedge between the FP and RC players' fairness ideas, thereby increasing disagreements.

Another key driver is the behaviour of fixed-payoff players. They are found to adopt weak bargaining strategies in risky environments, especially those who are more risk averse. These players demand less from the start, make larger concessions, and are more likely to accept. Together, these factors go a long way in explaining why the relatively less risk averse residual

[26] The choices in periods 6–10 were: certain versus ternary, certain versus binary, ternary versus binary, $(16, 20, 24)$ versus $(12, 20, 28)$, and $(16, 24)$ versus $(12, 28)$. In half of the sessions, the low risk binary and ternary distributions were used during periods 6–8; in the other half, the high risk were used in these periods. In half of the sessions, the RC's chosen pie-distribution was always implemented (transparent treatment); in the other half, the RC's choice was implemented 70% of the time (non-transparent treatment). See Section F of the supplementary materials for details of the design, as well as further results from these sessions including: an explicit analysis of the transparent versus non-transparent treatment; bargaining outcomes during the first periods, with exogenously chosen pie-distributions; and bargaining outcomes over the last five periods, with endogenously chosen ones.

[27] The effect is similar across the four indicator variables and it is not possible to reject the null hypothesis that all the coefficients are equal ($p = 0.604$). Specification (2) of Table 9 illustrates that this effect is not a result of the difference in risk: it shows a significantly positive effect for choosing the riskier pie-distribution in certain vs ternary even after controlling for the difference in variances of the pie-distributions.

claimants benefit the most from risk exposure. This observation is consistent with the predictions of the fairness-adjusted Nash bargaining solution (Bolton and Karagözoğlu, 2016): The fixed-payoff players' self-serving fairness idea is to split the expected surplus 50-50 and barely changes with the change in risk. In contrast, the fairness idea advantageous to the residual claimants improves the terms for them as their exposure to risk increases (cf. Table 5). Consequently, with the addition of risk, the fairness-adjusted Nash Bargaining solution predicts an increase in the effective frontier over which the agents are bargaining compared to the 50-50 split of the expected surplus, but only to include outcomes that are more advantageous to the residual claimant.

We cannot rule out that private information of risk preferences also plays a role, because it also predicts that the less risk averse residual claimants are most likely to benefit from risk. However, it is unlikely that private information alone provides a sufficient explanation of our results. Not least, a simulation study of various specifications of private information of risk preferences predicts that disagreements should decline as risk increases, in contrast to both intuition and observed disagreement rates. Thus, while private information may play a role, an interaction between fairness ideas, risk preferences and risk exposure, as described above, appears to be more compelling.

7. Conclusion

This paper reports the results of an experimental study on the effect of asymmetric exposure to risk in bargaining. Our results show that risk-exposed residual claimants are generally able to extract a risk premium from the fixed-payoff player and the premium is increasing in the riskiness of the pie-distribution. Furthermore, this premium can be large enough to make it beneficial (in expected utility terms) for residual claimants to bargain with some ex-post risk. That is, we find empirical support for the prediction from a theoretical benchmark model (White, 2006, 2008) that risk exposure can be beneficial in bargaining.

This benchmark model predicts—via a prudence mechanism—that it should be the relatively more risk averse residual claimants who benefit from risk exposure. While nearly all of our subjects' made decisions consistent with prudence a majority of the time, our results show that it is the comparatively *less* risk averse residual claimants who are most likely to benefit. Therefore, the reason why residual claimants benefit from risk must be something other than the prudence channel alone, as identified by White (2006, 2008). We find that fixed-payoff players adopt weak bargaining strategies when the pie is risky, which is an important driver of our results. Moreover, we identify the interaction between fairness ideas and risk exposure as an important factor. Specifically, asymmetric exposure to risk between the two parties creates a wedge between their fairness ideas and shifts the agreement towards residual claimants, sometimes, so much that they can benefit from risk exposure.

Circling back to our introduction, where we provided suggestive evidence that asymmetric exposure to risk is an important factor—at least as a negotiating tactic—in bargaining situations in the field, we now have controlled laboratory evidence of its importance. Our result, that it is possible for residual claimants to benefit from risk, is consistent with the perception that NFL owners have benefited from their risk exposure. Moreover, the behavioural channel that we identified is also consistent with these labour negotiations; namely, that asymmetric exposure to risk creates a wedge between what each party perceives as fair.

Appendix A. Additional material

A.1. Examining order effects

We first examine whether there are differences in the elicited risk preferences across the various types of sessions. Recall that in all cases, in the 2012 sessions, risk preferences were elicited after bargaining but before the unincentivized fairness elicitation, while in the 2019 sessions, risk preferences were either elicited at the beginning or at the end of the experiment. The average CRRA risk parameters were 0.350, 0.224 and 0.198, respectively for sessions 2012-BRF, 2019-BFR and 2019-RFB.[28] As is evident, there is no significant difference between the two 2019 session types ($p = 0.543$), but subjects do appear to be less risk averse in 2019 than in 2012 ($p = 0.003$). Of course, because of the significant lag between the 2012 and 2019 sessions, we cannot attribute the differences to the changes in the elicitation procedure. What we do see is that, in the 2019 sessions, the order does not appear to matter.

