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Supply-chain performance anomalies: Fairness concerns under private cost information

Fei Qin[a,*], Feng Mai[b], Michael J. Fry[c], Amitabh S. Raturi[c]

[a] *Soochow Thinktank and Dongwu Business School, Soochow University, Suzhou, Jiangsu 215021, PR China*
[b] *School of Business, Stevens Institute of Technology, Hoboken, NJ 07030, USA*
[c] *Department of Operations, Business Analytics & Information Systems, University of Cincinnati, Cincinnati, OH 45221, USA*

A R T I C L E I N F O

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A B S T R A C T

This work investigates how fairness concerns influence supply-chain decision making, while examining the effect of private production-cost information and touching on issues related to bounded rationality. We conduct laboratory work utilizing a supply-chain dyad with an upstream supplier feeding a downstream retailer under a simple wholesale-price contract. We perform human–computer (H–C) experiments where human subjects play the role of the supplier paired with the computerized retailer, as well as human–human (H–H) experiments where human subjects play the role of both supplier and retailer. These experiments allow us to isolate other effects like bounded rationality from the effects of fairness concerns on supply-chain decision making. We find that, compared to standard analytical model, the bounded rationality slightly reduces overall supply chain profit without changing its distribution between the supplier and the retailer, while fairness concerns lead to greater supply-chain profits and a more balanced supply-chain profit distribution. We further illustrate that under private cost information, the retailer's fairness concern is suppressed by the lack of reciprocity from not being able to observe her rival's profit information, but that the supplier's fairness concern from altruism persists. Based on our experimental results, we modify classical supply-chain models to include utility functions that incorporate both bounded rationality and fairness concerns. The estimated other-regarding coefficients are significantly lower under private information than under public information for the H–H experiments, and we find no evidence of inequity aversion for the H–C experiments.

1. Introduction

Supply chain performance under various contracting mechanisms has been explored extensively in theory typically following the standard *homo-economicus* assumption that supply chain agents are rational and capable of making decisions to maximize their long-term financial returns. Studies in behavioral economics and marketing (Croson, 1996; Katok, 2011a) have long recognized that social interactions among business units also affect agent behaviors and, consequently, supply chain performance. One such social effect arises out of human preference for equity or fairness concern. As noted by Kahneman, Knetsch, and Thaler (1986), "The traditional assumption that fairness is irrelevant to economic analysis is questioned. Even profit-maximizing firms will have an incentive to act in a manner that is perceived as fair if the individuals with whom they deal are willing to resist unfair transactions and punish unfair firms at some cost to themselves…The rules of fairness, some of which are not obvious, help explain some *anomalous* market phenomena."

For decades, powerful retailers in the supply chain have been known to erode suppliers' profits and take a bigger share of the overall channel profit. Wal-Mart is well known for using its power to squeeze supplier profits (Van Riper, 2007; Coolidge, 2015). Food suppliers in the United Kingdom have complained that they are unable to gain a sustainable margin from the retailer (Fredenburgh, 2015). Recently, stakeholders have started to realize that fairness and balance are vital in a strong retailer-supplier relationship, and can lead to better supply-chain performance. Empirical studies have shown fairness concerns have a positive influence on inter-firm relationships and mutual outcomes (Ring & Van de Ven, 1994, Arino & Ring, 2010). Such observations related to the importance of fairness concerns and equity have motivated recent behavioral operations-management (BOM) researchers to conduct various human experiments to investigate the impact of social preference over supply chain coordination (Loch & Wu, 2008; Ho and Zhang 2008; Katok & Pavlov, 2013).

* Corresponding author. Tel.: +1 5134882066.
E-mail address: fei.qin@mcgill.ca, qinfei99@gmail.com (F. Qin).

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Unsurprisingly, the introduction of human subjects distorts the well-established modeling framework for even the simplest class of pricing contracts. Our behavioral study explores the issue of why experimental results tend to differ from traditional analytical findings in decentralized supply chains. We examine the performance of a wholesale price-only contract in a laboratory setting for the validity of three assumptions in standard models: (1) supply chain agents are fully rational; (2) agents are concerned with only their own profits; and (3) both cost and return information are public to all agents.

While recent work on fairness and supply-chain coordination has generated useful new insights (Cui, Raju, & Zhang, 2007; Demirag, Chen, & Li, 2010; Katok, Olsen, & Pavlov, 2012), these existing papers do not explicitly examine how private manufacturing-cost information may affect supply-chain interactions in the presence of equity concerns. Regardless of the degree of competition and the complexity involved, it is likely that no two firms in a supply chain share the same amount and type of information (Chen, Graves, & de Kok, 2001; Kostamis & Duenyas, 2011). Scenarios involving a private cost structure are common in business. For instance, a retailer may not know the manufacturer's true costs, which prevents her from knowing whether she attains an equitable payoff in the channel. Yet in some cases, entities in the supply chain may choose to disclose private cost information. As an example, before hundreds of dairy farmers from across Europe traveled to Germany in 2013 to protest against downstream price pressures, the European Milk Board (EMB) published a report revealing production cost (Case, 2013). In the automaker industry, "Ability to Recover Material Cost" is a critical factor when suppliers rate their working relations with automakers (Ford.com, 2008). Thus, it is interesting to examine if the supply chain can be better off with private cost information and if the supplier would have an incentive to disclose cost information to the retailer. Therefore, we also explore how the fairness perception of the agent changes when only the supplier, but not the retailer, knows the manufacturing cost information.

Our laboratory work utilizes a two-echelon supply chain with an upstream supplier feeding a downstream retailer. To account for the possible causes of supply-chain performance anomalies, we examine two potential explanations in this bilateral monopoly: biases related to individual bounded rationality and concerns related to the preference for equity (fairness concerns or avoiding inequity). Moreover, we examine the effect of private cost information in conjunction with fairness concerns and bounded rationality, as illustrated in the following graph:

As bounded rationality and fairness concerns may be confounded in subjects' decision-making, our experimental design must distinguish these two causes. To isolate the effect of bounded rationality, we conduct human–computer (H–C) experiments with subjects in the role of the supplier to minimize biases from social preferences such as equity concerns. Our results show that other than slightly reduced supply-chain efficiency (defined as the realized supply-chain profit divided by the integrated supply-chain profit), the human supplier's decision and profit share are not significantly different from the standard model predictions (Fig. 1).

Next, we examine a human–human (H–H) experimental setting where both agents are represented by human decision makers. In the H–H experiment, we find that supply-chain efficiency is higher than predicted by the standard model. Moreover, the distribution of supply chain profits between supplier and retailer becomes more balanced than predicted. We attribute this anomaly to fairness concerns of the participants'. We also consider a second treatment of our H–H experiments where the cost information is supplier's private information. Although fairness concerns appear to be at work under both public and private information cases, a closer look at our results reveals that private cost information breaks the reciprocity link (Kahneman et al., 1986) between supplier and retailer, promoting retailer's self-interest and suppressing supplier's concern for equity.

Building on previous research (Heifetz, Shannon, & Spiegel, 2007; Loch & Wu, 2008), we then develop a behavioral model embedding fairness preference into the decision maker's utility functions and solve for the equilibrium. To measure the magnitudes of concerns for equity across all experimental treatments, we estimate other-regarding coefficients from our data using a maximum-likelihood method, leaving bounded rationality and other biases in the random error term. Our results indicate that withholding individual cost and benefit information weakens fairness considerations in the decentralized supply chain.

