Do Markets Make People Selfish?[*]

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Abstract

The predictions of economic theory in market settings are associated with the assumption that economic agents act to maximize their material self interest. This paper demonstrates that the agents will appear to be acting in their material self interest and market outcomes will be competitive under more general assumptions about preferences.
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1 Introduction

The earliest and most striking success of experimental economics was the confirmation of textbook behavior in simple markets.[1] Experimental markets clear at competitive prices even with small numbers of agents. The results of these experiments coincide with the predictions of equilibrium theories based on optimizing behavior by selfish actors. In contrast, even in the simplest bilateral bargaining settings, such as the ultimatum game, the predictions of game-theoretic models with rational, income-maximizing actors do not agree with experimental findings. These violations are systematic and widely replicated, casting doubt on the relevance of the descriptive power of standard models in strategic settings.

Researchers responded to the bargaining experiments by proposing models that are consistent with the experimental evidence. Models of bounded rationality, learning, or optimization of interdependent preferences all capture broad patterns of bargaining behavior.[2] On the other hand, I argue that the outcomes of market experiments are consistent with behavior far more general than selfish optimization. I examine a model in which agents are rational, but their preferences may depend on more than their material consumption. Elsewhere[3] it has been demonstrated that these models do a good job organizing experimental results that are at odds with standard predictions.

This paper adds to the literature by describing a family of preferences which can depend on both the distribution of monetary payoffs and the intentions of others. If players have these preferences, then equilibrium outcomes can be consistent with experiments that confirm standard theory and with experiments that reject it. Section 2 presents results in auction-style environments that have been studied in the literature. Buyers and sellers announce bid and ask prices and the market institution dictates that transactions take place at a market-clearing price. It is well known that when agents avoid weakly dominated strategies and maximize their monetary gains, exactly those individuals who have positive monetary gains from trade will transact in equilibrium. I show that the same conclusion holds even when agents have preferences that place non-zero weight on the material payoffs of others. That

[1]See, for example, Davis and Holt [10] for a textbook treatment and Smith [26] for a seminal study.

[2]See Camerer [7] or Sobel [27] for surveys.

[3]Bolton and Ockenfels [5] and Fehr and Schmidt [12] are two examples.

is, the existence of interdependent preferences does not change the volume of trade. The presence of these agents may influence the market-clearing price. However, equilibrium prices may differ from the prices predicted when agents maximize their monetary payoff only when markets are balanced in a sense I make precise. When there are equal numbers of buyers and sellers and all traders on the same side of the market share the same valuation, the market is balanced and the existence of unselfish agents might influence the equilibrium transaction price. This is the case in the ultimatum game where there is one agent on each side of the market. Hence my model is consistent with ultimatum game experiments in which proposers typically share the surplus equally rather than generating the unequal splits predicted by theory. In unbalanced markets, the standard forces that give power to the short side of the market operate even if traders care about the payoffs of their opponents.

There is a simple intuition for the results. Imagine a situation in which an agent only decides whether to trade at a market price. If his decision does not influence the market price or the volume of trade, then he has no opportunity to change the monetary payoffs of others in the economy. Therefore, pure self interest determines behavior. In the auction markets that I study players have limited ability to change market price or trading volume. As a result, they typically behave as if they care only about their own monetary payoff. My results depend on a replacement assumption that states, loosely, an agent would prefer to make a make a trade that increases his monetary payoff rather than let someone else make the same transaction. Section 2.2 contains a formal description of the assumptions needed for the main result. In Section 2.4 I show that familiar models of interdependent preferences satisfy my assumptions.

In Section 3, I study a general-equilibrium model in which agents have preferences that depend on more than their own consumption. Preferences over consumption bundles depend on the actions, endowments, or consumptions of others, but are general enough to include both altruistic and spiteful behavior. For my specification of preferences, consumers will always maximize their utility from material payoffs in a market equilibrium. This simple finding is almost a definition: If consumers take prices as given and can only trade directly in their own consumption goods, then there is no scope for making transactions that directly benefit or harm other agents. The issue then becomes, under what conditions is the price-taking assumption appropriate. The same question is valid under standard assumptions. The standard answer also applies: Under appropriate continuity conditions, if the economy is large, then price taking is approximately optimal.

Several papers point out that predictions of economic theory do not require rational behavior. Becker [4] demonstrates that budget constraints place some observable limits on demand even if otherwise behavior is random. Conlisk [9] shows that Cournot behavior in an economy with free entry and in which firms have small efficient scales will be approximately competitive for a range of boundedly rational behaviors. In a context similar to the model in Section 2, Gode and Sunder [16] demonstrate through simulations and experiments that optimizing behavior of selfish agents is not necessary for double-auction markets to arrive at competitive prices and efficient allocations. Gode and Sunder assume that some of their bidders have "zero intelligence." Zero-intelligence bidders are constrained to bid no more than their valuation, but otherwise behave randomly. Still, Gode and Sunder find that markets converge rapidly to competitive outcomes. Like the experiments, this work suggests that standard assumptions are not necessary for standard results.[4]

This paper differs from Gode and Sunder because I establish analytical results in a static auction environment, while they provide simulation results in a less constrained dynamic setting. In contrast to Becker [4], Conlisk [9], and Gode-Sunder [16], I do not relax the assumption that agents are goal oriented. My agents optimize a general utility function that includes standard income maximization. The other papers instead assume stochastic decision making constrained by feasibility or individual rationality restrictions. A final, important, difference is that the Becker [4], Conlisk [9], and Gode and Sunder [16] results operate at the aggregate level. They demonstrate that markets work well even when there is a random component to individual behavior. My model provides conditions under which individual agents choose to behave the same way as selfish agents even though they have different objectives.

Papers of Bolton and Ockenfels [5], Falk and Fischbacher [11], and Fehr and Schmidt [12] contain results similar to the ones I present in Section 2.3. These papers introduce models of interdependent preferences or reciprocity. They show that their models can be consistent with experiments both experiments that challenge and confirm predictions of standard models. My

[4]While Gode and Sunder [16] establish their results through simulations, earlier work of Hurwicz, Radner, and Reiter ([17] and [18]) provide a theoretical foundation for their findings.

paper advances the literature by extending the results to a richer class of environments and proving the result for a general class of preferences.

Economics assumes that agents are goal oriented and tailor behavior to fit their environment. The discipline accepts the fact that institutions (understood broadly to mean the rules of strategic interaction) influence behavior and has good techniques for studying how institutions influence behavior. On the other hand, economics assumes that agents are selfish and rational. Hence, from the perspective of traditional economic theory, the question of the title, "Do Markets Make People Selfish?" is not interesting because people are selfish by definition.

