# Neighborhood Sorting Through Parcel Acquisitions With Negative Externalities

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ABSTRACT

Residential segregation by categories, such as income and ethnicity, is prevalent in the United States. A large literature has developed to explain how various institutions affect sorting and the potential impacts of reduced diversity. Concurrently, experimental methods have been used in the literature on property to investigate questions regarding land acquisition. We combine these two streams of literature with a laboratory experiment to investigate a neighborhood where a new “neighbor” purchases parcels with attendant negative externalities for the initial residents. It is not our goal to model granular policies and institutions that either to promote or to impede neighborhood sorting. Rather, with a simple excess demand model as our guide, this paper aims to understand these negative externalities and the associated dynamics that lead to sorting in the absence of exclusionary institutions.

**I . Introduction**.

Residential segregation is prevalent in the United States. For instance, as of 2010, 28 percent of low-income families lived in majority low-income neighborhoods in America's largest cities (Pew Research Center, 2012).[1] Cities like New York City and Philadelphia are among the most income segregated in the United States. Likewise, neighborhoods often segregate by race. As of 2017, cities such as Milwaukee, New York City, and Chicago have dissimilarity indices over 70.[2] A large literature has developed to explain how various institutions affect sorting and the potential impacts of reduced diversity.[3]

Many factors have contributed to the rise of the sorting in neighborhoods, including, and not limited to, tax policy, school quality, zoning, historic neighborhood status, land use restrictions, deed and covenant restrictions, access to credit, highway construction, environmental conditions, disease environment, etc. The existence of such policies makes it difficult to understand the origins of sorting. Thus, in this paper, our goal is not to understand how these policies or events shape sorting. Rather, this paper studies the underlying externalities and dynamics that can lead to sorting in the absence of these institutions or events.

Preferences for homogeneity on a given dimension are one possible explanation for observed sorting. Such preferences have recently been measured in the literature; for example, Bayer et al. (2022) documents a preference for same race neighbors by estimating differential exit rates for incumbents following the arrival of new neighbors in North Carolina. Despite recent estimates for homogeneity preferences on average, theory, such as canonical work by Schelling (1972), highlights that the segregated outcomes need not reflect universally held household preferences for homogeneity.[4] Rather, sufficient heterogeneity in own group preferences can lead to

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[1] https://www.pewresearch.org/social-trends/2012/08/01/the-rise-of-residential-segregation-by-income/

[2] https://www.brookings.edu/blog/the-avenue/2018/12/17/black-white-segregation-edges-downward-since-2000-census-shows/

[3] For example, zoning policy has been studied extensively (see Fischel, 1987 and Ihlanfeldt, 2004 for overviews. Recent work, such as that by Chetty et al. 2016, Chetty and Hendron, 2018a, 2018b, explores the intergenerational mobility effects of neighborhoods on children.

[4] Schelling's original work focused on an individual's location along a line segment. Recent work has expanded the class of utility functions and network shapes where Schelling's model

dynamics that result in sorted neighborhoods and the creation of ghettos. Thus, while we observe many segregated neighborhoods, we do not fully understand the initial drivers that resulted in the sorted outcomes and how these outcomes may create a demand for exclusionary institutions.

On a separate note, a large experimental economics literature has developed that investigates issues of parcel (land) assembly (see, for example Cadigan et al., 2011; Collins and Isaac, 2012; Kitchens and Roomets, 2015; Isaac, et al., 2016; Winn and McCarter, 2018; DeSantis, et al., 2022; and Zillante, et al., 2020). This literature has examined "hold-out," contingent contracting, parcel-owner competition, eminent domain, and alternative institutions. These papers do not consider how the aggregation of parcels by a new neighbor would affect the valuations of incumbents. One exception is work by Portillo (2019), who extended this literature to include the case in which the assembling firm generates positive externalities for the neighborhood conditional on assembly. Portillo finds that positive externalities decrease assembly rates unless developers have the funds to pay for the capitalization upfront.

At the intersection of the residential sorting and parcel assembly literatures, a synthesis of questions involving (residential) parcel assembly, in which new purchasers generate negative externalities for existing homeowners, emerges.[5] The "negative externality" plays a central role in the Schelling (1972) style models of residential segregation. These externalities can be just as applicable today to issues of gentrification or developers buying single-family owner-occupied housing for multi-tenant student rental housing as for the original motivation of racist preferences by white homeowners.[6]

generates segregated neighborhoods (i.e., Mobius and Rosenblat, 2000; Zhang 2004, Pancs and Vriend, 2007; Fagiolo, et al., 2007; Grauwin et al. 2012, Zhang, 2011).

[5] Our study also has a close relation to the environmental literature on NIMBY preferences over environmental and agricultural development (see Boyle et al., 2019; Chiu and Lai, 2009; and Pelekasi, Menegaki, and Damigos, 2012). The key issue this literature examines is the presence of environmental externalities and local disamenities that hamper agricultural planning, mineral recovery, and energy development. In the presence of local "neighborhood" disamenities, a similar "hold-out" problem can still appear due to NIMBY responses to the externalities, as opposed to contractual frictions in land assembly.

[6] See, for example, the enactment of "rooming-house" regulations in Tallahassee, Florida as a reaction against developers placing multiple undergraduates in rental housing purchased in single-family owner-occupied neighborhoods. On the City of Tallahassee website, notice the

Thus, our research strategy is to examine the process of neighborhood sorting (or, in the extreme case, neighborhood "flipping") using standard models and laboratory markets that build on previous experimental designs from the parcel assembly literature. Our design will primarily vary the initial distribution of incumbent property owner valuations, which will determine the relative strength of the externality forces, and hence, the equilibrium level of sorting.

It is important to note at this point the role that one of the canonical theoretical models in the neighborhood sorting literature, "tipping points," plays in our research. Tipping points have been developed as theoretical constructs (Schelling) and quantified empirically (Card, Mas, Rothstein, 2008; Banzhaf and Walsh, 2013; Blair, 2017; Caetano and Maheshri, 2017). Tipping points are typically modelled as multiple-equilibrium problem with the "integrated" equilibrium being unstable while the two other "segregated" equilibria are stable. Our interest is broader than this and our design is specifically not an experiment on tipping-points narrowly defined. Our inquiry examines the broader questions of neighborhood sorting *even in those cases in which neighborhood resorting does not rely on a tipping point for fruition.* However, one of our three basic parameter sets has a form of a tipping point and thus forms an interesting benchmark, both for the theory and in comparison, with other designs.