The remainder of our work is organized as follows. Section 2 provides a literature review of related work and presents the standard model as well as a fairness-minded behavioral model. Section 3 introduces our detailed experimental design and the hypotheses to test the model predictions and verify the appropriateness of its assumptions. Section 4 reports our experimental results and provides analysis. Section 5 develops the behavioral model and estimates the corresponding parameters with our experimental data. Section 6 provides conclusions and suggests possible directions for future research. Detailed lab instructions and experimental procedures are provided in the Appendix.

2. Related literature and standard economic model

2.1. Related literature

An abundance of papers has examined supply-chain contracting mechanisms analytically (see reviews by Cachon, 2003; Li & Wang, 2007; among others). These papers usually follow the standard economic framework building on analytical models of decision makers, who are fully rational and capable of maximizing his/her monetary returns. Various types of contracting mechanisms have been examined in a simple dyadic supply chain with an upstream supplier feeding a downstream retailer. Among these contracts are the common wholesale price contract (Cachon, 2003), the two-part tariff contract (Jeuland & Shugan, 1983), the buy-back contract (Pasternack, 1985; Kandel, 1996), the retail-fixed-markup contract (Liu, Fry, & Raturi, 2009, 2012), and the revenue-sharing contract (Cachon & Lariviere, 2005).

Although theory on bounded self-interest within behavioral economics has long emphasized that people care about both giving and receiving fair treatment in a range of settings (Diamond & Vartiainen, 2007), biases from this preference for equity have only recently been introduced into the context of supply-chain modeling (Cui et al., 2007; Pavlov & Katok, 2011; Katok et al., 2012). Cui et al. (2007) show analytically that when supply chain members are concerned about fairness, the manufacturer may prefer a simple wholesale price contract to a more elaborate contract for coordinating the supply chain. Pavlov and Katok (2011) and Katok et al. (2012) further develop Cui's model by considering the case when the supply chain partners' fairness concerns are based on incomplete information. Their analysis shows that the supply-chain efficiency is strictly lower under incomplete information than when fairness preferences are common knowledge. The latter paper also provides an experimental test of their model predictions by obtaining the empirical distribution of the preferences.

Our paper extends the above work and investigates how private cost information may affect the supply chain dynamics under the influence of both fairness concerns and bounded rationality. Thus, it belongs to the relatively recent but quickly growing stream of BOM literature, which includes works such as Schweitzer and Cachon (2000), Lim and Ho (2007), Bolton and Katok (2008), Gino and Pisano (2008) and others. Loch and Wu (2007) and

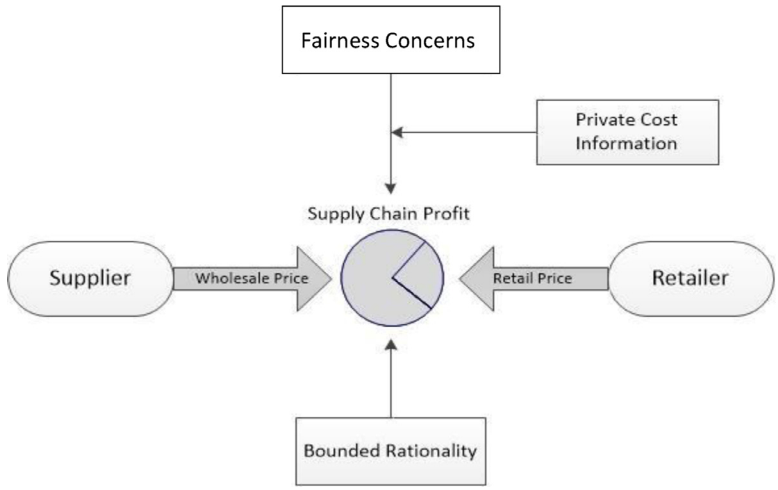

Fig. 1. Conceptual model of our experimental study.

Katok (2011a, 2011b) provide excellent reviews on using laboratory experiments for operations management study.

Two main areas of BOM research using experiments to test supply chain performance are (1) research that focuses on the newsvendor model under demand uncertainty (Katok & Wu, 2009; Gavirneni & Xia, 2009; Kalkancı, Chen, & Erhun, 2011,2014; Becker-Peth, Katok, & Thonemann, 2013); (2) research that focuses on supplier–retailer interaction under a deterministic supply chain setting (Loch & Wu, 2008; Ho and Zhang 2008). Our work is most closely related to the latter area. Loch and Wu (2008) provide experimental evidence that social preferences systematically affect decision-making in supply chain transactions. By varying the salience of individual motivation in a repeated, paired pricing game, the authors show that relationship preference promotes cooperation, individual performance, and high system efficiency, whereas status preference induces tough actions and reduces both system efficiency and individual performance. Ho and Zhang (2008) experimentally test the performance of two analytically equivalent frames of the fixed-fee contract: two-part tariff and quantity discount. They find that both contracts fail to improve supply-chain efficiency relative to the wholesale price contract, but an opaque frame of the fixed fee in terms of a quantity discount significantly improves supply-chain efficiency compared to a salient frame of the fixed fee as in a two-part tariff contract. Their further analysis suggests that the behavioral tendency of loss aversion has more explanatory power than complexity aversion to account for such a difference.

However, few of the previously cited papers separate the various possible causes of the supply-chain performance anomaly, where the agent decisions and pecuniary returns are significantly different from the model predictions. Katok and Wu (2009) first use H–C experiments to compare the performances of supply chain contracts while focusing on the effect of bounded rationality. We extend this line of work by using experimental treatments that attempt to separate the effects of equity from bounded rationality.

The recent work by Katok and Pavlov (2013) is perhaps the most related to our work presented here. They use behavioral experiments to examine equity concerns in a decentralized supply chain. However, Katok and Pavlov focus on a specific coordinating contract known as the minimum-order-quantity (MOQ) contract and investigate incomplete information about the retailer's behavioral parameters. Their study finds that incomplete information about fairness preferences is extremely influential in diminishing the competitiveness of MOQ contracts. Here, we consider a different type of incomplete information, which is on the supplier cost. Our work instead examines how fairness concerns affect the classical double-marginalization result (caused by the wholesale price-only contract) with or without a common knowledge of the manufacturing cost information. Table 1 summarizes the position of current study with respect to representative BOM papers.

The main question that we investigate is to what extent private supplier-cost information may change supply-chain interactions in the presence of human inequality aversion and bounded rationality. For a price-only contract under bilateral monopoly, we separate inequality aversion from bounded rationality by designing both H–C and H–H experiments. With the updated utility functions incorporating fairness concerns, we also measure the magnitude of the fairness concerns across all treatments from our data.

2.2. A dyad supply chain with deterministic demand

We briefly present the standard economic model for a bilateral monopoly dyad, where a wholesale price-only contract induces the double marginalization in the supply chain. We consider a simple supply chain with an upstream supplier feeding a downstream retailer, who then sells directly to the market. The supplier's manufacturing cost per unit is a constant c. The retailer faces a linear price-dependent demand function, $D(p) = A - \beta p$, where p is the retail price, A is the market size, and β is the price elasticity. The supplier moves first with a fee schedule for his margin and the retailer follows with a retail price for her margin. Classic analytical models assume that all information here is public to both players and the product does not have any salvage value; hence, the quantity sold to the end market, q, is equal to quantity ordered from the supplier and solely dependent on retailer price.

Table 1
A taxonomy of behavioral studies on supply chain performance considering bounded rationality and fairness concerns.