I argue that the question is interesting, and that recent models of extended preferences provide a non-trivial way to answer the question. Bowles [6, p. 89] observes that "the more the experimental situation approximates a competitive (and complete contracts) market with many anonymous buyers and sellers, the less other-regarding behavior will be observed." Bowles's article provides an excellent overview of a literature that suggests that institutions may influence preferences. He cites broad historical and anthropological evidence in support of the idea in addition to review. Since there is widespread evidence that the assumption of self-interested behavior is not a good one in different environments,[5] it is natural to conjecture that the environment in which economic transactions take place influences attitudes preferences.

The suggestion that people become selfish when placed in market environments is more common outside economics than within it. Classical political philosophy argued that it was the role of good government to make good citizens. Aristotle [2, 1103b3] wrote that "lawgivers make the citizen good by inculcating habits in them" and argues that it is the role of government to build the institutions that make good people. Lane [20, p. 17] states this position forcefully: "Inevitably the market shapes how humans flourish, the development of their existences, their minds, and their dignity."[6] Some anthropologists argue that markets replace exchange based on reciprocity and, in doing so, change the nature of humanity.[7] In his comparative study of the

[5]Camerer [7], Fehr and Schmidt [13], and Sobel [27] provide overviews.

[6]Lane derives his notion of dignity from Kant [19, p. 96], who argues that dignity cannot only be derived from things that are subject to commercial exchange: "In the realm of ends everything has either a price or dignity. Whatever has a price can be replaced by something else which is equivalent; whatever is above all price, and therefore has no equivalent, has dignity."

[7]For example, Mauss [21, p. 74] writes that "it is only Western societies that quite

development of markets in Indonesian villages, Geertz [15, p. 34] writes that "the general reputation of the bazaar-type trader for 'unscrupulousness,' 'lack of ethics,' etc., arises mainly from this role asymmetry in the retail market."

This paper does not reject the hypothesis that inserting individuals into market environments changes their preferences, but it suggests another way to look at the evidence. I argue that market participants look selfish, but their behavior in markets may not extend to other environments. The context in which behavior takes place changes the nature of decisions of goal-oriented agents, but it need not change their preferences. There is a dual observation that is perhaps more familiar. Certain environments induce people to act as if they were unselfish even if they care only about their monetary payoffs. Often in repeated games or in environments designed to induce cooperation, one cannot distinguish the behavior of selfish agents appropriately responding to incentives from people who care directly about the monetary payoffs of others.

I emphasize two implications of my approach. First it suggests that laboratory confirmations of the predictions of market models can be viewed as evidence of the robustness of the market institution rather than the prevalence of selfish behavior. Second, while I establish that competitive outcomes arise even when consumers are not selfish, the efficiency of these outcomes is not guaranteed. In fact, one can interpret the existence of non-market transfers as ways to remedy inefficiencies that arise in market equilibrium.

2 Market Games

This section describes how the standard predictions of market models continue to hold when agents have preferences may depend directly on the monetary payoffs of their opponents. Subsection 2.1 describes the basic model. Subsection 2.2 describes a general family of preferences. Subsection 2.3 states and describes the main results. Subsection 2.4 discusses how some extended preferences used in the literature satisfy the assumptions introduced in Subsection 2.2.

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recently turned man into an economic animal. But we are not yet all animals of the same species."

2.1 The Model

I focus on a call-market model in which there are m buyers and n sellers. Buyers demand at most one unit of a homogeneous good. Buyer B_i has valuation v_i. Sellers can produce at most one unit of the good. Seller S_j has cost c_j. For convenience, I assume that if $j < j'$, then $c_j \leq c_{j'}$ and if $i' > i$, then $v_{i'} \leq v_i$.

Simultaneously, each buyer makes an offer for the item (interpreted as the most he will pay to purchase an item) and each seller sets an asking price (interpreted as the least she will accept to produce the item). The market clears using the following price-formation mechanism. Put the $m+n$ bids (offers and asks) in non-decreasing order, $d_1 \leq d_2 \leq \cdots \leq d_{m+n}$. The $(m+1)^{\text{th}}$ of these quantities becomes the market price, p. Buyers who bid no less than p and sellers who ask no more than p are said to make acceptable offers. Buyers who bid more than p and sellers who ask less than p transact. Those traders offering p are marginal traders. If there are equal numbers of buyers bidding at least p and sellers asking no more than p, then all marginal traders transact. If there are more agents on one side of the market, then marginal agents on the short side (the side with fewer acceptable offers) transact, while marginal agents on the long side of the market transact with the common probability needed to make supply equal demand.[8] The transaction price is always p. It is possible to clear the market with any price between the m^{th} and $(m+1)^{\text{th}}$ bid. Using the $(m+1)^{\text{th}}$ bid gives the buyer some power to set prices in that a marginal buyer may be able to lower the market price and still trade by reducing his offer.

Seller S_j earns a monetary payoff of 0 if she does not transact and a monetary payoff of $p - c_j$ if she does transact. Buyer B_i earns a monetary payoff of 0 if he does not transact and a monetary payoff of $v_i - p$ if he does transact. To avoid existence problems, assume that bids must be elements of a discrete set.[9] I let $\delta > 0$ denote the monetary unit and assume that all costs and values are nonnegative multiples of δ. The results rely on a continuity condition, stated formally below, which requires that a seller prefers to make a favorable transaction at a given price with probability one than to transact

[8] If only one of the bids and asks is equal to p, then buyers bidding at least p and sellers asking less than p transact.

[9] For example, if seller has cost 0 and buyers have values 1 and 2, then buyer 2 would like to bid a bit more than 1 to get the item when other agents truthfully report their valuations.

with probability $(n-1)/n$ at a slightly higher price. This assumption is reasonable only if δ is small relative to the set of valuations and the number of agents.

If the $(m+1)^{\text{th}}$ bid, d_{m+1}, is strictly greater than d_m, then $p = d_{m+1}$ and buyers who bid at least p transact with sellers who ask less than p. When $d_m = d_{m+1}$ describing the outcome is a bit more complicated because there is the possibility that marginal traders on one side of the market trade with a probability strictly between zero and one. Appendix A describes the more general expressions. The outcome of the call market is a price p and a specification of the set of agents who transact.[10] Denote the outcome by $(T; p)$ where T consists of the buyers and sellers who trade at p. The outcome is market clearing because equal numbers of buyers and sellers trade and active traders consist of exactly those agents whose bids were compatible with the market price.[11] The specification above guarantees that the maximum number of compatible trades are made. If players maximize an increasing function of their monetary payoffs, then equilibrium theories predict that the market price must be **competitive** in the sense that it is market clearing and agents who have strictly positive monetary gains from trade at the market price transact while those who lose from transacting do not.

Formally, let k^* be the maximum sustainable number of transactions with strict gains from trade – that is, $c_{k^*} + \delta \leq v_{k^*} - \delta$, but $c_{k^*+1} \geq v_{k^*+1}$.[12] I assume throughout that $k^* > 0$.

