University of Cyprus
Department of Economics

Working Paper 13-2018

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Vote trading in power-sharing systems: A laboratory investigation*

(Short Title: Vote trading in power-sharing systems)

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July 25, 2020

Abstract

Vote trading in power-sharing systems—i.e., systems in which a voter's utility with respect to the election's outcome is proportional to the vote share of her favourite party—is, in theory, welfare improving. However, trading votes for money in majoritarian systems may have detrimental welfare effects, especially when voters' preference intensities are similar (Casella *et al.*, 2012). We use a laboratory experiment to test the effect of vote trading in each of these popular electoral systems on voter welfare and find strong evidence in support of the above intuitions: vote trading in power-sharing systems boosts aggregate welfare across all considered specifications, but it is not welfare improving in majoritarian systems. Importantly, and contrary to theoretical predictions, a substantial share of subjects consistently lose from vote trading even in power-sharing systems, indicating that its welfare effects are not unambiguous.

Keywords: vote trading; power-sharing systems; majoritarian systems; experiment; social welfare.

JEL classification: D72

*The paper benefited significantly from the constructive comments of three anonymous referees and the editor, Gilat Levy. We are also grateful to George Voucharas for excellent research assistance, as well as to Philippos Louis and seminar participants at AUEB, ETH Zurich, UCY and University of Macedonia for valuable feedback. Financial support by University of Cyprus Starting Grant 8037E-32806 is also gratefully acknowledged. All remaining errors are our own. Contact Information: *Nikolas Tsakas*, Department of Economics, University of Cyprus, P.O. Box 20537, 1678, Nicosia, Cyprus; E-mail: `tsakas.nikolaos@ucy.ac.cy`, *Dimitrios Xefteris*, Department of Economics, University of Cyprus, P.O. Box 20537, 1678, Nicosia, Cyprus; E-mail: `xefteris.dimitrios@ucy.ac.cy`, *Nicholas Ziros*, Department of Economics, University of Cyprus, P.O. Box 20537, 1678, Nicosia, Cyprus; E-mail: `n.ziros@ucy.ac.cy`

1 Introduction

Economic theory predicts that a society whose members are endowed with amounts of certain private-consumption commodities will gain by allowing its members to trade: in this way, individuals who lack a certain good that they would enjoy consuming, but possess another one about which they do not really care, can trade the latter with the former and increase their consumption utility. Importantly, the voluntary nature of trade guarantees that everybody will end up better off than with no trade, leading to increased collective welfare. However, this positive feature of trade does not easily generalise to circumstances where the traded goods are not exclusively private-consumption commodities and may involve externalities, like emissions' permits, fishing rights, or votes. Indeed, the claim that all members of the society enjoy larger utility if trade is allowed relies on the simple observation that when trade is allowed and all commodities are privately consumed, each individual can enjoy at least the same utility level as with no trade, since being actively involved in trade is non-mandatory. This is not true when the trade of certain goods induces externalities to non-traders. Consider, for instance, a society that allows its members to trade votes. A particular individual may abstain from vote trading, but her utility level will be crucially affected by the decisions of the vote traders, since their trading decisions will largely shape the electoral outcome.

For this reason, a large literature in economics tries to assess the non-trivial impact of vote trading on collective welfare. Many scholars have argued that vote trading cannot improve collective welfare for a variety of reasons, but it was only recently that formal arguments were provided by Casella *et al.* (2012), Casella and Turban (2014), and Casella *et al.* (2014).[1] These studies demonstrated that vote trading may, indeed, reduce ex-ante collective welfare (defined by the expected sum of individual utilities before the individual preferences are drawn from a given distribution) when voters are sufficiently homogeneous in their preference intensities (i.e., how much they care about the election's result), but may increase welfare if voters are substantially heterogeneous in this respect. Moreover, Casella *et al.* (2012) and Casella *et al.* (2014) provided experimental evidence in support of these findings. Hence, this long-standing question seems to have received, at last, a satisfactory answer.

Yet, these results are specific to elections between two candidates under majority rule. Undeniably, decisions that are taken by simple majority are at the core of the formal study of democratic institutions and are of great empirical relevance, since many real elections fit this description. However, in many occasions, collective entities employ the so-called power-sharing institutions to make certain important decisions, especially as far as the composition of multi-member bodies are concerned (e.g., councils or executive boards).[2] For instance, in most parliamentary democracies,

[1]See also Riker and Brams (1973) and Piketty (1994).

[2]The literature on the topic was initiated by Lijphart (1984). Some standard references include Austen-Smith

the composition of the legislature follows proportional electoral systems that attribute more parliament seats to parties that receive larger vote shares. Moreover, in many local elections, different parties are assigned public offices in proportion to the share of votes that they received. Hence, it is important to explore whether vote trading has the same effects in these systems, too.