	Bounded rationality	Fairness concern	Study both
Complete information	Katok and Wu (2009), Kalkancı et al. (2011)	Loch and Wu (2008)	Ho and Zhang (2008)
Incomplete information	Kalkancı et al. (2014)	Katok et al., 2012	Katok and Pavlov (2013), our current paper

For an integrated supply chain where the supplier and the retailer act as a single entity, the retail price, p, maximizes the overall supply chain profit, $\Pi_C = (p-c)q = (p-c)(A-\beta p)$. For a decentralized supply chain, we may obtain the sub-game Nash equilibrium using backward induction starting from the retailer's optimal price decision followed by solving the supplier's optimization problem. Under a wholesale price-only contract, the retailer profit is $\Pi_R(p) = (p-w)(A-\beta p)$, and the supplier profit is $\Pi_S(w) = (w-c)(A-\beta p^*)$, where p^* is the retailer's best response to her own profit maximization problem. The equilibrium solutions under a wholesale price-only contract yield a supply-chain efficiency of 75 percent due to double marginalization.

Under the assumption that both parties have extended utilities including fairness concerns, we modify the above classical models to incorporate social fairness concerns. Following the work of other behavioral researchers, and specifically the analytical framework described in Heifetz et al. (2007) and Loch and Wu (2008), we consider the case when both the supplier and the retailer utility functions include concerns for the other party's payoffs in addition to his/her own. Due to linearity of the utility functions, they can be normalized as $U_S = \Pi_S + \theta_S \Pi_R$ for the supplier and $U_R = \Pi_R + \theta_R \Pi_S$ for the retailer, where θ_S and θ_R are the weights assigned to the other party's return.[1] Similar to Loch and Wu (2008), we refer to θ_S and θ_R as "other-regarding coefficients" to incorporate the overall concern that one party has for the other party. Obviously, when θ_S or θ_R is zero, the subject is purely self-interested without concerning the other party. The parameters capture the individual subject's relative perception on the fair return of the other party.

We choose this formulation mainly due to its tractability. As noted by Cui et al. (2007), fairness has much more substance than a simple mathematical representation can capture. The authors also provide a complex utility function for inequity aversion that allows for different reference points and can deliver additional informative results. Next, we use the fairness-dependent extended utility functions to derive the optimal equilibrium decisions. We start with the retailer's utility maximization using backward induction[2]:

$$U_R = (p-w)(A-p\beta) - (w-c)(A-p\beta)\theta_R. \tag{1}$$

From the first-order condition, the retailer will choose price $p^* = \frac{A+w\beta-(w-c)\beta\theta_R}{2\beta}$, given the supplier's wholesale price w. The supplier picks a wholesale price w to maximize

$$U_S = (w-c)(A-p^*\beta) + (p^*-w)(A-p^*\beta)\theta_S. \tag{2}$$

The equilibrium prices of the model are therefore

$$w^* = \frac{A + c\beta - 2c\beta\theta_R - A\theta_S + c\beta\theta_R^2\theta_S}{\beta(1-\theta_R)(2-(1+\theta_R)\theta_S)}, \tag{3}$$

and

$$p^* = \frac{3A + c\beta - (2A + (A+c\beta)\theta_R)\theta_S}{2\beta(2-(1+\theta_R)\theta_S)}. \tag{4}$$

All sub-game perfect equilibrium prices and profits are given in Table 2 for the integrated supply chain and the decentralized supply chain with or without fairness concerns under complete information.

[1] Before the normalization, the original model is $U_S = \Pi_S + a_S\Pi_R + b_S(\Pi_S - \Pi_R)$ for the supplier, and $U_R = \Pi_R + a_R\Pi_S + b_R(\Pi_R - \Pi_S)$ for the retailer. In U_S, the first component, $a_S\Pi_R$, captures altruism that is weighted on the other party's payoff; the second component, $b_S(\Pi_S - \Pi_R)$, captures inequality seeking/avoiding that is weighted on the payoff difference. Here, a_S is the altruism parameter and b_S is the inequality seeking parameter.

[2] The negative sign before (w-c) is to make our estimated θ_R positive, but the positive sign will work as well.

In the next section, we test these analytical outcomes for subjects' decisions and supply-chain performance in behavioral experiments. The design of our experiments enables us to explore two possible reasons related to human decision making that may depart from standard results: individual bounded-rationality biases (errors, heuristics), and varying individual interests (risk attitude, equity concern, and status concern). We further relax the complete information assumption by concealing the manufacturing cost value from the retailer, thus making only the supplier aware of the profit distribution in the whole supply chain.

3. The experiment and hypothesis

3.1. Experimental design

Human decision makers may violate standard modeling assumptions for reasons including the following: (1) bounded rationality caused by errors or heuristics in decision-making, (2) different utility functions that may include aspects such as loss aversion and social preference such as concern for fairness. The effects of these aspects in experiments often commingled with each other and with the subjects' rational goal for monetary returns. To account for these multiple possible causes of anomalies, our experimental design attempts to empirically separate the effects of bounded rationality and social preference using both Human–Computer (H–C) and Human–Human (H–H) experiments.

1. We first conduct H–C experiments to test primarily the effect of bounded rationality, when biases from social preferences such as equity concerns are minimized from the lack of human interactions.
2. In light of the results from the H–C experiments, we then perform H–H experiments to examine supply-chain decision making under both bounded rationality and social preferences such as fairness concern.
3. Using the H–H experiments, we also explore the supply-chain dynamics when only the supplier, but not the retailer knows the unit production cost, and consequently possesses full supply-chain profit information. We label this experiment treatment as H–H–P.

In a bilateral monopoly setting, we conduct both H–C and H–H experiments to mimic a Stackelberg game under a price-only contract. In the H–C game, the retailing agent is automated such that it always picks the price to optimize its own profit. The subjects play the role of the supplier, knowing that they are playing against automated retailers. In the H–H game, the retailer and the supplier are both human subjects. They are matched randomly and anonymously in each round so that each round is a single-shot game. The H–H–P experiment explores how the fairness perception of the player changes when only the supplier, but not the retailer, possesses the unit production cost and the consequent supply-chain profit information.

We control the preference related to uncertainty such as loss aversion by adopting a deterministic demand function. To ease the subjects' calculation burden, we use $A = 20$, $\beta = 1$, and $c = 4$ in all our experiments. Therefore, the quantity sold in the market is $q = 20 - p$, and under a simple wholesale price contract, the supplier profit is $\Pi_S = (w-4)q$, and the retailer profit is $\Pi_R = (p-w)q$.

3.2. Hypothesis

Standard analytical models provide supply-chain equilibrium decisions and outcomes under complete information. Based on these results, we formulate our first hypothesis, which compares

Table 2
Theory predictions for an integrated and a decentralized supply chain.