Let $E(p)$ be defined to be the excess supply function (assuming that agents maximize monetary surplus). That is, $E(p)$ is the difference between the number of sellers with costs strictly less than p and buyers with valuations strictly greater than p. It is clear that $E(0) < 0$, $E(1) > 0$ and $E(\cdot)$ is increasing. Consequently, the values $\underline{p}$ and $\bar{p}$ given by

$$\underline{p} = \min\{p : E(p) \geq 0\} \tag{1}$$

and

[10] One could also include a specification of the trading partner of each active agent. I assume that preferences are independent of this information and suppress it in the notation.

[11] That is, all buyers who offer more than p trade with probability one; all sellers who ask less that p trade with probability one; all buyers who offer less that p trade with probability zero; and all sellers who ask more than p trade with probability zero.

[12] I assume that the difference in valuation between the marginal traders is at least 2δ because otherwise there exists no price that gives strictly positive material surplus to both S_{k^*} and B_{k^*}.

$$\bar{p} = \max\{p : E(p) \leq 0\} \tag{2}$$

are well defined with $\bar{p} \geq \underline{p}$. Competitive prices are those $p \in [\underline{p}, \bar{p}]$. $\underline{p} > c_{k^*}$ and $v_{k^*} > \bar{p}$. Further, if $c_{k^*+1} = b_{k^*+1}$, then $\underline{p} = \bar{p} = c_{k^*+1} = b_{k^*+1}$.

It is straightforward to show that if agents maximize strictly increasing functions of their monetary payoffs, then the dominant strategy of a seller S_j is to ask c_j. It is clear that sellers have nothing to gain from bidding less than their valuation. The trading institution guarantees that if a seller trades with positive probability, then reducing her bid will not change the market price. Hence the strategy of bidding strictly more than c_j is also weakly dominated. It is also a weakly dominated strategy for a buyer to offer more than his valuation. If all of the traders follow their dominant strategy, then the equilibrium price will be equal to the lowest price at which market demand is equal to market supply.[13] To determine the equilibrium behavior of the buyers, let d_k^* denote the k^{th} lowest valuation in the population. Given that the sellers ask their true valuation, it is a best response for the buyer with the smallest valuation greater than or equal to d_{m+1}^* to be the price setter. If valuations are distinct ($d_k^* < d_{k+1}^*$ for all k), then the price-setting buyer offers d_m^*. If there are two or more price-setting buyers, then they may offer as much as d_{m+1}^*. It is a best response for all buyers other than the price setter(s) to offer to pay their valuation.

2.2 General Preferences for Market Games

The outcome of a market game determines a distribution of money over the population. Standard theory posits that a player's utility is increasing in his own monetary payoff and independent of the distribution of payoffs received by the other players. I wish to allow preferences that are more general in two different ways.

The first generalization is to permit preferences to depend on the entire distribution of income. So, for example, a player's utility may be based on a weighted sum of the monetary payoffs to the individuals in the game, with non-zero weights on what opponents' receive. This kind of preference relationship can exhibit altruism, spite, utilitarianism, or inequity aversion depending on the weights. Permitting distributional preferences of this kind

[13] There are also equilibria in weakly dominated strategies. For example, all sellers can ask more than the highest valuation and all buyers can bid less than the lowest valuation.

is fully consistent with standard game theory. The second generalization is to permit preferences to depend on the strategic context. Models of this sort have been proposed by Geanakoplos, Pearce, and Stacchetti [14], Rabin [23], and Segal and Sobel [25] among others. In this environment, preferences over outcomes may depend on the strategy choice.

Recall that in a market game an outcome is a pair (T, p) where T is the set of active traders and p is the price. Each outcome determines a distribution of monetary payoffs, $O(T; p) = (x, y)$ where $x = (x_1, \ldots, x_j, \ldots, x_n)$ where x_j is the monetary payment to seller S_j and $y = (y_1, \ldots, y_n)$ is the vector of monetary payments to the buyers. It follows that $x_j = p - c_j$ if seller S_j is in T and 0 otherwise. Preferences of the players are defined over elements of $\mathbf{R}^{m+n}$. I permit the preferences $\succ_{B_i,\sigma^*}$ and $\succ_{S_j,\sigma^*}$ (and corresponding indifference relations, $\sim_{B_i,\sigma^*}$ and $\sim_{S_j,\sigma^*}$) to depend on the strategy profile σ^* of the game.

I now present some properties of preferences that are useful in subsequent subsections. In the statements below, σ^* denotes a strategy profile.

Individual Rationality (IR) For all σ^*, if $S_j \in T$ and $p < c_j$, then for all p' and T' with $S_j \notin T'$,

$$(\mathbf{T}', \mathbf{p}') \succ_{S_j,\sigma^*} (T, p) \tag{3}$$

and if $B_i \in T$ and $p > v_i$, then for all p' and T' with $B_i \notin T'$

$$(\mathbf{T}', \mathbf{p}') \succ_{B_i,\sigma^*} (T, p) \tag{4}$$

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Replacement (R) For all σ^*, if $p > c_j$ and T is obtained from T' by replacing $S_{j'} \in T'$ by $S_j \notin T'$, then

$$(T, p) \succ_{S_j,\sigma^*} (T', p) \tag{5}$$

and if $p < v_i$ and T is obtained from T' by replacing $B_{i'} \in T'$ by $B_i \notin T'$, then

$$(T, p) \succ_{B_i,\sigma^*} (T', p) \tag{6}$$

.

Continuity (C) For all σ^* and $p > c_j + \delta$ such that if T is obtained from T' by replacing $S_{j'} \in T'$ by $S_j \notin T$, then

$$(T, p - \delta) \succ_{S_j,\sigma^*} \frac{n-1}{n}(T, p) + \frac{1}{n}(T', p) \tag{7}$$

and if $p < v_i - \delta$ such that if T is obtained from T' by replacing $B_{i'} \in T'$ by $B_i \notin T'$, then

$$(T, p - \delta) \succ_{B_i,\sigma^*} \frac{m-1}{m}(T, p) + \frac{1}{m}(T', p). \tag{8}$$

Gains From Trade (GT) If $c_i + \delta < v_j$ and $T = T' \cup \{B_i, S_j\}$ for $B_i, S_j \notin T'$, then there exists $p^*_{i,j}$ such that for all σ^* and T containing $\{B_i, S_j\}$, then

$$(T, p) \succ_{S_j,\sigma^*} (T', p) \tag{9}$$

for all $p \geq p^*_{i,j}$ and

$$(T, p) \succ_{B_i,\sigma^*} (T', p) \tag{10}$$

for all $p \leq p^*_{i,j}$.

Redistribution Indifference (RI) For all σ^* and all $j = 1, \ldots, n$, and all p and p', if $S_j \notin T$, then

$$(T, p) \sim_{S_j,\sigma^*} (T, p'). \tag{11}$$

Individual Rationality states that traders would prefer not to trade than to obtain negative monetary surplus. This assumption holds by definition in most experimental settings in which experimental designs typically prevent agents from making monetary losses.