Additionally, our manipulation of the incumbents' valuations, enables us to sidestep the creation of endogenous amenities as neighborhoods evolve. Separately identifying the impact of endogenous amenity creation from other factors driving sorting has made it difficult to pinpoint the precise drivers of sorting in the empirical literature on neighborhood change. Few studies have been able to credibly separate the changing composition of the neighborhood from endogenous amenities. The conflation of these factors matters because the gentrification

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explicit reference to negative externalities: "On September 7, 2000, the City Commission adopted the 'Rooming House Ordinance' to address concerns about dormitory style housing in existing single-family residential neighborhoods. The ordinance was adopted in response to concerns that when a large number of people rented rooms in one home, there were sometimes negative side effects such as cars parked in the yard, frequent parties, and other disturbances. The Rooming House Ordinance was designed to protect the character and stability of our neighborhoods, while also respecting individual property rights." https://www.talgov.com/neighborhoodservices/na_resources#rooming literature has documented that neighborhood change accelerates as local amenities endogenously change (Diamond, 2016; Baum-Snow and Hartley, 2020; Couture and Handbury, 2020; Diamond and Gaubert, 2022; Su, 2022). The benefit of our study is that we can test the role of a specific mechanism, negative externalities imposed on single-family homeowners, on neighborhood sorting outcomes.

## II. Experimental Design

Our experimental design is built around an economic environment of eight parcels. For purposes of exposition, the parcels are visually presented as on outer ring of a 3x3 matrix (see Figure 1).

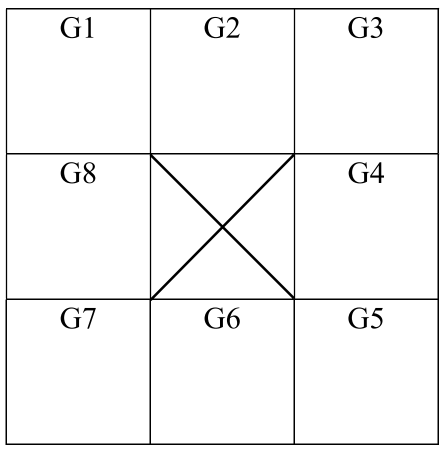



Figure 1. Parcel Display

The subjects in the experiment are divided into three types, characterized here (and in the instructions) by color. In the stage game, each of the eight parcels is originally owned by one "Green" player, who is endowed with a (known) "holding value." In addition, each green player can potentially earn higher profits by selling the parcel to either a "Yellow" or a "Red" player, forgoing the initial holding value. There are two "Yellow" players who can be thought of as new entrants to the neighborhood of a type similar to the Green players. Yellow players are endowed with an acquisition value for at most one unit, ranging from 160 to 190 Experimental Currency Units (ECUs). They can earn additional profits by purchasing a parcel for less than their acquisition value. They can also earn capital gains profits by purchasing a parcel and then re-selling it to a "Red" player.

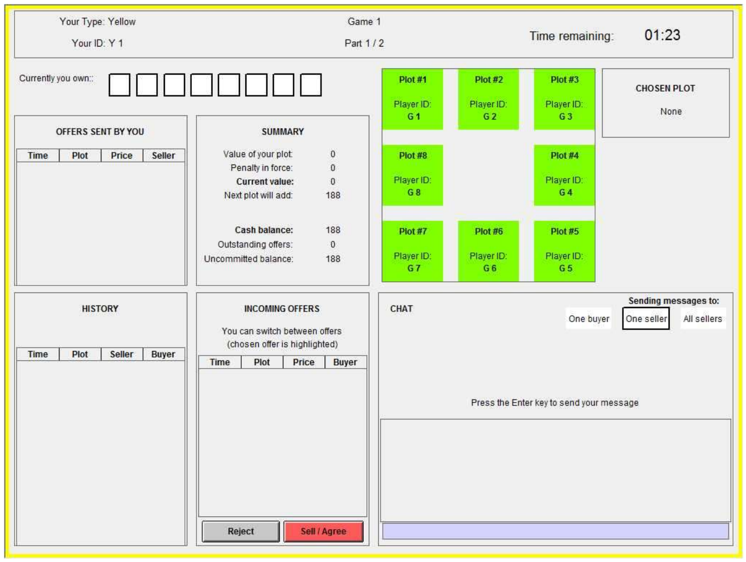
There is one “Red” player. The Red player is modeled as having extensive market power in that they will have acquisition values for all eight parcels. The most distinctive feature of Red is that as Red purchases properties, they impose negative externalities on all Green and Yellow players that hold parcels, as detailed in Table 1 below. Note that the marginal penalty function is concave, with the maximum marginal penalty occurring at the purchase of the $5^{th}$ unit. Given these rules, it is possible that the Red could purchase the entire neighborhood, what we will call a neighborhood “flip;” whether flipping is an expected outcome will depend on parameter values and upon our theoretical model. Both will be discussed in greater detail in the next section.

**Table 1: Penalty Schedule**

| # Units Owned by Red | Cumulative Penalty |
|---|---|
| 1 | 5 |
| 2 | 15 |
| 3 | 30 |
| 4 | 50 |
| 5 | 75 |
| 6 | 95 |
| 7 | 110 |

Trading was handled through an open-book offer/acceptance process on the trading page (see Figure 2). Each buyer (who could be Red or Yellow) could make an offer to a specific current owner (that is, a potential seller --- either Green or Yellow). In our baseline condition, the ownership status in the 3x3 matrix was updated by owner “color” in real-time. Sellers could accept or reject an offer. A treatment feature was a chat box that allowed (if turned “on” in that session) for non-binding cheap talk communication both between the buyer and a potential seller and among the sellers. Each stage, which served as a period in each four-period session, lasted twelve minutes. Each period was divided into four three-minute parts. At the end of each part, there was a short break in which summary information of the market so far was displayed. As will be discussed below, the nature of this information forms the basis for potential additional treatments.

**Figure 2: Trading Interface** (chat treatment)




The following are the information conditions in this game. The penalty function was common knowledge (and in fact was printed on the paper instructions handed to each participant). Every subject knew the range of possible values for each owner type, each subject knew their own value, but no one knew the exact holding value or acquisition value of any other subject. There were four stage games (periods) in each session, with a parameter rotation schedule. The four-game structure was announced to the subjects.