Optimal solutions	Integrated	Decentralized	Decentralized with fairness concerns
Wholesale Price w	–	$\frac{A+\beta c}{2\beta}$	$\frac{A+c\beta-2c\beta\theta_R-A\theta_S+c\beta\theta_R^2\theta_S}{\beta(1-\theta_R)(2-(1+\theta_R)\theta_S)}$
Retail price p	$\frac{A+\beta c}{2\beta}$	$\frac{3A+\beta c}{4\beta}$	$\frac{3A+c\beta-(2A+(A+c\beta)\theta_R)\theta_S}{2\beta(2-(1+\theta_R)\theta_S)}$
Retailer's profit Π_R	–	$\frac{(A-\beta c)^2}{16\beta}$	$\frac{(A-c\beta)^2(1-\theta_R\theta_S)(1+\theta_R(-3+(1+\theta_R)\theta_S))}{4\beta(1-\theta_R)(2-(1+\theta_R)\theta_S)^2}$
Supplier's profit Π_S	–	$\frac{(A-\beta c)^2}{8\beta}$	$\frac{(A-c\beta)^2(1-\theta_S)(1-\theta_R\theta_S)}{2\beta(1-\theta_R)(2-(1+\theta_R)\theta_S)^2}$
Supply chain profit Π_C	$\frac{(A-\beta c)^2}{4\beta}$	$\frac{3(A-\beta c)^2}{16\beta}$	$\frac{(A-c\beta)^2(1-\theta_R\theta_S)(3-(2+\theta_R)\theta_S)}{4\beta(2-(1+\theta_R)\theta_S)^2}$
Supply chain efficiency (percent)	100	75	$\frac{(1-\theta_R\theta_S)(3-(2+\theta_R)\theta_S)}{(2-(1+\theta_R)\theta_S)^2}$
Supplier profit share (percent)	–	66.67	$\frac{2(1-\theta_S)}{(1-\theta_R)(3-(2+\theta_R)\theta_S)}$
Parameters			
c:	The supplier's manufacturing cost per unit		
A:	The retail market size		
β:	The price elasticity for the market demand		
θ_S:	The supplier's weight for the retailer's return		
θ_R:	The retailer's weight for the supplier's return		

supply-chain efficiency and optimal decisions from our experimental settings to their analytical model benchmarks. If neither bounded rationality nor fairness concerns affects decisions, then $\theta_S = \theta_R = 0$ and Hypothesis 1 should hold.

Hypothesis 1. (Standard-Model Hypothesis): Human subjects' decisions should be consistent across all three experimental conditions in accordance to the standard analytical model predictions. This means that supply chain efficiency will be 75 percent and the supplier's profit share will be 66.7 percent. The supplier will charge a wholesale price $w = 12$, and the retailer follows with her optimal response of $p = 10 + 0.5w(12) = 16$ with $\Pi_S = 32$ and $\Pi_R = 16$.

In Hypothesis 2, we compare our experimental results between the H–C and H–H experiments. If the human player behaves in the same fashion between the H–C and H–H games, the supply-chain decisions and outcomes will be the same. However, if there is a significant difference that is not explained by bounded-rationality concerns, then such a difference will provide evidence of the possible impact from fairness concerns. Thus, Hypothesis 2 provides a test for social preference that is likely to be related to equity (after excluding the risk aversion from the game setting)[3]. For example, when $\theta_S = \theta_R = 1$, the Pareto-optimal fair contract is achieved with w=8, p=12, which leads to a profit of 32 for both parties. But when $\theta_S = \frac{2}{3}$ and $\theta_R = 0$, the supplier would still set $w = 8$ and the rational retailer would instead set $p = 10 + 0.5w(8) = 14$ with $\Pi_S = 24$ and $\Pi_R = 36$. Therefore, our behavioral model enables us to predict supply chain dynamics with various combinations of other-regarding coefficients θ_S and θ_R. We can also estimate these coefficients from our experiments to check whether the supplier could trust his retailer, when he is offering a "fair" wholesale price.

Hypothesis 2. (Fairness-Concern Hypothesis): Human subjects' decisions will be the same in the H–C and H–H treatments under complete information. As a result, supply-chain performance measured by supply-chain efficiency and supplier's profit share should also be the same in these two treatment conditions.

[3] The retailer's optimization task is a straightforward deterministic newsvendor problem in our game. Therefore, bounded rationality of the human retailer is not likely to be significant under H–H treatment.

In the case of private cost information when the retailer does not know her supplier's unit cost and the resulting profit distribution, Hypothesis 3 examines how private cost information may affect supply chain interactions in the presence of fairness concern.

Hypothesis 3. (Private Information Hypothesis): The fully rational self-interested decision makers should pick the same optimal prices regardless of private cost information. Thus, both the supplier and retailer's pricing decisions shall be the same in the H–H and H–H–P treatments.

3.3. Experimental procedures

The experiments took place in a college of business at a research university located in the Midwestern United States from October 2012 to March 2013. 28 business undergraduates participated in the H–C game to examine the effects of bounded rationality. In each round, the subjects play the role of the supplier (S) and the computer plays the role of the retailer (R). Here we obtain 28 independent observations after averaging the outcome from six decision rounds.

For the Human–Human game, we ran the H–H and H–H–P concurrently in a separate session with yet another 32 business undergraduate students participating, half for H–H and half for H–H–P respectively. In this session, each subject's role (either supplier or retailer) is randomly selected, and revealed at the beginning of the game. The experiments consisted of eight decision rounds. In each round, a human supplier is matched randomly and anonymously with a different human retailer. To control for reputation building and mitigate retaliatory effects, no two subjects are matched more than once. All of the subjects go through two rounds of training, as detailed in the appendix to minimize the effect of learning in the early rounds. Our design of experiments is consistent with previous studies of Ho and Zhang (2008) and Katok et al. (2012), which is meant to increase the number of observations and to curb any potential learning effects.

Each subject makes a decision in each round. For the supplier, she picks a wholesale price first; the retailer then follows with her order quantity and the retail price (For H–C game, the retailer decisions are automatically computed). At the end of the round, the

Table 3
Summary statistics per treatment condition.

	Standard Model	H–C ($n=28$)	H–H ($n=64$)	H–H–P ($n=64$)
Decision variables				
Wholesale price	12	12.68 (2.23)	10.09 (2.93)	10.72 (1.55)
Retail price	16	16.30 (1.13)	14.61(2.20)	15.36 (0.90)
Supply chain outcome				
Supplier profit	32	27.41 (4.69)	27.66 (9.70)	29.92 (3.23)
Retailer profit	16	15.64 (8.20)	24.77 (13.11)	22.00 (6.99)
Supply chain efficiency (percent)	75	67.30 (16.00)	81.91 (20.56)	81.13(10.10)
Supplier profit share (percent)	66.7	66.10 (12.30)	54.98 (18.28)	58.55 (9.40)

Table 4
Hypothesis tests of supply-chain performance results.

		t-statistics	*p*-Value
Supply chain efficiency			
H–C	H_0: Efficiency in lab = 75 percent	−2.5653	0.0162
H–H	H_0: Efficiency in lab = 75 percent	2.6887	0.0092
H–H–P	H_0: Efficiency in lab = 75 percent	4.8536	0
Supplier profit share			
H–C	H_0: Share= 66.7 percent	−0.2507	0.8039
H–H	H_0: Share= 66.7 percent	−5.0165	0
H–H–P	H_0: Share= 66.7 percent	−6.9409	0
Optimal decisions			
H–C	H_0: w=12;	1.6063	0.1198
H–H	H_0: w=12;	−5.2116	0
H–H–P	H_0: w=12;	−6.6221	0
H–C	H_0: p=16;	1.3825	0.1781
H–H	H_0: p=16;	−5.0542	0
H–H–P	H_0: p=16;	−5.711	0

supplier and retailer profits are calculated and revealed to each player respectively. When cost information is public, each party is informed of the other party's payoff. The subjects are rewarded by extra course credits proportional to the total profits that they are able to make from the game[4] (see Katok, 2011a on incentive issues in BOM).