The Replacement assumption states that any trader would prefer to participate in an individually rational trade if he or she does so by replacing an active trader. That is, if there are k traders, (R) requires that an agent would prefer to be active rather than inactive at any market price that allows gains from trade. The continuity condition states that traders are willing to undercut the current price if by doing so they increase their probability of making a profitable transaction. The continuity condition simply requires

(R) to continue to hold if replacement requires trading at a slightly less favorable price. If prices could take on any real value and preferences were continuous, this condition would be satisfied. Because we assume that the sets of prices and valuations are discrete, the condition makes sense when the grid size is small.

The Gains from Trade assumption has two parts. First it states that whenever two traders have strictly positive monetary gains from trade, there is a price at which they would be willing to trade. Second it states that a buyer (seller) who willing to trade at price p is also willing to trade at a lower (higher) price. If traders cared only about their monetary payoff, then any price strictly between the seller's cost and buyer's valuation would satisfy (9) and (10). For example, one can take $p^*_{i,j} = c_j + \delta$ for all i. In general, one can think of $p^*_{i,j}$ as a fair price at which both B_i and S_j are happy with the division of their joint surplus.

The Redistribution Indifference condition states that inactive Sellers do not care about the distribution of income earned by active traders. It implies that agents have no incentive to bid in order to manipulate the price when they are not going to trade. For my main result, this condition need only be imposed on S_1 and (11) can be weakened to $(T, p) \succeq_{S_1\sigma^*} (T, p')$ when $p > p'$. I use the condition only to rule out no-trade equilibria.[14]

The five conditions hold for many models of interdependent preferences.[15] Section 2.4 discusses this in more detail.

2.3 Competitive Outcomes with Extended Preferences

This subsection presents the main result, a proposition that states that competitive outcomes arise in market settings under broad assumptions on preferences. Recall that the volume of trade is competitive if there are exactly k^* trades, where k^* is the largest index for which $v_k - c_k > \delta$ and the set of competitive prices is $[\underline{p}, \bar{p}]$. There is **excess demand** if $v_{k^*+1} - c_{k^*} > \delta$ and **excess supply** if $v_{k^*} - c_{k^*+1} > \delta$. If there is neither excess demand nor excess supply, then I say that the market is **balanced.**

[14] I do not need to apply the condition for buyers because of asymmetric way in which call markets treat marginal buyers and sellers.

[15] An exception is utilitarian preferences. If individuals cared only about the total surplus distributed, then (R) need not hold.

Proposition 1 *In a market game, if preferences satisfy IR, C, R, GT, and RI then in all equilibria in undominated strategies, the volume of trade is competitive. Moreover, if there is excess demand the equilibrium price must be the highest competitive price and if there is excess supply, then the equilibrium price must be the lowest competitive price. If* $v_{k^*+1} = c_{k^*+1}$*, then the equilibrium price is equal to* v_{k^*}*.*

Proposition 1 states that one should expect the competitive volume of trade under a wide range of conditions. These conditions include standard income maximizing behavior and, as I show in the next subsection, the Fehr-Schmidt model of inequity aversion. Furthermore, when the market has either excess supply or excess demand, the market equilibrium price is unique (and agrees with the price that would arise under standard assumptions on preferences). Only when the market is balanced does relaxing the greed assumption change the set of predictions. In this case, the call-market institution gives the buyers the power to set prices and leads to the lowest competitive price when buyers are selfish. With extended preferences, a higher price is possible.

Appendix B contains a proof of the proposition, but the intuition is instructive and straightforward. If players do not use weakly dominated strategies, (GT) and (RI) guarantee that there is at least one trade in equilibrium.[16] Once it is known that the market is open, all traders with positive gains from trade at the equilibrium price must be active. To see this, consider the behavior of a buyer with positive gains from trade but is inactive in a putative equilibrium. This buyer can lower his asking price and trade with positive probability at the market price. Doing so either would lead to the same volume of trades or increases the number of transactions. In the first case, the replacement assumption guarantees that the deviation is attractive. In the second case, the continuity assumption guarantees that competition between active sellers will insure that the price drops low enough so that all B_k with $k \leq k^*$ are willing to enter the market.

Proposition 1 includes the standard ultimatum game as a special case ($n = m = 1$ and $c_1 = 0$, $v_1 = 1$). Think of the buyer's offer as the proposal. The seller accepts the proposal with a bid that is less than or equal to the buyer's offer and rejects it by asking for more. The unique equilibrium in

[16]Existence of an equilibrium satisfying the conditions in Proposition 1 does not require (RI).

undominated strategies is to trade at the smallest positive price. Proposition 1 implies that if players have extended preferences, then it is still an equilibrium to trade, but that the equilibrium price may be higher than δ. In fact, depending on preferences, the equilibrium price may be as high as the "fair" price identified in (GT), $p^*_{1,1}$. Two things prevent the selfish outcome from arising in ultimatum games. First, the buyer may believe that out of fairness or some other consideration, it is not appropriate to take all of the surplus for himself. Second, the seller may believe out of spite or some other consideration, that it is unacceptable to agree to an offer than gives too great a share to the buyer. In both cases, a player can unilaterally act to prevent transactions at unacceptable prices. In market settings, individuals always have the ability to opt out of unattractive net trades, but when they do so they typically have no direct impact on the welfare of other players. If a seller refuses to transact, then at a market equilibrium her trading partner will just transact with someone else. When a seller refuses an offer she views as unfair, the buyer simply finds another seller.

The individual rationality assumption plays an important role in the proof. Relaxing the assumption could create additional equilibria although would not destroy the competitive equilibrium under our assumptions. For example, suppose there are two buyers, one with valuation zero and the one with valuation one and a single seller with cost slightly less than one. Suppose that both buyers bid one. The seller may bid more than one (and cause the market to be inactive) rather than bid less than one and cause the buyer who bids more than his valuation from transacting at a loss. In this case, the buyer may make an offer that does not satisfy individual rationality if by doing so he raises the utility he receives from lowering the material payoffs of others.

When there are only two players, or, more generally, when the market is balanced, a trader who is angry with the behavior of the trader on the other side of the market or jealous of that person's potential wealth can directly punish that player by refusing to trade (a seller does this by increasing her asking price; a buyer does this by decreasing his offer price). In all other situations, traders on the long side of the market cannot punish their opponents because there is always another trader there to replace an agent who makes an extreme bid. Hence in market settings traders have extremely limited opportunities to maximize the "unselfish" component of their utility function. As a result, they behave, and the market functions, in the same way as one containing conventionally greedy agents.

It is worthwhile stating our results for a special case of the model. A **homogenous market game** is one in which all buyers have the same valuation, $v_i = 1$ for all i and all sellers have the same valuation, $c_j = 0$ for all j.