Between games, we used the following rotation scheme: the Red player remained the Red player in all four stage games, and the computer randomly reassigned Greens/Yellows to be Greens/Yellows in the transition to each game. Subject role assignments and the rotation method were common knowledge to the subjects. A copy of the initial written instructions is contained in Appendix I. In addition, subjects went through a short quiz (Appendix II) before beginning the experiments. Each subject had to answer (with multiple attempts possible) each question correctly before continuing to the next question.

The values of the parameters and the rotation sequence were chosen by the experimenter in advance. The parameter sets are rotated within groups, and we chose four different rotation schedules to avoid overall order effects (see Appendix III). All experiments were conducted at the Florida State University XSFS Experimental Social Sciences laboratory, subjects were recruited through ORSEE, as described by Greiner (2004). The experiment was programmed and conducted using z-Tree (Fishbacher, 2007). A total of 12 sessions have been run to date, 8 in the treatment including the chat feature and 4 without the chat. Each session consisted of 11 participants; therefore, each session represents a single independent observation.[7] In total, we had 130 participants, who earned an average of $20.76 per session, including a $10 show up fee.

## III. Theoretical Predictions

Our baseline theoretical model is one of excess demand for a fixed number of parcels. We trace out the following path of parcel ownership at point $\tau$. With $\tau = 1$, we list the induced values for a parcel from highest to lowest. We assume that the trading will allocate the eight units to the eight highest value potential buyers (recall that Red alone has values for multiple parcels). With this new allocation of the eight units, we see how many parcels are owned by Red, and then apply the appropriate penalty to any Green or Yellow owners. With these new (potentially reduced, for Green and Yellow) values in place, we begin the process again for $\tau = 2$, and so forth, until the process yields no more profitable trades,

Throughout the experiment, we implement three distinct parameter sets that we rotate throughout the four stages of each session. We report the parameters in Table 2 below.

[7] In the event that an individual voluntarily left, or if only 10 subjects participated, one of the experimenters assumed the role of a Green player and followed a simple profit maximization rule. In sessions where the chat feature was available, the experimenter would request 20 ECU above their value, but accept any formal offer above their holding value.

**Table 2: Parameter Sets**

| Player Role | Green | | | Yellow | | | Red | | |
|---|---|---|---|---|---|---|---|---|---|
| Unit Value | E | H | F | E | H | F | E | H | F |
| 1 | 198 | 198 | 190 | 190 | 166 | 165 | 125 | 125 | 125 |
| 2 | 195 | 195 | 180 | 188 | 164 | 160 | 123 | 123 | 123 |
| 3 | 180 | 180 | 140 | | | | 120 | 120 | 120 |
| 4 | 179 | 130 | 130 | | | | 118 | 118 | 120 |
| 5 | 95 | 95 | 95 | | | | 118 | 118 | 118 |
| 6 | 90 | 90 | 90 | | | | 118 | 118 | 118 |
| 7 | 65 | 65 | 65 | | | | 118 | 118 | 118 |
| 8 | 40 | 40 | 40 | | | | 118 | 118 | 118 |

One set of parameters, which we call "Full Flipping" (and will denote as set "F" throughout the paper) will yield all eight parcels being owned by Red after five iterations. For example, from Table 2, it is clear that the Red and Yellow players have acquisition values in excess of the four lowest valued units initially held by Green players. After the first round, Red and Yellow will each hold two units. Following these transactions, a penalty of 15 will be applied to Green and Yellow players holding units, resulting in one additional mutually beneficial trade between Red and a Green. Given the parameters, the iterative process continues until the Red player acquires all 8 units.

A second set of parameters, which we call "Hard Partial," will, under the iterative process described above, stop at a mixed neighborhood after two iterations. (We will refer to this as set "H" for exposition purposes.) The integration profile in the neighborhood is three Green, two Yellow, and three Red. The reason we call this the "hard" partial is the following. The iterative process we outlined above assumes trades occur in order along the demand curve: the highest values trade in; the lowest values trade out. But that ordering may not occur in our open book market, Red could "beat Yellow to the punch" for an extra two units in the first iteration. Because of the additional negative externality imposed upon Yellow, the process then proceeds to a full flip after five iterations.

A third set of parameters, which we call "Easy Partial," will, under the iterative process above, stop at a partially flipped neighborhood after one iteration. (We will refer to this as set E for expositional purposes). The integration profile in the neighborhood is four Green, two Yellow, and two Red. Unlike in the hard partial, we are unable to find any off-equilibrium paths that result in a fully sorted neighborhood.

We summarize the equilibrium predictions in Table 3, Column 2. Formally, our framework generates two testable predictions regarding the final distribution of unit ownership, a point prediction and an ordered hypothesis.

*Hypothesis One (Point Prediction):* The number of Red parcel holders at the end of a period will be 8 with the F parameter set, 3 with the H parameter set, and 2 with the E parameter set.

*Hypothesis Two (Ordered Prediction):* The following ordering of the number of Red parcels owned is predicted:

$$F \geq H > E$$

As mentioned, this design was not chosen to be a "best case" test of a Schelling-style tipping point theory. But, nevertheless, we can ask whether our designs can in anyway be informed by the basic logic of the tipping points models, namely, the existence of an unstable partially sorted equilibrium and two fully sorted stable equilibria. In the F parameter set, this cannot be an issue because there is no obvious interior partially sorted prediction. However, for our two partial flipping parameter sets (E, H), we can ask the following question. Suppose that a single Green parcel owner sells at a price below their holding value. Will that single deviation from the equilibrium described above cause an "unravelling" in the parcel sortings? To give this tipping point concept its best shot, we assume that it is the highest value Green who sells below the holding value. With that one deviation from the equilibrium, we then proceed with the same iterative demand process as above.

The end result is that the Easy Partial parameter set is robust to this single deviation. The market does not move any further towards the Red purchaser. However, the Hard Partial is a different story. That single deviation, through the now increased negative externalities on the other Green and Yellow property owners, results in a fully Red-sorted neighborhood. So, while not a formal test, the tipping point logic has validity for our H parameter set, which provides an added motivation for Hypothesis 2.

Finally, although not an equilibrium prediction, it is instructive to look at the outcome that would be chosen by a utilitarian social planner who internalizes the negative externalities. Indeed, in two of the cases (F and H) the utilitarian optimum includes fewer Red purchases than the equilibrium; that is, in the F and H parameter sets, we predict more Red parcels in equilibrium than the utilitarian optimum (see Table 3).