We programmed the computer interface using ASP.NET web application framework. The experiment website was set up on Amazon's Elastic Compute Cloud, which allowed students to bring their own laptops to participate. The detailed experimental instructions, procedures and program interfaces are listed in the Appendix.

4. Results

Table 3 presents summary statistics of the prices, profits, and supply-chain efficiencies across the three experimental conditions with standard deviation in the parentheses. We now discuss these results by focusing on the hypotheses introduced previously.

4.1. Hypothesis 1: standard-model predictions testing and results

Table 4 presents the hypothesis-testing results for supply-chain decisions and performance against the theoretical benchmark across all three experiments. In the H–C game, we have 28 independent observations by averaging each subject's six decisions so that each observation is independent. The price-only contract achieves 67.3 percent supply-chain efficiency, below 75 percent as predicted by the standard analytical model (Anand, 2008). On average, the human supplier picks a wholesale price of 12.68, which is not significantly different from the standard-theory prediction, and the computerized retailer responds with a retail price of 16.30. These decisions result in supplier profit share of 66.1 percent, which is not significantly different from 66.7 percent as predicted by the standard analytical model. These results present experimental evidence that although bounded rationality slightly reduces supply-chain performance; the subjects' aggregated price decisions are not significantly different from the optimal values. Using the H–C condition to test the bounded-rationality effect, Hypothesis 1 test results support that human subjects are capable of making optimal decisions for this bilateral monopolistic setting. Previous research has shown that human biases from bounded rationality can be at least partially remedied with education and experience (Katok & Wu, 2009), which requires extra training periods and more practice rounds in the game. Moreover, the profit distribution from the experiment does not deviate from the model prediction, suggesting that the influence from subjects' social preferences is very mild.

Contrary to the H–C condition, Hypothesis 1 test results are significant at the 1 percent confidence level for both H–H and H–H–P conditions: the supplier and retailer's prices are significantly less than the standard model predictions. Thus, when a human supplier is paired with a human retailer, the supplier may charge a wholesale price less than the optimal price on average. In return, the human retailer also responds with a retail price less than the optimal price. Our test results support that under both H–H and H–H–P conditions, the supplier profit is less than the theoretical prediction while the retailer profit is greater than the theoretical prediction. The experimental outcome reveals a more balanced profit allocation than would be expected by the standard model, with the supplier taking 54.98 percent of the supply chain profit, which is significantly less than 66.7 percent predicted by the standard model. In addition, the supply-chain efficiency is significantly different (higher) than the analytically predicted level of 75 percent, showing that supply-chain efficiency is improved in the H–H and H–H–P conditions.

We also check for learning effects in our results. Such effects, if identified, could potentially reduce the bounded-rationality biases. However, Fig. 2 indicates that learning-by-doing (Bolton & Katok, 2008) measured by round effect is not significant in our experiments. From Fig. 2 and the regression on rounds, subjects do not systematically adjust their choices toward the optimal wholesale price (equal to 12 in this experiment), supporting the belief that there is minimal or no learning effects. Similar analysis has also been applied to H–H and H–H–P conditions (as shown in the Appendix). The results provide no sign of learning in terms of round effects so that we may safely exclude learning from our explanation of the experimental outcomes.

4.2. Hypothesis 2: fairness concerns testing and results

Table 5 presents the testing results for Hypothesis 2. The differences between the H–C and H–H experiments are all significant. Under H–H the pricing decisions are significantly different from the standard-model predictions, resulting in higher supply-chain efficiency and more balanced profit distribution. These results are contrary to our findings in the H–C experiment, where the prices and supply-chain profit distribution are close to what is predicted by the standard model with slightly reduced supply-chain efficiency.

We expect subjects to be influenced by bounded rationality under both the H–H and H–C experiments. However, in the H–H case, the supplier charges an average wholesale price less than that in the H–C case and the retailer follows with a lower retail price as well. The supply chain achieves a more balanced profit distribution and a higher efficiency. Therefore, we conclude that the pricing decision and performance anomaly observed in the H–H

[4] Cash payments based on subjects' performance are against our IRB protocol, and thus impractical for the experiment.

Fig. 2. Supplier decisions by rounds under H–C (in this and all following figures, the dashed line shows the theoretical optimal value).

Table 5
Hypothesis tests of fairness concern and results.

	t-statistics	*p*-Value
Supply chain performance		
H_0: Efficiency (H–C)=Efficiency (H–H)	−3.3501	0.0012
H_0: Share (H–C)=Share (H–H)	2.9332	0.0043
Optimal decisions		
H_0: Player decisions (H–C)=Player Decisions (H–H)		
H_0: w (H–C) = w (H–H)	4.1673	0.0001
H_0: p (H–C) = p (H–H)	3.8303	0.0002

Table 6
Hypothesis tests of private cost information and results.

	t-statistics	*p*-Value
Supply chain performance		
H_0: Efficiency (H–H)=Efficiency (H–H-P)	0.2729	0.7856
H_0: Share (H–H)=Share (H–H–P)	−1.342	0.1829
Pricing decisions		
H_0: Wholesale price w (H–H) = w (H–H–P)	−1.5104	0.1342
H_0: Retail price p (H–H) = p (H–H–P)	−2.5242	0.0135

condition can only be caused by fairness concerns, which is missing in the H–C condition. The rejection of Hypothesis 2 on supply-chain decision and performance provides strong evidence that there is a significant impact from human fairness concerns in the H–H treatment, but not in the H–C treatment.

Next, we take a closer look at the results between the H–H and H–H–P treatment conditions focusing on the potential impact from private cost information.

4.3. Hypothesis 3: private cost information testing and results

In the H–H and H–H–P experiments, the human players are influenced by both bounded rationality and social-preference concerns. According to the standard analytical model, a fully rational profit-driven supplier will pick a wholesale price $w^* = \frac{A+\beta c}{2\beta} = 12$ and a retailer will choose a retail price $p = \frac{A+\beta w}{2\beta} = 10 + 0.5w$. Moreover, when the manufacturing cost c is known only to the supplier, a rational retailer should not alter her response, as the optimal retail price does not depend on the manufacturing cost c but only on the wholesale price w charged by the supplier. Therefore, if there is an impact from private cost information under H–H–P, it is unlikely to affect the retailer's bounded rationality since the retailer's profit-maximizing process is identical between H–H and H–H–P experiments. Similarly, private cost information should not alter the supplier's bounded rationality as he faces the same optimization task between H–H and H–H–P treatments.

However, subjects' fairness concerns can differ between H–H and H–H–P. With fairness concerns, a supply-chain-agent utility function includes the other agent's profit in addition to his own payoff. However, under the H–H–P treatment, the retailer is not able to observe the supplier's profit during or after her selection of the retail price. The supplier may also shift his decision, knowing that the retailer is not able to observe the supplier or channel profit. Therefore, we suggest that private cost information may potentially alter both the human supplier and retailer's decisions through their fairness concerns, but not through bounded rationality.

Table 6 presents the *t*-test results for the private information hypothesis. Hypothesis 3 testing-results are not significant except for the choice of retail price, *p*. This result motivated us to conduct additional measurements to explore the private information effect over the eight rounds.

First, we present the subjects' pricing decisions graphically over eight rounds. Fig. 3 illustrates the supplier (first mover) wholesale prices, averaged over the round per condition. The dashed line is the price predicted by a rational decision-maker from the standard model. Although the average wholesale price in both conditions, H–H and H–H–P, is less than the theoretical value, it is higher in the H–H–P condition than in the H–H condition for seven out of the eight rounds. This result indicates that the human supplier is more aggressive when the unit cost becomes his private information.