Corollary 1 *In a homogenous market game, if preferences satisfy IR, C, R, and GT, then in all equilibria in undominated strategies, the volume of trade is* $\min\{m, n\}$. *If* $m > n$, *then the market price is* 1. *If* $m < n$, *then the market price is* 0.

Corollary 1 is an immediate consequence of Proposition 1. When $n = 1$, the homogeneous market game reduces to the proposer-competition game studied experimentally by Prasnikar and Roth [22]. They analyze a game in which there is a single seller and m buyers. The buyers are assumed to have the same valuation. The buyers each make an offer. The seller can either reject all offers or trade at the highest one. This game is equivalent to a homogeneous market with $n = 1$. In their experiments when $m > 1$ proposer competition permitted the sole seller to obtain all of the gains from trade in equilibrium. Fehr and Schmidt [12] present a special case of Corollary 1 for inequity averse agents.

2.4 Preferences that Satisfy The Assumptions

In this section I discuss the relationship between the assumptions of Section 2.2 and several models of interdependent preferences. Consider an environment in which there are N players indexed by $i = 1, \ldots, N$ and in which utility depends on the monetary outcome $(x_1, \ldots, x_N)$ and the context σ^*.

Fehr and Schmidt look at an environment in which there are N players indexed by $i = 1, \ldots, N$. If the monetary outcome is $(x_1, \ldots, x_N)$, then the utility function of player k is given by

$$U_k(x) = x_k - \alpha_k \frac{1}{N-1} \sum_l \max\{x_l - x_k, 0\} - \beta_k \frac{1}{N-1} \sum_l \max\{x_k - x_l, 0\} \tag{12}$$

where $\beta_k < \alpha_k$ and $0 \leq \beta_k < 1$ for all k. The first term in (12) is the material payoff to player k. The functional form allows the possibility that the agent experiences disutility from having less wealth than some agents (this is the second term) and from having more wealth than other agents (this is the third term). The restrictions on α_k and β_k guarantee that the agent prefers to be a unit richer than another agent than one unit poorer ($\alpha_k \geq \beta_k$) and prefers an extra dollar of material wealth even taking into account the distributional impact ($\beta_k \leq 1$).

Fehr and Schmidt constrain the monetary outcomes to be non-negative (their applications are equivalent to models in which buyers all have valuation 1, sellers all have cost 0, and offers and asks are constrained to be in the unit interval). Consequently, (IR) follows in Fehr and Schmidt by the construction of the game.

To verify (GT) let $p^*_{i,j} = (c_j + b_i)/2$. This function clearly satisfies the monotonicity assumptions in (GT). Assume that S_j and T_i are not in T and consider an outcome in which these agents trade at a price $p' \geq p^*_{i,j}$. Relative to not trading, S_j gains the material utility $p' - c_j$. Provided that $p' \geq p^*_{i,j}$, when S_j goes from not trading to trading, the loss associated with earning less than other agents must go down while the loss associated with earning more than others could go up. On the other hand, the loss compared with each agent is bounded by his own material payoff, $p' - c_j$. Hence his utility from interpersonal comparisons can decrease by at most $\beta_{S_j}(p' - c_j)/(N-1)$ per agent. Since there are $N-1$ other agents and $\beta_{S_j} < 1$, (GT) follows. A similar argument establishes (GT) for buyers. The assumption that $p' \geq p^*_{i,j}$ is important. Without this assumption, it is possible that S_j would prefer not to trade rather than give B_i a large share of the surplus.[17]

The same argument confirms (R) and (C). When one moves from an outcome in which S_j does not trade to one in which she does trade, she gains material utility $p - c_j$ and can lose at most than much in comparison to other agents. Finally, it follows from (R) that traders strictly prefer to be involved in a trade at p than to be left out of the market. Provided that δ is sufficiently small, (C) must hold as well. Finally, (RI) holds since if a trader is not trading, (12) depends only on the total surplus generated, not on how it is distributed.

Charness and Rabin [8] propose preferences represented by a utility function of the form:

$$U_k(k;\sigma^*) = \lambda_1 x_k + \lambda_2 \sum_{j=1}^{N} x_j + \lambda_3 \min_{j=1,\ldots,N} x_j, \tag{13}$$

[17] It is for this reason that individuals with Fehr-Schmidt preferences may reach more even splits in the ultimatum game than selfish agents.

for $\lambda_1, \lambda_2, \lambda_3 \geq 0$. That is, Charness and Rabin assume that agents maximize a weighted average of their material utility, the minimum, and the total surplus. Provided $\lambda_1 > 0$, this functional form clearly satisfies (GT), (C), and (RI). (GT) holds for $p^*_{i,j} = c_j + \delta$ because compared to making no trade, making a trade that generates positive surplus will increase the first and third terms on the right-hand side of (13) while not reducing the second term. (R) need not hold. It is conceivable that a seller would prefer not to trade if trading destroys a transaction that would generate greater surplus. This is obvious when $\lambda_1 = 0$. Including concerns for total surplus create no problems if equilibria have the property that if one seller (buyer) is active then any seller (buyer) with a lower (higher) cost (valuation) is also active. This property holds if I restrict attention to monotonic strategies (with asking prices weakly increasing in costs and bids weakly decreasing in valuations). Furthermore, it is possible to show that monotonicity holds for Charness-Rabin preferences if one applies iterative deletion of weakly dominated strategies.[18] Therefore there always exists an equilibrium that is competitive when preferences are represented by (13) and the equilibrium is unique under standard refinements.[19]

Bolton and Ockenfels [5] present another specification of interdependent preferences. They assume that agent k has a utility function of the form

$$v_k(x_k, \sigma_k), \tag{14}$$

where x_k is the agent's monetary payoff, and σ_k is the agent's share of the total surplus generated.[20] Bolton and Ockenfels assume that $v_k(\cdot)$ is increasing in its first argument and is single-peaked in the second argument, attaining a maximum at $1/N$. If the distributional preferences captured by the second argument of $v_k(\cdot)$ are sufficiently strong, then (R) and (GT) need not hold for this model. An agent may prefer to stay out of the market rather than earn more than his share of the total surplus. The failure of the assumptions can be traced to an implausible implication of (14). Imagine that there is a large population in which all sellers have cost 0, all but one buyer has valuation ϵ (where ϵ is positive but small), and the remaining buyer has a huge valuation. If the high-valuation buyer trades, then the distribution of income will

[18] Provided that $\lambda_1 > 0$ in (13), iterative deletion of weakly dominated strategies implies that S_j will not bid above $c_j + \delta$.

[19] Andreoni and Miller [1] proposed that $U_k(\cdot)$ should be given by (13) with $\lambda_3 = 0$. Consequently, our results apply to their analysis as well.

[20] σ_k is $1/N$ if $x_k = 0$ for all k.

be unequal. Under (14), distributional preferences may be strong enough to prevent this trade from happening in equilibrium. (R) and (GT) will hold in market games when preferences can be represented by (14) provided that populations are homogenous (in the sense that buyers a common valuation and sellers have a common cost) if N is sufficiently large.