**Table 3: Equilibrium and Utilitarian Optimal Payoffs**

| Parameter Set | Equilibrium | Payoffs in Equilibrium | Utilitarian Optimum | Payoff in Utilitarian Optimum |
|---|---|---|---|---|
| F | 8 R | 960 | 2R 2Y 4G | 1123 |
| E | 2R 2Y 4G | 1288 | 2R 2Y 4G | 1288 |
| H | 3R 2Y 3G | 1121 | 2R 2Y 4G | 1191 |

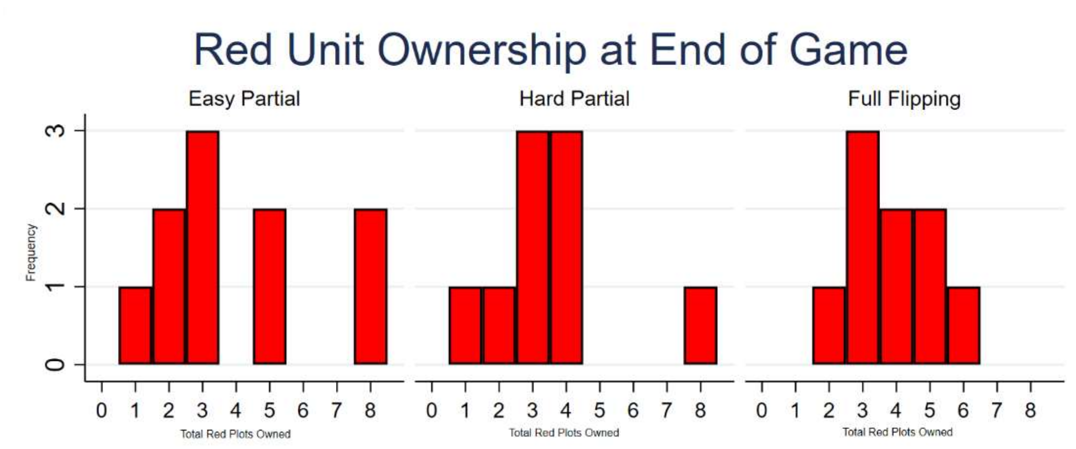
## III. Experimental Results

We report the results of eight initial sessions. In Figure 3 we report the distribution of parcels owned by Red at the conclusion of each game by parameter set (E - "Easy Partial," H - " Hard Partial", and F - "Full Flip."). Relative to the point predictions, we find that the average number of units purchased by Red is higher than expected in the E parameter sets but remarkably close to the prediction in the H parameter set. In the case of the Easy Partial parameter set (E), an average of 3.688 units were purchased by the Red relative to a point prediction of 2 units. In the Hard Partial (H) parameter set 3.063 units were purchased relative to a point prediction of 3 units. Notice that in both parameter sets the "average: statistic hides variance. The over-purchase by Red in these parameter conditions can reflect any (or all) of the following: 1 ) in the H parameter set, this could represent exactly the off-equilibrium-path behavior that we conjectured as a possibility; 2 ) "R" types could be paying in excess of their current value for potential strategic reasons (causing later "panic" selling) or, 3) possibly, such "panic selling" could be emerging endogenously among the Green and Yellow types. Both of these latter phenomena were at least anecdotally reported in the racially motivated "block busting" on the 1960s.

However, what is most striking in our initial data is the failure of Red types to purchase all units in the Full Flip (F) condition (3.6125 vs. 8 predicted!).

Given the small samples, statistical tests are underpowered, yet it is clear from that the pattern that emerges that the data are inconsistent with the order hypothesis (Hypothesis 2). None of the three predicted orderings is statistically different at traditional levels using a Mann-Whitney tests.[8]

**Figure 3: Total Red Unit Acquisitions by Parameter Set (Chat Design)**




[8] We report one observation for each session. In each session, a different one of the treatments is repeated. We use the average of the two stages for that treatment in each session.

**Table 4: Pairwise Rank Tests of Red Plot Ownership by Parameter Set (Chat Design)**

| Parameter Set | Obs | Average Red Plots | Std. Dev. | T-Score |
|---|---|---|---|---|
| Easy | 8 | 3.688 | 2.535 | 0.603 |
| Hard | 8 | 3.063 | 1.474 | |
| Parameter Set | Obs | Average Red Plots | Std. Dev. | T-Score |
| Easy | 8 | 3.688 | 2.535 | 0.058 |
| Flip | 8 | 3.625 | 1.664 | |
| Parameter Set | Obs | Average Red Plots | Std. Dev. | T-Score |
| Hard | 8 | 3.063 | 1.474 | -0.716 |
| Flip | 8 | 3.625 | 1.664 | |

## IV. Two conjectures about the initial results and a new treatment.

The most obvious conundrum of these initial results is the frequent failure of the Red buyers to purchase the predicted eight parcels in the F parameter set. Watching the session in real time, we noticed two effects of the chat feature that we conjecture were important in driving these surprising results.

First, in the seller-to-seller chat we noticed discussion similar to cooperative cheap talk common in a public goods experiment. In this design, the chat takes the form of exhortations for everyone not to purchase from the Red player. In Appendix IV, we highlight examples of chat sequences consistent with holdout behavior.

We think that the potential policy implications of exploring this are significant. This low-cost environment for (apparently successful) seller-to-seller cheap-talk communication in real time as the Red player is attempting to assemble parcels (and impose negative externalities) can be thought of a paradigmatic for a neighborhood with extensive social networks, whether formal (active homeowners' associations) or informal (perhaps long-standing cultural networks of family and neighbors). Indeed, some participants went as far to suggest the formation exclusionary institutions, such as an HOA (Appendix IV, Example 3).

Secondly, we noticed that in the communication between the Red buyer and the sellers that the bilateral communication often became both very extensive but also very intense bargaining, much like two people engaged in a focused bilateral chat on social media or texting platform. This perhaps had side effects of diverting the Red buyer's attention from the bigger picture of bargaining with other potential sellers, and certainly using up more of the 12 minutes than we had imagined. This effect was specifically highlighted as a deliberate strategy by one set of Green subjects (Appendix IV, Example 2). In a sense, the Red buyers were "texting and driving." However, looking at naturally occurring residential real estate markets we noticed that this chat possibility, unlike the seller-to-seller chat discussed above, is really quite an anomaly. The back and forth of offers in residential real estate is, in most cases, mediated through one or two real estate agents.[9] It is very seldom that we would expect buyer and seller to engage in such focused, direct, real-time back and forth. (On the other hand, it is not at all unlikely that the previously noted "cheap talk" communication among potential sellers --- neighbors--- could take place either face-to-face or on immediate-response modes of modern text communication).