In Table A.1, we provide summary statistics on key outcome variables (Agreed FP Payment and Disagreement) as well as the fairness idea of each player type, broken down by pie-distribution and session type. Highlighted cells indicate a statistically significant difference between the two session types for the particular pie-distribution at the 5% level based on a Mann-Whitney rank-sum test. As can be seen, of the 60 possible pairwise comparisons, only two are significant at the 5% level, which is well within the bounds of chance.[29] The most noticeable differences appear to be that residual claimants do not demand quite as large of a risk premium when fairness preferences are elicited first.

[28] As in the main body of the paper, we focus only on those subjects for which $|\rho| < 1$. See Note 2 in Table A.1 for what these session type acronyms mean.

[29] If we consider the 10% level of significance then we see that 8 of 60 pairwise comparisons meet the threshold, which is also not far from what could be expected by chance.

Table A.1
A Comparison of Key Bargaining Outcomes and Fairness Ideas by Session Type.

(a) Agreed FP Payment

Distribution of Pie	Session		
	2019-BFR	2019-RFB	2012-BRF
(20)	9.97	10.08	10.13
(16, 20, 24)	9.71	9.87	9.64
(16, 24)	9.45	9.86	9.56
(12, 20, 28)	9.29	9.41	9.04
(12, 28)	8.70	9.05	8.79

(b) Disagreement (%)

Distribution of Pie	Session		
	2019-BFR	2019-RFB	2012-BRF
(20)	5.21	2.08	4.17
(16, 20, 24)	9.38	10.42	6.25
(16, 24)	5.21	7.29	14.58
(12, 20, 28)	12.50	10.42	10.42
(12, 28)	6.25	7.29	18.75

(c) Fairness Idea (FP Player)

Distribution of Pie	Session		
	2019-BFR	2019-RFB	2012-BRF
(20)	10.25	10.63	9.96
(16, 20, 24)	10.39	10.99	10.33
(16, 24)	10.32	10.98	10.29
(12, 20, 28)	10.07	10.13	9.88
(12, 28)	9.85	9.82	9.58

(d) Fairness Idea (RC Player)

Distribution of Pie	Session		
	2019-BFR	2019-RFB	2012-BRF
(20)	9.55	10.21	9.92
(16, 20, 24)	9.57	9.65	9.44
(16, 24)	9.11	9.84	9.44
(12, 20, 28)	7.99	8.98	8.42
(12, 28)	7.92	8.50	8.06

Note 1: The numbers in each cell represent the matching group average, broken down by pie-distribution and session type. In the column headings, B stands for Bargaining; R stands for Risk Elicitation; and F stands for Fairness elicitation, and the triple represents the order in which students completed the tasks.
Note 2: Cells which are shaded in grey indicate that the variables are significantly different from each other at the 5% level or better according to a Mann-Whitney rank-sum test.

A.2. Tables

Table A.2
Pairwise Comparison of Bargaining Outcomes in the Exogenous Design (Periods 1-10).

	(20)	(16,20,24)	(16,24)	(12,20,28)	(12,28)	(20)	(16,20,24)	(16,24)	(12,20,28)	(12,28)
	Final Earnings					*Agreed FP Payments*				
(20)	9.67	>***	>***	>***	>***	10.05	>**	>***	>***	>***
(16,20,24)		8.86	<	>***	>***		9.78	>	>***	>***
(16,24)			8.87	>**	>***			9.64	>***	>***
(12,20,28)				8.24	>				9.31	>***
(12,28)					8.04					8.86
	Disagreements					*Time Remaining*				
(20)	3.8	<***	<*	<***	<**	168	>***	>***	>***	>***
(16,20,24)		9.2	>	<	>		85	>*	>***	>*
(16,24)			7.9	<	<			74	>**	>
(12,20,28)				11.2	>				60	<
(12,28)					9.2					70

Notes: The symbol indicates how the outcome measure of the row distribution compares (statistically) to the column distribution. ***1%, **5%, *10% significance using standard errors clustered at the matching group level.

Table A.3
Pairwise Comparison of Bargaining Outcomes in the Exogenous Design (Periods 1-10) – Robustness Check using Matching Group Averages.

	(20)	(16,20,24)	(16,24)	(12,20,28)	(12,28)	(20)	(16,20,24)	(16,24)	(12,20,28)	(12,28)
	Final Earnings					*Agreed FP Payments*				
(20)	9.67	>***	>**	>***	>***	10.05	>**	>***	>***	>***
(16,20,24)		8.86	<	>**	>***		9.76	>	>***	>***
(16,24)			8.87	>**	>***			9.64	>**	>***
(12,20,28)				8.24	>				9.29	>***
(12,28)					8.04					8.86
	Disagreements					*Time Remaining*				
(20)	3.8	<***	<	<***	<**	169	>***	>***	>***	>***
(16,20,24)		9.2	>	<	>		87	>**	>***	>**
(16,24)			7.9	<	<			75	>**	>
(12,20,28)				11.2	>				61	<
(12,28)					9.2					71

Notes: The symbol indicates how the outcome measure of the row distribution compares (statistically) to the column distribution. ***1%, **5%, *10% significance using signed rank test on matching-group level averages. Note that there are 20 independent observations per comparison.

Appendix. Supplementary material

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.geb.2020.12.005.

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