Finally, (GT), (R), and (C) will hold for some models that exhibit intrinsic reciprocity. Segal and Sobel [25] give conditions under which preferences over strategies can be represented as a weighted average of the material payoffs of traders in the population:

$$U_k(k;\sigma^*) = x_k + \sum_{j \neq k} a^k_{j,\sigma^*} x_i, \tag{15}$$

where the a^k_{j,σ^*} are weights that can depend on the strategic context (as represented by the strategy profile σ^*). It is straightforward to check that (GT), (R), and (C) hold provided that buyers place non-negative weights on the utility of those traders who bid less that the market price, non-positive weight on the utility of those traders who bid more than the market price, and zero weight on marginal traders, while sellers place non-positive weights on the utility of those traders who bid less that the market price, non-positive weight on the utility of those traders who bid more than the market price, and zero weight on marginal traders. These weights respond to the kindness of strategies as compared to market behavior. For example, a buyer should interpret a low ask from a seller as "nice" because it facilitates trade at the current price (or acts to keep the price low).

3 Price-Taking Behavior

The previous sections assumed a special market environment and made restrictive assumptions on preferences. This section studies a general model in which the appearance of self-interested behavior follows directly from the definition of price-taking behavior.

Consider a pure-exchange economy with N commodities; agents are elements of an index set A. Each agent is described by his direct consumption set, his initial endowment, and his preferences. The direct consumption set describes the set of commodity bundles that the agent controls. For each agent a it is a non-empty, convex subset $X(a)$ of $\mathbb{R}^N$ that is bounded below. The initial endowment of agent a is $w(a) \in X(a)$. An economy E consists of a subset of A. For now, I will be interested in a fixed economy with a finite set of agents.

In standard models, an agent has preferences over only his direct consumption. That is, a preference relationship for agent a is a binary relationship on $X(a)$. I wish to consider the case where preferences are extended. Assume that preferences can be represented by a utility function of the form:

$$U_a(x; E) = u_a(x(a)) + v_{-a}(x_{-a}; E), \tag{16}$$

where $x : A \rightarrow \prod_{a' \in A} X(a')$. $u_a(\cdot)$ is a utility function defined over direct consumption; I assume that $u_a(\cdot)$ is continuous and quasi-concave. When $v_{-a} \equiv 0$, the model reduces to standard one in which each agent's preferences depend only on direct consumption.

The second term in (16) permits an agent's utility function to depend on the characteristics and consumption of other agents in the economy. If the number of agents and their endowments are fixed, then I can treat $v_{-a}(\cdot)$ as a function of the direct consumption of the other agents. To permit an agent's utility function to depend on the characteristics and consumption of other agents in the economy, it must be indexed by the agents who are actually in the economy.

This formulation permits preferences to depend on the consumption of other agents and the initial endowments. Segal and Sobel [25] provide a representation theorem for a special case of (16) for general strategic environments. Although the Segal-Sobel representation theorem supplies an additively separable form for preferences, in general separability is a strong assumption. It plays an important role in what follows for two reasons. It is an immediate consequence of separability that agents maximize their selfish material utility in equilibrium. Also, I study the properties of the economy as the number of agents changes. If preferences can be represented as in (16), then an individual's preferences restricted to direct consumption remains fixed as the economy grows.[21]

Let $P = \{p \in \mathbb{R}^N : \sum_{i=1}^N p_i = 1 \text{ and } p_i \geq 0\}$ be the price simplex. A **competitive equilibrium** is a pair $(p^*, x^*) \in P \times X$ such that for each $a \in A$ $x^*(a)$ solves:

$$\max_{x \in X(a)} U_a(x, x^*_{-a}; E) \text{ subject to } p \cdot x = p \cdot w(a) \tag{17}$$

[21] The results do not require that $v_{-a}(\cdot)$ is separable across agents $a' \neq a$.

and

$$\sum_{a \in A} x^*(a) \leq \sum_{a \in A} w^*(a) \tag{18}$$

This specification is a standard model of a market with externalities. The textbook treatment of Arrow and Hahn [3, Chapter 6.2] provides a general treatment. For completeness, I provide simple conditions sufficient for existence of equilibrium. For a fixed economy E, define the demand correspondence of agent a, $\zeta_a(p, x^*)$, be the set of solutions to problem (17). If $x \in \mathbb{R}^N$, we write $x = (x^1, \ldots, x^i, \ldots, x^N)$. To make the existence proof simple, assume that demand satisfies a boundary condition:

Boundary Condition: If $p_i = 0$, then $\zeta_a^i(p, x) > w_a^i$.

Proposition 2 *If for each a preferences can be represented by (16) with $u_a(\cdot)$ quasi-concave and the boundary condition holds, then equilibrium exists.*

Standard proof techniques apply to this model. So I omit the proof of Proposition 2.

Proposition 3 *If for each a preferences can be represented by (16), then agents maximize material utility in equilibrium. The set of equilibrium prices is independent of $v_{-a}(\cdot)$.*

Proposition 3 follows from the definition of equilibrium. While the result is essentially a tautology, it deserves some comment. In strategic models, an agent with extended preferences can take an action that directly influences the consumption of his opponent. Consequently, there is scope for an altruistic agent to sacrifice consumption to help another player. In a market setting, transactions are anonymous. Players do not take into account that their actions might influence the consumption of others either directly (one agent's net trades determine the resources available to others) or indirectly (one agent's net trades determine market prices, which in turn determine the consumption opportunities of other agents).

One difference between the Proposition 3 and the special results in Section 2 is that monotonicity in the one-commodity world will hold even if preferences are not separable. For example, the inequity aversion preferences of Fehr and Schmidt [12] are not separable since agents evaluate the wealth of others relative to their own wealth.

Proposition 3 states that agents who act as price takers will behave as if they care about only their material consumption even if this is not true. The issue then becomes: Why would agents act as price takers? This question is valid in the standard models. Roberts and Postlewaite [24] posed and solved this problem for pure-exchange economies when agents care only about their material consumption. Their results extend with essentially no modification to our framework. Next I describe their model and state my extension formally. I follow the notation in Roberts and Postlewaite.

Let $\mathcal{S}(a)$ denote the set of all correspondences S from $P \times X$ to $\mathbb{R}^N$ such that $S(p,x) + w(a) \in X(a)$ and $p \cdot z = 0$ for all $p \in S(p,x)$. That is, $\mathcal{S}(a)$ consists of all net-trade correspondences that satisfy the feasibility constraints of agent a. The net trades of a price-taking agent must maximize preferences. The net trades of a strategic agent need only be elements of a "distorted" individual excess demand correspondence in $\mathcal{S}(a)$.