Fig. 4 shows the retailer price decisions across all rounds, along with their best responses (rational choices to maximize retailer profits for any given w). Fig. 4(a) shows that the average retail price under H–H–P is significantly higher than that under H–H in all rounds. A more interesting observation from Fig. 4(b) is that the retail price in the public information case is consistently below the best response, while the retail price in the

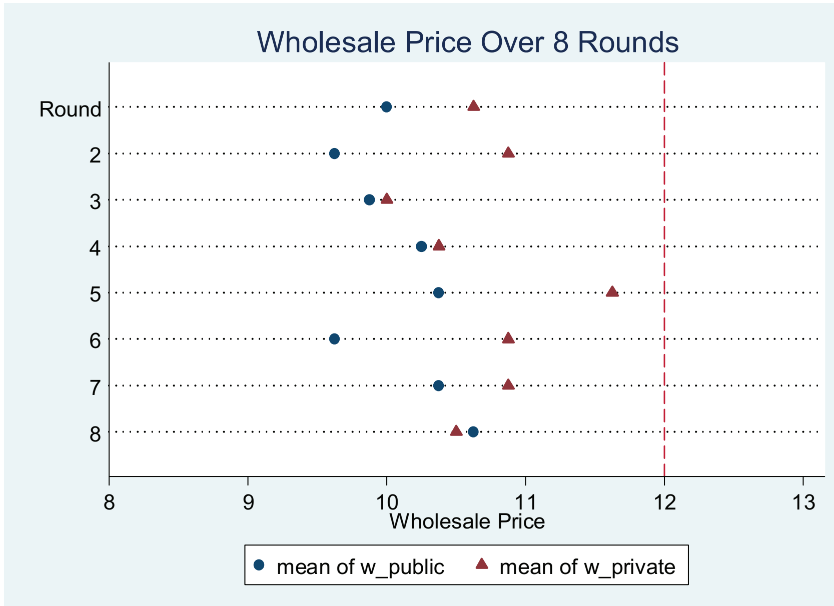

Fig. 3. Wholesale price decisions over eight rounds under H–H and H–H–P.

private case nearly matches the best response. This indicates that private cost information promotes "rational" retailer decision-making as though the retailer is making self-interested decisions without considering her rival's profit share. To statistically test for such a hypothesis, we estimate the analytical model of $p = k_1 + k_2 w$ between H–H and H–H–P condition. A rational retailer should respond with a retail price $p = 10 + 0.5w$ in our experiment. For all (w, p) pairs under the H–H condition, the estimated equation is $\hat{p} = 8.391(0.576) + 0.616(0.055)w$. The p-values for the F-test of the estimates $k_1 = 10$ and $k_2 = 0.5$ are 0.007 and 0.038, respectively; both are rejected at 5 percent level of significance. For all pairs under the H–H–P condition, the estimated equation is $\hat{p} = 9.645(0.313) + 0.533(0.029)w$, p-values for the F-test of the estimates $k_1 = 10$ and $k_2 = 0.5$ are 0.261 and 0.257, respectively; thus, we find no evidence to support that the human retailer under H–H–P sets her retail price differently than the best response. In addition, paired t-tests between the retailer pricing and her best response provide a p-value of 0.0095 in public information and 1.000 in private information, supporting that the retailer sets her price reliably below her best response in the public case while choosing the best response in the private case.

Next, we compare supply chain profits between H–H and H–H–P experiments. As Fig. 5(a) illustrates, under both H–H and H–H–P treatment conditions, the supplier (retailer) earns less (more) than the theoretical benchmark in all rounds. Furthermore, both the supplier and the retailer profits move closer to the theoretical prediction from public to private cost information in seven out of the eight rounds, resulting in the supplier profit share being closer to the theoretical prediction (0.667) in six out of the eight rounds as shown in Fig. 5(b).

The comparison of H–H and H–H–P reveals how private cost information affects supply-chain interactions in the presence of fairness concerns. Both the supplier and the retailer set prices consistently higher in the private case than in the public case, showing subjects to be more aggressive under H–H–P. Nonetheless, even when the retailer behaves rationally under private cost information, the equity concern effect is still significant as the wholesale price is less than the standard-model prediction.

Two competing effects may play a role in explaining the outcome of the H–H–P experiment: the broken link of reciprocity and the supplier's preference for equity. Due to a lack of supplier cost information and profit information, the retailer's utility for fairness is suppressed, yielding her selfish responses in retail price. Under private cost information, the supplier can no longer set a "fair" wholesale price and expect the retailer to order more units in return for his favor since the retailer cannot tell whether there is such a favor offered by the supplier. Therefore, the reciprocity between the supplier and retailer is likely to be suppressed. However, as demonstrated by our experiments, the supplier still exhibits certain fairness concerns that may be due to altruism and have nothing to do with the retailer's action.

5. Closing the gap: fair-minded model revisited

Using our experimental data, we estimate the other-regarding coefficients for the behavioral model incorporating fairness concerns from Section 2.2. Such estimation enables us to measure how the supplier's fairness concerns shifts between H–H and H–H–P conditions, when both the supplier and the retailer are subject to random errors accounting for bounded rationality effects.

5.1. Equilibrium price and estimation

Substituting our experimental parameters $A = 20,\ \beta = 1,\ c = 4$ into (3) and (4), the equilibrium prices for the supplier and the retailer are

$$w^* = \frac{4\left(6 - 2\theta_R - 5\theta_S + \theta_R^2\theta_S\right)}{(1 - \theta_R)(2 - (1 + \theta_R)\theta_S)}, \tag{5}$$

and

$$p^* = \frac{4(8 - (5 + 3\theta_R)\theta_S)}{2 - (1 + \theta_R)\theta_S}. \tag{6}$$

Under the H–H–P game, the supplier's cost and profit information are unknown to the retailer, so we cannot directly use our analysis above. However, from Section 4.3, we find that under private cost, the retailer behaves *as if* she simply maximizes her own profit when she has no information on her rival's cost or profit-share[5]. We then have $U_R = \Pi_R$ by setting $\theta_R = 0$ for H–H–P

[5] This observation does not apply to other supply-chain settings in general, because nothing prevents the retailer from having a belief about her supplier cost.

Fig. 4. Retail price and comparison with best response over eight rounds. (a) retailer prices under public and private cost information; (b) retail price vs. best response under public and private cost information.

treatment. Thus, in the H–H–P game, the equilibrium prices (5) and (6) reduce to $w^* = \frac{24-20\theta_S}{2-\theta_S}$ and $p^* = \frac{32-20\theta_S}{2-\theta_S}$.