Elaborating on the discussion above, we conjecture that the cheap-talk communication among legacy owners resisting the externality-generating new buyer is a real and potentially quite important local institution (where formal or informal). It can be viewed as a part of the social capital or social fabric of the neighborhood. On the other hand, our inadvertent creation of hyper-focused real-time "texting" is, we conjecture, an unintended design artifact.

As a result of these considerations, we developed a second design, identical to the first, with the exception that we completely turned off the chat feature. Our motivation was to see whether, by going to the opposite extreme of eliminating mediating chat possibilities, we could give "full flipping" its best shot. If indeed this makes a difference, we can potentially go further and examine each of the chat features (seller-to-seller and buyer-to-seller) independently to see if either was, by itself, the main driver of any difference in results. So far, we have conducted four experiments in this second, no-chat design.

## V. Results From the Second (No Chat) Design

With only for only four observations to date, we do not intend to draw any formal conclusions regarding the impact of the chat on Red's ability to acquire units. However, there are a few initial patterns. First, the average number of units acquired by the Red player in the Easy and Full Flip (F) parameter sets is closer to the point prediction. In particular, the number of

[9] The share of residential real estate that is sole as "for sale by owner" is estimated to be only seven percent, according to https://realestateagentpdx.com/for-sale-by-owner-homes-sell-for-14-less-2022-report/22140 citing a study by the National Association of Realtors.

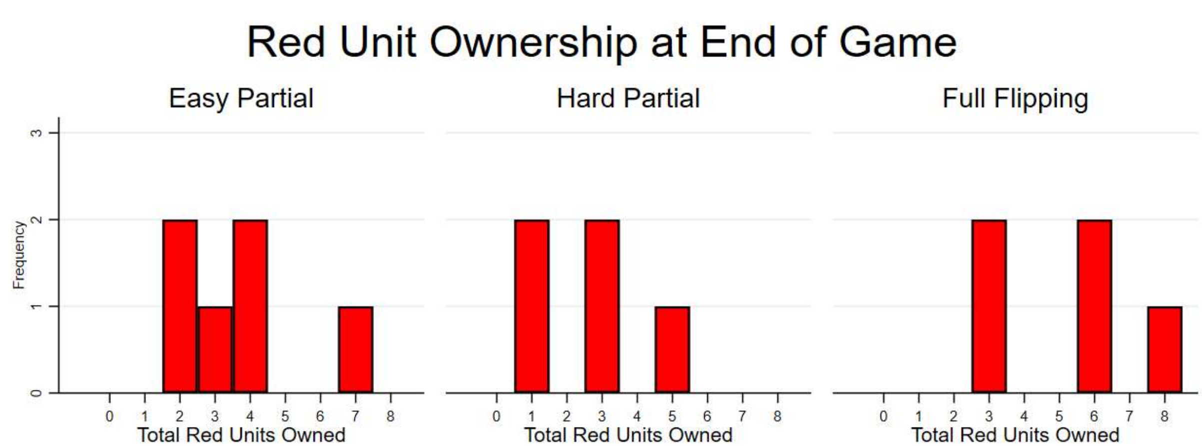
units acquired in the Full Flip (F) parameter set increases to an average of 5 compared to 3.6 in the chat condition. We present them as motivation that our current, ongoing series of experiments (lacking the chat feature) has the potential to exhibit behavior different than the quite surprising initial results presented above.

An additional result to note is that, even with just four sessions, we are already observing some of the “right tail” over-purchase by the Red buyers in the E and H parameters sets which should stop at 2 and 3 Red units respectively.

**Table 5: Pairwise Rank Tests of Red Plot Ownership by Parameter Set (No-Chat Design)**

| Parameter Set | Obs | Average Red Plots | Std. Dev. | T-Score |
|---|---|---|---|---|
| Easy | 4 | 3.375 | 1.109 | 0.614 |
| Hard | 4 | 2.75 | 1.708 | |
| Parameter Set | Obs | Average Red Plots | Std. Dev. | T-Score |
| Easy | 4 | 3.375 | 1.109 | -1.929** |
| Flip | 4 | 5.125 | 1.436 | |
| Parameter Set | Obs | Average Red Plots | Std. Dev. | T-Score |
| Hard | 4 | 2.75 | 1.708 | -2.129** |
| Flip | 4 | 5.125 | 1.436 | |

**Figure 4: Total Red Unit Acquisitions by Parameter Set (No-Chat Design)**




## VI. Conclusions

This paper presents work in progress. Our first series of eight sessions demonstrated that we have created a laboratory market in which items can be traded and re-traded from the existing owners with one category of entrants imposing negative externalities upon everyone else. This design allows a comparison to theoretical predictions which derive from a standard excess demand model. Nevertheless, these predictions are not trivial; this design can in principle and does in fact admit of behavior that comes from behavioral insights not captured by the excess demand model. Of particular note, our first set of eight sessions found that, in the parameter set in which the "R" player was predicted to purchase all eight parcels, this never happened; indeed, the average number of parcels purchased by "R" in this parameter set was barely above 3.6 parcels.

Two behavioral issues stood out as we observed these initial sessions, both involving our initially included chat features. First, Green (legacy) owners were easily framing not selling to the Red player (and thus avoiding the negative externalities). Thus seller-to-seller chat was reminiscent of the powerful effect of "cheap talk" communication in providing a public good (in this case, denying sales to Red). We argue that, if this effect is confirmed through the research process we have under way with new sessions, this insight on a form of neighborhood social capital will be extraordinarily important for policy insight involving such as neighborhood gentrification.

The second effect is, from our point of view, more artifactual. The Red buyers frequently engaged in highly focused chat reminiscent of intense real time text chat. This is not something that we anticipated; indeed, in actual real estate exchange markets this type of real-time negotiation through texting between buyers and sellers, although possible, is typically not representative as the vast majority of negotiations are mediated through one or more real estate agents or attorneys, which adds a well-known time-delay element to the institution.