Think of an economy E as a mapping that assigns to each agent a a correspondence $S(a; x^*) \in \mathcal{S}(a)$. A price p is market clearing for an economy if there exists $z(a; x^*) \in S(a)$ such that $\sum_{a' \in A} z(a'; x^*) = 0$ and $x^*(a') = z(a'; x^*) + w(a')$. Let $Q(E)$ be the set of market-clearing prices for E.

Given the response correspondences of the other agents, agent a can manipulate the economy by proposing an alternative response correspondence. A price $\hat{p}$ is attainable for a' if there is $\hat{S} \in \mathcal{S}(a')$ such that $0 \in \sum_{a \in A, a \neq a'} S(\hat{p}) + \hat{S}(\hat{p})$. Let the set of attainable prices be $H(a, E)$. A net trade $z(a)$ (consumption $x(a)$) is attainable if there exists $p \in H(a, E)$ such that $0 \in \sum_{a \in A, a \neq a'} S(\hat{p}) + z(a))$ $(x(a) = w(a) + z(a))$.

The competitive response in **individually incentive compatible** for $a \in E$ if, for any consumption vector x attainable by $a \in E$, there exists a competitive consumption y for $a \in E$ such that y is preferred to x for a. If $\{E_k\}$ is a sequence of economies, then the competitive mechanism is **limiting individually incentive compatible** if for any $\epsilon > 0$ there exists $\overline{k}$ such that $k > \overline{k}$ implies that for each x attainable by a in E_k there exists a competitive allocation y in E_k such that $U_a(y; E_k) > U_a(x; E_k) - \epsilon$.

In an infinite economy with a non-atomic distribution of agents, no single agent can influence market-clearing prices. Hence, when the economy is truly large, no agent can do no better than use his competitive excess demand correspondence. The competitive response is therefore individually incentive compatible in limit economies. Roberts and Postlewaite formulated conditions under which this result is approximately true in large finite economies. While they show that some continuity is necessary for the result, they identify conditions under which the competitive response is limiting individually incentive compatible. Under the proper continuity assumptions, their result – both statement and proof – continue to hold.

The theorem of Roberts and Postlewaite imposes continuity conditions. To state the conditions, we need a way to describe the convergence of a sequence of economies. To formulate this property, assume that there is a measure space $\mathcal{M}$ of all compactly supported probability measures on $\mathcal{S}$. An element of $\mathcal{M}$ is an abstract economy; if $\mu \in \mathcal{M}$ is a counting measure on a finite set, then μ describes a simple economy. A measure μ^* describes a limiting economy if there is a sequence of simple measures μ_n that converge to μ^* in the topology of weak convergence of measures. The set of market-clearing prices for an economy $Q(\cdot)$ can be thought of as a mapping from $\mathcal{M}$ into P. Roberts and Postlewaite provide an example to show that the competitive response need not be limiting individually incentive compatible if $Q(\cdot)$ fails to be continuous at the limit point. So we will assume that $Q(\mu)$ is continuous in the neighborhood of the limit economy.

Proposition 4 *Let $\{E_k\}$ be a sequence of finite economies such that $\#E_k \to \infty$. Suppose that the sequence of simple measures describing E_k converges to μ^* and that $Q(\cdot)$ is continuous at μ^*. Suppose $\overline{a}$ belongs to E_k for all k and that an inverse utility function for $\overline{a}$ exists and is continuous in a neighborhood of $Q(\mu)$. Then the competitive response is limiting individually incentive compatible for $\overline{a}$ in $\{E_k\}$.*

The proof of Roberts and Postlewaite [24] establishes this Proposition 4. My result differs because the domain of preferences differ. In addition to the assumption that the equilibrium correspondence is continuous at μ^*, the theorem also requires that the indirect utility function is continuous. Roberts and Postlewaite's proof uses this condition, but in my context it plays the additional role of guaranteeing that the "unselfish" part of preferences $v_{-a}(\cdot)$ is well behaved as the economy grows. The assumption is consistent with $v_{-a}(\cdot)$ being the average of material utilities of all of the other players.

Unlike the auction environment, in this section I *assume* price-taking behavior. For a family of utility functions the assumption of price taking leads to the conclusion market outcomes coincide with competitive outcomes. While this result holds under general assumptions on preferences, when agents are strategic the price-taking assumption cannot be justified unless the economy is large.

The results of this section demonstrate that when agents are price takers, then market outcomes will be competitive and individual behavior looks selfish even if agents have preferences over the direct consumption of others. This result does not provide support for the assumption of rational self-interested behavior, but it does provide an important argument in favor of some of the propositions of economics. To the extent that certain results hold under weaker assumptions than typically imposed, we become more confident that the results are descriptive. The greater generality of the propositions means that field or experimental evidence consistent with the predictions of standard theory should be viewed as evidence of the restrictions implicit in the market institutions rather than evidence of the selfishness or rationality of agents.

Not all of the standard theorems of economic theory extend to the more general setting studied in this section. Even though the outcomes of the exchange economy we study in this section are competitive and individual behavior looks selfish, it may be that agents have extended preferences and equilibrium outcomes are not Pareto efficient. Plainly, interdependent preferences constitute an externality. Unless agents' preferences depend only on direct consumption, there are likely to exist personalized transactions outside of the market environment that are Pareto improving. One possible way to remedy the inefficiencies is to define new personalized commodities and markets for those commodities. While markets typically replace this sort of exchange, one can interpret charitable institutions that direct contributions to particular groups as market-based remedies.

4 Discussion

This section discussions reasons why market outcomes may not change when agents are unselfish and places our results is perspective.

The most important reason why non-selfish behavior may not influence outcomes is lack of market power. In Section 2, the ability of a trader to set the price is severely constrained by the behavior of other traders since the market price must be between the m^{th} and $(m+1)^{\text{th}}$ bids of the other traders. Yet the only way in which a trader can influence the welfare of others is by changing the price. When agents cannot control the market price, they cannot directly influence the welfare of others. Consequently, they will act to maximize their own material payoff.

The primary reason why non-selfish preferences cannot express themselves in market settings is that there is typically no opportunity to directly influence the consumption of others in markets. When agents are literally price takers, as in the model of Section 3, there is essentially nothing that an agent can do besides maximize material utility. When agents are price takers they cannot control the market price. Under the assumption of separability, this implies that the economy will behave as if actors cared only about their own direct consumption. This observation forces us to ask another question: When is price taking a sensible assumption? The standard answer, that price taking is a best-response to the market clearing assumptions when each agent is small relative to the entire economy, holds in my model for precisely the same reasons that it holds when agents care only about material consumption. Another implicit assumption of the general equilibrium model of Section 3 is that transactions are anonymous. The ability to make personalized transactions would give agents the opportunity to influence the consumption of other agents directly. If personalized transactions were feasible, then generally people with extended preferences would behave differently than those interested solely in their own direct consumption.