We now estimate the other-regarding parameters in our behavioral model. We model the bounded rationality using the random decision error term. Let the subscript t denote the individual rounds, each of which corresponds to a different supplier-retailer pair. Since each subject plays multiple rounds in our design (albeit only once for each pair), we use random effect error terms to capture the possible non-independent, within-subject variation. Pricing decisions made by the supplier i (1…8) and retailer j (1…8) in round t (1…64), p_t and w_t, are assumed to follow the sum of two bivariate normal distributions:

$$\begin{pmatrix} w_t \\ p_t \end{pmatrix} \sim N\left\{ \begin{pmatrix} w^* \\ p^* \end{pmatrix}, \begin{pmatrix} \sigma_w^2 & \rho\sigma_w\sigma_p \\ \rho\sigma_w\sigma_p & \sigma_p^2 \end{pmatrix} \right\} + N\left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_i^2 & 0 \\ 0 & \sigma_j^2 \end{pmatrix} \right\}, \tag{7}$$

where the terms w^* and p^* are the equilibrium predictions of the behavioral model in Eqs. (5) and (6), σ_w^2 and σ_p^2 are the idiosyncratic errors and σ_i^2, σ_j^2 capture the individual-specific variability. The choice of w and p from a single round are correlated by nature, as reported by Loch and Wu (2008). We hence use the parameter ρ to capture the correlation coefficient. To estimate our model, we use Bayesian statistical inference with Markov Chain Monte Carlo (MCMC) methods. We use non-informative priors for all parameters and implement the model in the RStan package (2015).

We consider two different models for the H–H treatment[6]. One restricts the fairness parameters θ_S and θ_R to be 0, and the other model does not. If the equity concern exists as we hypothesized, we should expect the second model to be a better fit for the data, while having none-zero estimates for the fairness parameters, and vice versa.

Under the H–H–P condition with private cost information, we estimate three models. The first model restricts θ_S and θ_R to be 0. The second model only sets $\theta_R = 0$ because the retailer has no information on the production cost to anchor her equity concerns on. The third model again allows both fairness parameters to be

[6] We thank one of the reviewers for suggesting this analysis.

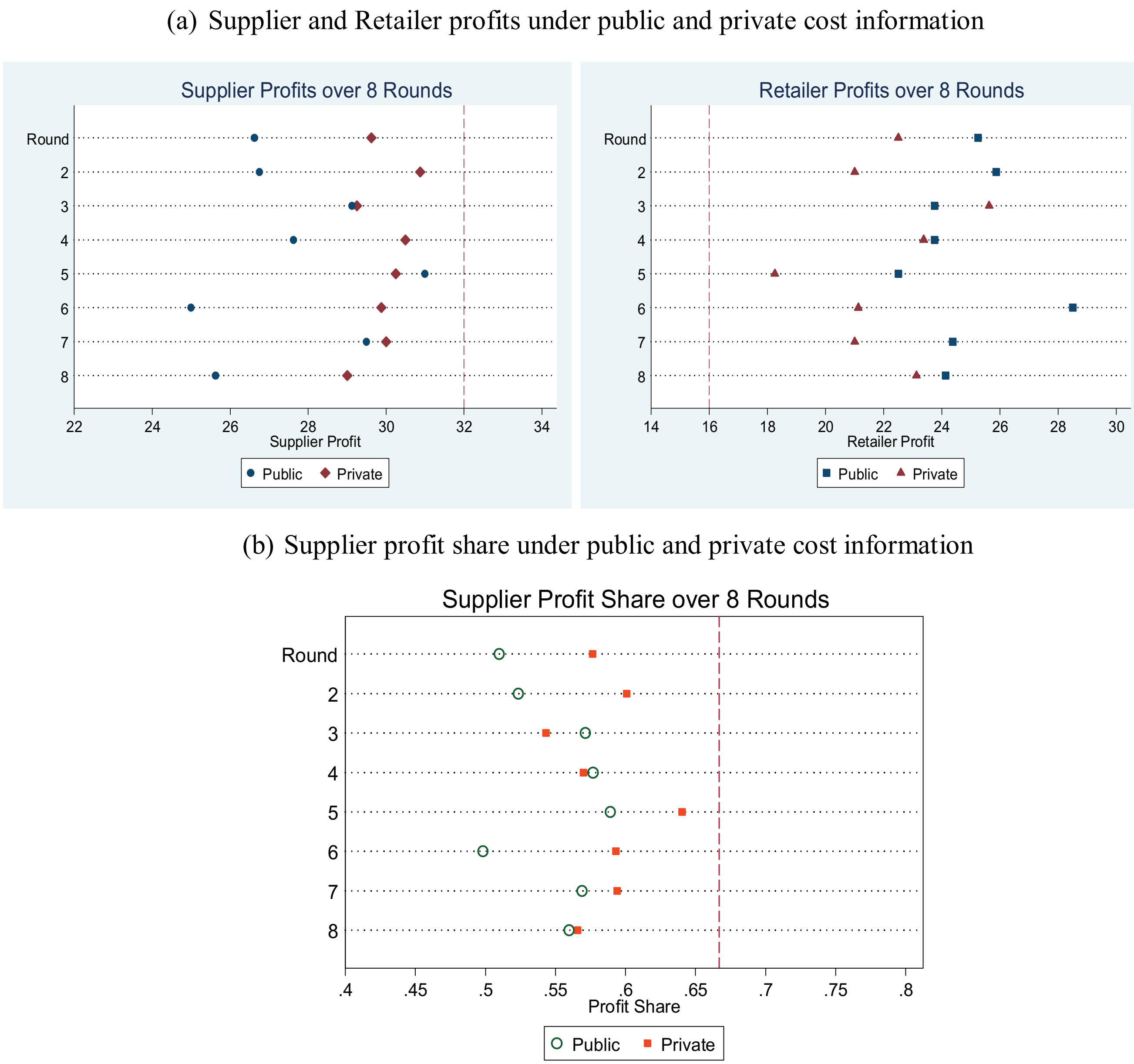

Fig. 5. Supply-chain agent profits over eight rounds. (a) supplier and retailer profits under public and private cost information; (b) supplier profit share under public and private cost information.

estimated. We expect the estimated other-regarding coefficient θ_S to be smaller than that under the H–H condition, because the supplier now lacks motivation for retailer reciprocation in his equity concern. In addition, if the experiments were conducted ideally, we should expect θ_R to be close to zero.

Similarly, we estimate two models with and without θ_S, the supplier's other-regarding coefficient, for the H–C game. Since the computer always chooses the best response price, we use a univariate normal distribution to model the values of w_t, $w_t \sim N(w^*,\ \sigma_w^2)$. In this model, we no longer need the individual effect component since we have one observation for each subject.

5.2. Estimation results

Table 7 shows the estimation results. Under each treatment condition, we first compare different models' performance using the Bayesian information criterion (BIC). BIC is defined as $-2LL + k\log(n)$, where k is the number of free parameters and n is the sample size (Schwarz, 1978). BIC balances the model likelihood and the complexity, allowing us to choose the best model to present data under each treatment. For H–H models where cost information is public (Panel A), the model with fairness parameters dominates the model with no fairness parameters, providing compelling evidence that fairness is important in the setting. In Panel B, under the private-cost-information treatment (H–H–P), the model with only θ_S is better than the model with both fairness parameters or the model with no fairness parameter at all. This attests our analysis of the experiment to be valid. In addition, the results show that even knowing the other party does not have the cost information, the other-regarding parameter should still be considered.

Now we examine the parameter estimates and pinpoint the scale of supplier fairness concerns under these two conditions. The supplier other-regarding parameter is estimated to be $\theta_S = 0.624$

Table 7
Parameter estimations across all three treatments.