We are currently in the ongoing conduct of, and we report here preliminary results from, a second design in which both types of chat are removed. If it turns out that Red players can now have greater success in the "full flip" parameter set, that will argue for new sessions in which the chat features are individually turned back on. Given the greater field validity and the potential policy importance, our intention is that we will first study adding back in the seller-to-seller chat. At the current time, the small number of new sessions suggest that the Red players are indeed increasingly successful at purchasing more parcels in the parameter set in which full flipping is predicted.

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**Appendix I: Sample Instructions (chat treatment)**

## General Instructions

**General Information:** The purpose of this experiment is to study how people make decisions in a market in which items can be kept or sold and resold under various kinds of costs. From now and until the end of the experiment any verbal or written communication with other participants is not permitted, except through the software interface as explained below. If you have a question, please raise your hand and one of us will come over to answer it.

You will receive $10.00 for showing up on time for the experiment. In addition, you will have an opportunity to earn more money during the experiment. All currency in this experiment will be denominated in Experimental Currency Units (ECUs). At the end of the experiment, those ECUs will be translated into U.S. currency at the rate of 40 (ECUs) = 1 (US$). At the end of the experiment you will be paid by cash or check the sum of your show-up fee and earnings from the experiment. You will be paid privately and we will not disclose any identifiable information about your actions or your payment to other participants in the experiment.

**Roles, Groups, Parts, and Games:** Depending on how many subjects showed-up for today's experiment, there are either 11 or 22 people at terminals in the room. In today's experiment, subjects will interact in groups of 11, so there are either one or two groups in the room today. If there are 22 people, the computer will randomly assign each of you to one of the two groups. You will remain in this group throughout the experiment. The decisions of the two groups are completely independent. That is, nothing anyone does in Group 1 will affect anything going on in Group 2, or vice versa.

Today's experiment will consist of "*Games*" and "*Parts*". In each of four successive *Games*, you will be assigned the role of a Green, Yellow, or Red player. At the end of a *Game*, your earnings will be stored. Following *Games* 1, 2, and 3, you will be assigned a potentially new role within your group according to a computer algorithm, and then a new *Game* will begin. (Two things to note: Some of you may stay in the same role at the reassignment, and the algorithm will not be affected by any decisions that you make during the course of the experiment. *Game* 4 will be the last *Game* of the experiment.)

During each *Game*, there will be four *Parts.* Each *Part* consists of a block of time. At the end of each *Part*, there will be a brief pause where summary information from the previous *Part(s)* will be provided on your screen. The next *Part* within a *Game* will resume where the prior *Part* left off. A summary information screen will appear at the conclusion of each *Game*.

**Description of the Decision Task(s) and Payoffs:**

This is an experiment with markets for eight units, denoted G1-G8. In each game, these eight units are initially owned by "Green" players. Green players are paid depending upon whether they hold on to their units or sell them (as will be discussed below). Both Yellow and Red players will be paid for the acquisition of units according to "acquisition values" which will be discussed below.

Units are represented in the figure below:

| | | |
|---|---|---|
| G1 | G2 | G3 |
| G8 | | G4 |
| G7 | G6 | G5 |

Each Green player is endowed with one unit. The Yellow and Red players may make an offer to buy the units. If a player accepts an offer, ownership of the unit will transfer to the buyer. Once the unit is transferred to a Yellow or Red player, these players are free to sell the unit to other potential buyers. Once a Green player sells their unit, they exit the market for that game (keeping their earnings from the sale).

*Penalty:* As the Red Player acquires units, Green and Yellow players who own a unit will experience a penalty according to the schedule in the table below.

**PENALTY SCHEDULE**

| **# Units Owned by Red** | **Cumulative Penalty** |
|---|---|
| 1 | 5 |
| 2 | 15 |
| 3 | 30 |
| 4 | 50 |
| 5 | 75 |
| 6 | 95 |
| 7 | 110 |
| 8 | 120 |

*Green Player Earnings:* In each game, a Green player's holding *value* is an integer determined by the experimenter in advance. There are 8 possible holding values ranging from **40 to 198** ECUs. No Green player's starting holding value depends on the value of any other player.

If a Green player does not sell his or her unit to a buyer, that Green's earnings for that game equal their holding value minus the penalty for properties owned by Red (see the table above).

If a Green player sells their unit to a buyer, the Green player receives the price paid by the buyer (instead of the Green player's holding value minus the penalty for properties owned by Red). Note that this means if a Green player sells their unit, they do not pay the penalty for properties owned by Red from the table above.

Each Green player will receive a new holding value every game, but as was mentioned above, a computer algorithm will reassign roles from game to game, so if you are a Green player in one game you might not be a Green player in the following game.

*Yellow Player Earnings:* In each Game, each Yellow Player is assigned an acquisition *value* which is an integer determined by the experimenter in advance. There are 2 possible acquisition values ranging from **160 to 190** ECUs. No Yellow player's acquisition value depends on the value of any other player. In addition, each Yellow player is assigned a starting ECU cash balance of 200 ECUs in each game.

If a Yellow player does not buy a unit from a seller, Yellow's earnings are the starting ECU cash balance (200 ECUs).

If a Yellow player buys a unit and holds it until the end of the game, Yellow earns their starting ECU cash balance plus acquisition value minus the price paid for the unit, minus the penalty for properties owned by Red (see the table above). That is, the additional profit (above the starting ECU cash balance) for a Yellow player for each unit owned at the end of a game is the following:

Additional Profit = Acquisition Value for the Unit – Price Paid – Penalty for Units Owned by Red

If a Yellow player resells a purchased unit to a buyer (either the other Yellow player or the Red player), the Yellow player receives, at the end of the period, the price paid by the buyer in addition to his or her remaining ECU cash balance (the starting ECU cash balance minus the original purchase price). Note that if a Yellow player either does not purchase a unit, or purchases and then resells a unit (and hence does not own a unit), that Yellow player does not pay the penalty for properties owned by Red.

No Yellow player may make a bid for a unit in excess of their total ECU cash balance.

Each Yellow player will receive a new acquisition value every game, but as was mentioned above, a computer algorithm will reassign roles from game to game, so if you are a Yellow player in one game you might not be a Yellow player in the following game.

*Red Player Earnings:* The Red Player's earnings are a little more complicated. At the beginning of each game, each Red player receives a starting ECU cash balance for that game of 150 ECUs. Additionally, the Red player can borrow funds from the bank in excess of that starting cash balance in 100 ECU increments. All debts must be repaid to the bank. At the end of each *Game* the computer will automatically make the repayment from the Red Player's cash balances.