In auction markets with finitely many agents, individual traders retain some market power, but the power is limited. Unlike bargaining situations, an agent cannot deny surplus to a trader on the other side of the market if there is another agent ready and willing to take part in the transaction. In this way, market institutions makes it hard for traders to express their concern for the monetary payoffs of others. The results in Section 2.3 indicate that the existence of "excess" supply or demand is sufficient for an economy with extended preferences to duplicate competitive prices. In particular, large numbers are not needed for the result. Large numbers do make the price-taking assumption of Section 3 more reasonable. The existence of a large number of potential traders would also, in sensible formulations, shrink the gap between c_{k^*} and v_{k^*} and thereby cause the equilibrium price in a market with extended preferences converge to the selfish equilibrium price. Self interested behavior by a small number of agents may be enough to eliminate the impact of non-selfish players. This influence appears in the context of the call market of Section 2, where it takes only one selfish buyer to push the market price to the lowest competitive level.

Appendix A

This section describes the payoffs of market games more completely.

Arrange the offers $\{d_k\}$ so that

$$d_1 \leqslant \ldots \leqslant d_l < d_{l+1} = \ldots = d_h = p < d_{h+1} \leqslant \ldots \leqslant d_{n+m}.$$

Here, d_l is the largest offer strictly less than p ($l = \max\{k : d_k < p\}$) and h is the number of offers no greater than p. If offers are distinct, then $l = m$ and $h = m + 1$. In general, $l \leq m$ and $h \geq m + 1$. Denote by t the number of buyers who bid p. Now we can specify the monetary payoffs. Denote by $d(S_j)$ the offer of seller S_j and by $d(B_i)$ the offer of buyer B_i. When $d_{m+1} > d_m$, $p = d_{m+1}$ and the buyers who bid at least p transact with sellers who ask less than p. The profit of seller S_j, π_j, is given by:

$$\pi_j = \begin{cases} p - c_j, & \text{when } d(S_j) < p \\ 0, & \text{when } d(S_j) \geq p \end{cases}$$

and the surplus of buyer i, γ_i, is:

$$\gamma_i = \begin{cases} v_i - p, & \text{when } d(B_i) \geq p \\ 0, & \text{when } d(B_i) < p \end{cases}$$

The formulas are more complicated when $d_m = d_{m+1}$ because there is the possibility that marginal traders on one side of the market trade with a probability strictly between zero and one. If there is a long side of the market, say more buyers with $d(B_i) \geqslant p$ than sellers with $d(S_j) \leqslant p$, then those agents on the long side of the market who offer p are uniformly rationed. The monetary payoffs in the general case are given by:

$$\pi_j = \begin{cases} p - c_j, & \text{when } d(S_j) < p \\ L_j(p - c_j), & \text{when } d(S_j) = p \\ 0, & \text{when } d(S_j) > p \end{cases}$$

where L_j is the lottery that pays $p - c_j$ with probability $\min\{1, \frac{m-l}{h-l-t}\}$[22] and zero otherwise. For the buyers,

$$\gamma_i = \begin{cases} v_i - p, & \text{when } d(B_i) > p \\ M_i & \text{when } d(B_i) = p \\ 0, & \text{when } d(B_i) < p \end{cases}$$

[22]The minimum is taken to be 1 when $h = t + l$.

where M_j is the lottery that pays $(v_i - p)$ with probability $\min\{1, \frac{h-m}{t}\}$ and zero otherwise.

Appendix B

Proof of Proposition 1 Fix an equilibrium. The first step is to show that there are trades in equilibrium. First I establish that it is a weakly dominated strategy for S_j to ask more than $p^*_{1,j}$, the price at which she would be willing to trade with the highest valuation buyer. Recall that a seller's ask determines the market price only if she does not transact. Therefore, by asking $p^*_{1,j}$ instead of something higher, a seller who is trading does not influence the market price. If this lowers the market price without allowing her to trade, the deviation is not costly by (RI). If it increases the probability of trading without increasing the volume of trade, it is strictly better by (R). Since S_j would all prefer to transact at $p^*_{1,j}$ rather than be out of the market by (GT), a seller who is not trading would weakly prefer to ask $p^*_{1,j}$ than any higher price. It follows that it is weakly dominated for a seller to ask for more than $p^*_{1,j}$. Therefore, in any equilibrium in which the sellers do not use dominated strategies, there will be at least one transaction, since by (GT) the buyer with the highest valuation would prefer to transact at $p^*_{1,1}$ rather than be left out of the market.

Let k^* be the number of traders with strict gains from trade – that is, $c_{k^*} + \delta < v_{k^*}$, but $c_{k^*+1} + \delta \geq v_{k^*+1}$. I claim that there will be at least k^* trades in equilibrium. In order to obtain a contradiction, assume that there are $1 \leq k < k^*$ transactions at the market-clearing price p. Let B_i be the buyer who trades at the smallest probability among $\{B_1, \ldots, B_{k^*}\}$. Since $k < k^*$, this buyer cannot trade with probability one. If the buyer is currently asking the market price, then he must trade with positive probability. If this probability is less than one, then by raising his bid by δ he will increase his probability of trading without changing the volume of trade. Provided that $p < b_i - \delta$, this deviation will be attractive by (R) and (C). If B_i is trading with probability zero, then by raising his bid to the market price, he will trade with positive probability, although by doing so he may increase the volume of transactions by permitting S_j to trade for some j. By (GT), this is attractive provided that $p \leq p^*_{i,j}$. Therefore if there are fewer than k^* transactions, then the market price must exceed $p^*_{i,j}$. Applying the analogous argument from the perspective of S_j, however, implies that the market price must be lower than $p^*_{i,j}$ (because otherwise S_j can lower her bid and improve her payoff by trading more frequently with B_i).

When $c_{k^*+1} > v_{k^*+1}$, this completes the proof, because I have established that the trading volume is competitive and by individual rationality trade takes place at a competitive price. When $c_{k^*+1} = v_{k^*+1}$, the arguments above demonstrate that the equilibrium price must be in $[c_{k^*+1} - \delta, c_{k^*+1} + \delta]$. To see this, suppose, for example that $p - \delta > c_{k^*+1} = v_{k^*+1}$. At most k^* buyers bid p or greater by individual rationality. Consequently at most k^* sellers trade with probability one in equilibrium. It follows from (C) and (R) that the seller $i \leq k^* + 1$ asking the most would be better off either by matching the market price or undercutting it by δ.

Suppose that there is a buyer B_j with $j > k^*$ such that $b_{k^*+1} > c_{k^*}$. The equilibrium price must be at least $b_{k^*+1} - \delta$, because otherwise a buyer B_j who trades with the minimum probability of $j \in \{1, \ldots, k^* + 1\}$ can improve his payoff by either increasing his bid to the market price or δ more than the market price. This deviation cannot increase the volume of trades and it makes buyer B_j better off because he replaces an active trader. Similarly, if there is a seller S_i with $i > k^*$ such that $b_{k^*} > c_{k^*+1}$, then the equilibrium price must be no greater than $c_{k^*+1} + \delta$. ■

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