	No fairness parameters		With fairness parameters	
	Estimate	95 percent CI	Estimate	95 percent CI
Panel A: Estimates for H–H models				
Fairness				
θ_S	set as 0	–	**0.624*** **(0.058)**	**(0.518, 0.752)**
θ_R	set as 0	–	**0.124*** **(0.060)**	**(0.052, 0.273)**
Decision errors				
σ_w	2.077* (0.345)	(1.375, 2.745)	**0.823*** **(0.338)**	**(0.229, 1.509)**
σ_p	1.426* (0.262)	(0.940, 1.964)	**0.915*** **(0.302)**	**(0.344, 1.546)**
ρ	0.938* (0.069)	(0.751, 0.998)	**0.773*** **(0.217)**	**(0.193, 0.996)**
Model LL	−305.381		**−286.844**	
Model BIC (lower is better)	689.780		**661.024**	

	No fairness parameters		With θ_S		With θ_S and θ_R	
	Estimate	95 percent CI	Estimate	95 percent CI	Estimate	95 percent CI
Panel B: Estimates for H–H–P models						
Fairness						
θ_S	set as 0	–	**0.302*** **(0.037)**	**(0.227, 0.374)**	0.286* (0.062)	(0.161, 0.406)
θ_R	set as 0	–	set as 0	–	−0.038 (0.068)	(−0.170, 0.092)
Decision errors						
σ_w	0.485* (0.252)	(0.116, 1.033)	**0.593*** **(0.230)**	**(0.196, 1.089)**	0.534* (0.204)	(0.170, 0.968)
σ_p	0.392* (0.167)	(0.104, 0.736)	**0.336*** **(0.140)**	**(0.087, 0.608)**	0.299* (0.122)	(0.090, 0.552)
ρ	0.718* (0.246)	(0.117, 0.993)	**0.776*** **(0.232)**	**(0.139, 0.997)**	0.733* (0.248)	(0.084, 0.995)
Model LL	−227.628		**−201.918**		−204.155	
Model BIC (lower is better)	534.275		**487.013**		487.329	

	No fairness parameters		With fairness parameters	
	Estimate	95 percent CI	Estimate	95 percent CI
Panel C: Estimates for H–C models				
Fairness				
θ_S	set as 0	–	−0.184 (0.112)	(−0.381, 0.042)
Decision errors				
σ_w	**2.390*** **(0.325)**	**(1.860, 3.133)**	2.334* (0.330)	(1.793, 3.062)
Model LL	**−63.461**		−62.658	
Model BIC (lower is better)	**130.254**		131.981	

Note: * denotes the parameter estimates that are significant at the 0.05 level. Bolded are the best model according to the BIC. The parameter estimates are the posterior means followed by the posterior standard deviations. 95 percent CI stands for 95 percent credible interval. Individual mixed effect estimates for Panels A and B are omitted.

under the public-cost-information treatment (H–H), and $\theta_S = 0.302$ under the private-cost-information treatment (H–H–P). Both θ_S estimates are significantly larger than zero; this indicates that the supplier's utility is positively related to the retailer's profit. Additionally, we see that because the θ_S value in the H–H–P treatment is only half of the amount in H–H treatment, suggesting that the supplier puts significantly less value on the retailer's profit in the private information game.

Consistent with our previous finding that the H–C game is not likely to be affected by fairness concerns, the model with no fairness parameter is slightly better in terms of BIC. Further, the other-regarding parameter θ_S is estimated to be −0.184 in the H–C condition and not statistically significant even when we include θ_S. As expected, fairness concerns are minimized in the H–C experiment where the human supplier knows that the retailer decisions are automated.

The other-regarding coefficient for the retailer, θ_R, is estimated to be 0.12; thus it is significantly larger than zero in the H–H condition, which means that the retailer's utility is also positively correlated with the supplier's profit. Under public cost-information, the retailer reciprocates the supplier's fairness concerns by charging a retail price less than the theoretical best response. We also find that the decision errors of the supplier's wholesale price (σ_W) are not significantly different between the H–H and H–C conditions.

As a robustness check, we estimate the behavior models using a maximum-likelihood method similar to Ho and Zhang (2008) and Becker-Peth et al. (2013). The results are reported in the Appendix and are consistent with the findings reported in Table 7.

Combining the estimation results of the inequity aversion parameters, we conclude that the supply-chain performance anomalies are mostly due to fairness concerns. Social-fairness concerns

Table 8
Summary of experimental findings related to human equity.

	H–C	H–H	H–H–P
Supplier	No equity concern	Equity concern (strong)	Equity concern (weak)
Retailer	–	Equity concern	No equity concern

persistently affect supply-chain dynamics even under private information when only the supplier knows unit production cost.

In summary, our behavioral model and other-regarding parameter estimates support our conclusions in Section 4 that fairness concerns affect supply-chain decision making for both the supplier and the retailer under public information, but only affect the supplier's decision to a lesser extent under private cost information. Our parameter estimates also demonstrate that such concerns do not significantly affect the H–C experimental outcome.

6. Conclusions

Our behavioral study establishes empirical evidence of human preference for equity in supply-chain decision making. Our H–H experiment reveals salient and sustained impact from fairness concerns, which is separable from other effects like bounded rationality as shown in the H–C experiments. Under a simple wholesale price contract, we show that fairness concerns lead to pricing decisions that deviate from the standard analytical predictions, which improves supply-chain performance in terms of increased efficiency. Both our experiments and recent analytical work (Cui et al., 2007; Katok et al., 2012) indicate that wholesale-price contract can coordinate a channel consisting of fair-minded supply chain agents.

As we further explore how fairness concerns affect the channel under private production-cost information, our results support that the preference for equity is relatively invariant of other effects like bounded rationality, but sensitive to private cost information. When the retailer has no information on the supplier cost and profit, the retailer's utility for fairness is suppressed, yielding selfish retail-price responses. Under private cost information, the supplier can no longer set a "fair" wholesale price and expect the retailer to order more units in return. Therefore, the reciprocity between the supplier and retailer is likely to be suppressed. However, as demonstrated by our experiments, the supplier still exhibits certain fairness concerns that may be due to altruism and have nothing to do with the retailer's action. We then use our experimental data to estimate the other-regarding coefficients in the generalized behavioral model. These measurements of social-fairness concerns support our conclusions that the sharing of the manufacturing cost information significantly alters how equity affects supply-chain decisions and profits. Table 8 summarizes the main findings of our experiments related to human equity.

Our study of social fairness concerns in the presence of private cost information has several important real-world implications. First, our work provides empirical evidence that, due to fairness concerns, even the simple wholesale-price contract may coordinate a channel consisting of fair-minded supply chain agents. In conjunction with Katok and Pavlov (2013)'s work which reveals that contracts that coordinate in theory may not actually coordinate the channel in reality, we provide further explanation on why simpler, theoretically-suboptimal contracts are commonly preferred in practice. Second, our results in the private cost information case illustrate weakened social-fairness considerations when the supply-chain profit distribution is unobservable by the retailer. Therefore, our findings suggest that disclosing private cost information can incentivize cooperation between suppliers and retailers, while not disclosing cost information to the retailer changes the pricing decisions and shifts the distribution of channel profit to the supplier's advantage.

One possible avenue of future work is testing the robustness of the equity effects under other coordinating contracts such as a two-part tariff or revenue sharing. Apart from a simple price-only contract, we are curious whether our conclusions still hold under contracts that are more complex. We suspect that contract complexity may result in a stronger effect from bounded rationality. Here, we refer to Kalkancı, Chen, and Erhun (2014) for further reading. In their paper, the authors find that fairness concerns tend to be weaker when the complexity of the contract is high. Our work motivates future attempts to close the gap between the supply-chain modeling and subjects' behavioral biases.

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Supplementary materials

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