For each unit purchased, the Red player has an acquisition value associated with the unit, ranging from **118 to 125** ECUs. Red players have positive redemption values for eight units, and the acquisition value of each additional unit will either stay the same or drop from one unit to the next in a given game.

The earnings of the Red player will be calculated as follows.

If the Red player does not purchase any units, they earn 0 from acquisitions, plus their 150 ECU starting cash balance.

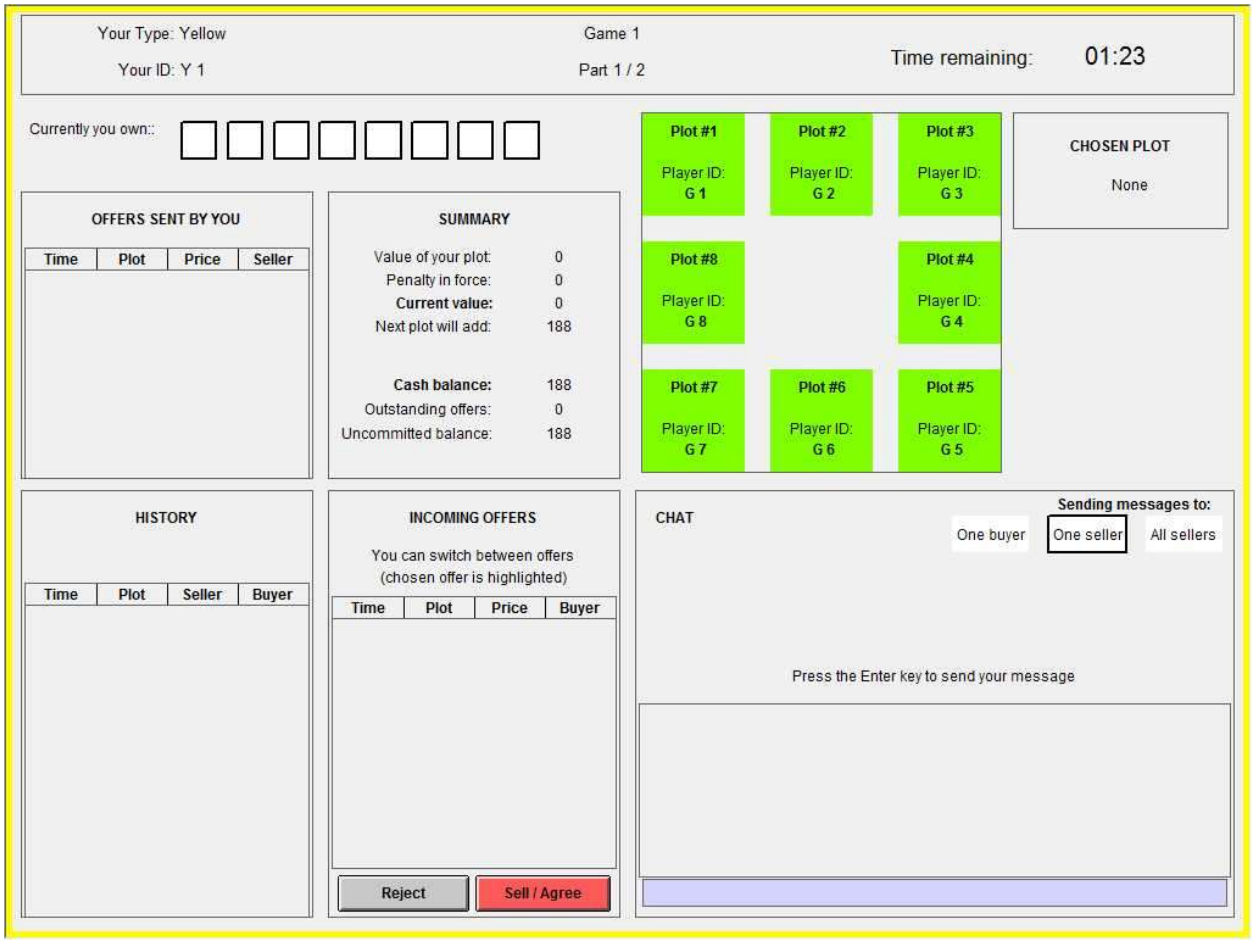
If the Red player buys at least one unit, they earn the sum of their 150 ECU starting cash balance plus the acquisition values of all units purchased minus the sum of prices paid to sellers. Furthermore, any outstanding bank debt will be automatically repaid. Notice the Red player *never* has to pay the penalty for Red owning properties

*Final Notes About Earnings:*

Should any participant in the experiment finish a *Game* with earnings less than zero, they will have their earnings adjusted to zero for that *Game.*

**Description About How Items Are Bought and Sold:**

The following is a screenshot of the market interface.




Notice the display of the eight units in the top right hand side. The top left corner indicates that this sample screen shot belongs to a Yellow type player, with ID Y 1. In the next row on the left are a series of empty boxes indicating that this player currently owns no units. Below that line is a summary, which indicates information about unit holdings and values. This hypothetical seller currently owns no units, so the value of the current unit is 0. However, the next unit that this player would purchase would have a value of 188. Below that, we see that this player has a cash balance with which to purchase units of 188.

The rest of the market interface is divided into two basic activities: One is making and/or accepting offers. The other is chatting with other participants.

Making or accepting offers. A player can make an offer to purchase a unit by clicking on the unit ID in the "grid" at the top right side. A player must have enough funds in that player's cash balance account to make the purchase, and once the offer is made it cannot be withdrawn.

If you own a unit, you will see offers for your units arriving in the "INCOMING OFFERS" box at the lower center of the screen. When another player makes an offer for one of your units, that information will populate a line on the "INCOMING OFFERS" box with the time, the unit ID, the price being offered, and the ID of the buyer making the offer. You can reject the offer by clicking on the relevant offer (highlighting it) and then clicking the “Reject” button. Similarly, you can sell that unit (that is, agree to the price) by clicking on the relevant offer (highlighting it) and then clicking on the “Sell/Agree” button. Or, you can do neither and leave the offer for further consideration.

Yellow and Red buyers may withdraw any outstanding offers which can be found in the “Offers sent by you” box. To withdraw, or equivalently “cancel” the outstanding offer, the buyer must select the outstanding offer of interest in the 'Offers sent by you' box, and then click the cancel button to confirm the selection. Cancelling an outstanding offer will withdraw your offer and it will be deleted from the respective buyer's 'Incoming offers' box.

Whenever a seller accepts a Yellow buyer’s offer, any outstanding offer previously sent by that Yellow buyer will be automatically canceled.

Note that accepted offers are final and cannot be rescinded or changed.

Chatting with other participants.

Notice that on the market interface, in the bottom right hand corner, there is an area in which you can choose to (but do not have to) send chat messages to other participants. You can send a message to either one potential seller, all potential sellers, or a specific buyer. Please be advised that your messages scroll on our monitor terminal, and we will not allow threatening, abusive or vulgar messages. *We reserve the right to terminate your participation in the experiment if you violate these rules.* Please re-read the preceding sentence.

**Description of the Reassignment Algorithm:**

There will be four G*ames* in today’s session. In the first *Game*, the initial assignments of Green, Yellow, and Red are strictly random. After *Game* 1, and after each subsequent *Game*, the following reassignment algorithm will be used.

The “Red” participant will remain “Red” for all of *Games* 2 – 4.

The computer algorithm will reassign “Green” and “Yellow” participants to be either “Green” or “Yellow”. The basic model is one of random reassignment. Any participant that is not “Red” will have a one in five chance of being “Yellow” in any one of the games today.

## Appendix II: Instruction Quiz Questions

1. Suppose you were the owner of a Green unit, with an initial holding value of 130 ECUs. Further suppose that at the end of the period , you still own this unit (i.e. you have not sold). Suppose further that the Red player has purchased two units which imposes a total penalty of 15 ECUs. What are your earnings for holding the unit?
   a. 115 ECUs
2. Suppose you were a Red player with a value for a unit of 100 ECUs. You paid a yellow player 70 ECUs for a unit. What would be your end of period profit on that transaction?
   a. 30 ECUs
3. The numbers used in the previous two questions will always be the actual holding values in this experiment. (True/False)
   a. False
4. Red players also have to pay the penalty on their final value of holdings. (True/False)
   a. False
5. Yellow players can borrow (interest free) and then repay the loan from their cash balance. (True/False)
   a. False
6. Red players can borrow (interest free) and then repay the loan from their cash balance. (True/False)
   a. True

**Appendix III: Parameter Set Rotation**

| Parameter Set Sequence | Game 1 Parameters | Game 2 Parameters | Game 3 Parameters | Game 4 Parameters |
|---|---|---|---|---|
| Sequence 1 (EFEH) | Easy | Flip | Easy | Hard |
| Sequence 2 (EHEF) | Easy | Hard | Easy | Flip |
| Sequence 3 (FHFE) | Flip | Hard | Flip | Easy |
| Sequence 4 (HFHE) | Hard | Flip | Hard | Easy |

## Appendix IV: Holdout Behavior in Chat Logs

**Example 1:** Session 2 Game 2

| Sender | Receiver | Message |
|---|---|---|
| G4 | All Sellers | can we all agree to not sell |
| G4 | G2 | i j messaged evryone LMAO |
| G2 | G4 | do you have any other yesses? |
| G8 | G4 | lol but for green's if there are no reds we just make out holding value sooo |
| Y2 | R1 | hey how much you selling for |
| G4 | G2 | ya G8 said they were down |
| Y2 | R1 | how much you selling for |
| G4 | G2 | but like if we sell we all lose out |
| Y2 | R1 | how much you selling for |
| R1 | Y2 | id sell for 90 |
| G4 | G2 | rather than sticking as a team and collectively making money |
| G5 | G4 | I have a couple offers Im selling it for 110 |
| G8 | G4 | we'd all still make something without selling. but if one person sells to red we start losing money becase of the penalty |
| G2 | G4 | nice |
| Y2 | R1 | would you be able to do 85 |
| R1 | Y2 | yes |
| Y2 | R1 | deal |
| G4 | G2 | ya if evryone j held out we would all make more |
| G4 | G8 | G2 said they wont sell hope they didnt lie LMAO |

**Example 2:** Session 5 Game 2

| Sender | Receiver | Message |
|---|---|---|
| Y2 | All Sellers | we need to keep R1 distracted |
| Y2 | All Sellers | keep trying to barter with them |
| Y1 | All Sellers | will do |
| Y1 | All Sellers | will do |
| Y2 | All Sellers | good--just keep bartering with them and making a relationship |
| G3 | R1 | ill sell it to you for 90 |
| Y2 | All Sellers | don't sell tho |

**Example 3:** Session 8 Game 3

| Sender | Receiver | Message |
|---|---|---|
| G3 | All Sellers | WHAT IS HE OFFERING |
| G2 | All Sellers | red legit just offered me 110. |
| R1 | All Sellers | how much do yall need to sell it for |
| R1 | All Sellers | I have 100 |
| G8 | All Sellers | u say 100 but u offer 50 |
| G5 | All Sellers | I need 100 |
| G2 | All Sellers | HE IS OFFERIN ME THE WORLD |
| G6 | All Sellers | 100... |
| G5 | All Sellers | I'm selling for 100 |
| Y2 | All Sellers | it was at the beggining |
| G8 | All Sellers | listen g6 im broke |
| G3 | All Sellers | I'LL GIVE YOU 10 MORE THAN WHAT HE'S OFFERING |
| R1 | All Sellers | will you take 100 to come out even and make it less boring? |
| G3 | All Sellers | HOLD FIRM PEOPLE |
| G6 | All Sellers | must...give...in |
| G2 | All Sellers | Diamond hands here |
| G3 | All Sellers | A CHAIN IS ONLY AS STRONG AS ITS WEAKEST LINK |
| G5 | All Sellers | I will |
| Y2 | All Sellers | get me my money back pls |
| G6 | All Sellers | i only have 40 :( |
| G8 | All Sellers | ill sell but im holding till the end so i can watch chat lol |
| R1 | All Sellers | thank you |
| G6 | All Sellers | uh oh |
| G8 | All Sellers | WHO DID IT |
| G1 | All Sellers | sold |
| G2 | All Sellers | betrayal |
| G3 | All Sellers | I can't believe this. |
| G6 | All Sellers | CODE RED CODE RED |
| G8 | All Sellers | BAD BAD |
| G8 | All Sellers | no more reds |
| G3 | All Sellers | Right on my street too. |
| G6 | All Sellers | welp |
| G2 | All Sellers | Alright guys form an HOA to make reds life mildly inconvienent |
| G8 | All Sellers | G3 how could you let this happen |
| G4 | All Sellers | i am ashamed of my next door neighbor |