In this paper, we first note that vote trading in power-sharing systems—i.e., systems in which a voter's utility from the result of an election is proportionally increasing in the vote share of her favourite party/candidate—is, in theory, welfare improving. That is, it increases the ex-ante welfare regardless of how similar voters' intensities are. This is not just an aggregate phenomenon, but actually works at the individual level: every player, independent of how much she cares about the election's outcome, expects higher utility when vote trading is allowed than when it is not.[3] This salient difference compared to simple majority frameworks arises mainly due to the fact that externalities from vote trading can vanish in expectation in power-sharing systems. Consider a two-party power-sharing system where every voter is known to be the supporter of each party with even probability. In this case, a player who refrains from vote trading expects that her preferred party will receive her vote and half of the rest of the votes, independent of the exact number of players that decide to trade. Indeed, as long as the individual does not hold a given vote, she expects that it will be cast to her preferred party with probability one-half. Additionally, vote trading in such systems exhibits a redistributive effect of the relative expected utilities: individuals who do not care a lot about the election's result profit substantially from vote trading, while players who do care a lot do not always benefit as much.

These effects of vote trading in power-sharing systems are robust to a variety of different assumptions regarding the rules of vote trading, including both price-making and price-taking environments. But are they pertinent to real elections? That is, *should we consider allowing voters to trade votes for money in real power-sharing systems?* Many theoretical analyses generate predictions that require unrealistically sophisticated reasoning on behalf of the subjects and hence fail to be validated in contexts of empirical interest. Are the above arguments a mere theoretical artefact, or do they also carry practical implications? In light of the obvious importance of these questions, especially as far as policy design is concerned, we regard empirical testing as imperative. This is the main task that we undertake in this paper.

We conduct a comparative laboratory investigation of vote trading in power-sharing and majoritarian electoral systems, considering both the possibility that voters are heterogeneous in terms

and Banks (1988), Ortuño-Ortín (1997), Grossman and Helpman (1999), Alesina and Rosenthal (2000), Baron and Diermeier (2001), Morelli (2004), Llavador (2006), Sahuguet and Persico (2006), Merrill and Adams (2007), De Sinopoli and Iannantuoni (2007), Iaryczower and Mattozzi (2013), Herrera *et al.* (2014), Saporiti (2014), and Matakos *et al.* (2016), among others.

[3] We construct our formal argument considering the setup in which vote trading is most usually studied, namely, when two parties participate in the election and individual preferences are the voters' private information (Casella *et al.,* 2012; Casella and Turban, 2014; Casella *et al.*, 2014; Xefteris and Ziros, 2017).

of their preference intensities and also that they might not differ dramatically in this respect. Our results confirm, by and large, the theoretical predictions. We consider a strategic-market environment (à la Shapley and Shubik, 1977),[4] and we find that collective welfare is larger when trading votes for money is allowed in power-sharing systems, across all employed intensity distributions. This welfare improvement is more significant, in statistical terms, when voters are more heterogeneous in their preference intensities, and it is always relatively moderate in magnitude. Indeed, vote trading is found to increase election-related payoffs by up to 4%. Furthermore, the redistributive effect is always significant both in statistical and in economic terms. In fact, we identify a striking increase of up to 50% (depending on the treatment) in the election-related payoffs of the voters that care the least about the election's outcome and mild or no welfare increases to voters that care about the election in an intermediate or significant manner. As far as majoritarian elections are concerned, we find that vote trading substantially decreases welfare when voters care similarly about the election's result, and it has a milder negative effect on collective welfare when voters care about the election to different degrees.

Our main experimental framework demonstrates that vote trading increases welfare in power-sharing systems, but we further investigate whether this finding is a consequence of the particular setup or if it generalises to alternative environments, especially in regards to trading institutions. For this reason, we perform additional tests considering alternative trading institutions: one modified strategic-market environment and one price-taking institution. We find that our main result is robust to these modifications.[5] That is, increases in welfare are identified across all employed trading institutions and distributions of preference intensities.

However, these encouraging results about vote trading in power-sharing systems do not come without caveats. A regular finding in our experiments is that not all subjects enjoy benefits from vote trading. Indeed, the theoretical results regarding power-sharing institutions do not suggest that in every election all voters should enjoy a higher utility compared to the no-trade outcome, but that in the long term—i.e., after a large number of elections—each voter should have accumulated a higher payoff than if trading votes for money were not allowed. In our experiment, though, despite the sufficiently large number of elections, there is a considerable share of subjects that end up with a payoff that is smaller than the one they would enjoy if vote trading were not allowed. On aggregate, this negative effect is smaller compared to the positive effect of vote trading on the payoffs of individuals that do gain from it, so vote trading does increase collective welfare. Nevertheless, the fact that vote trading generates winners and losers, even in power-

[4]Certainly, these games are not the only ones that could be used, but their explicit trading rules makes them attractive for our purpose. For some standard references see Shubik (1973), Dubey and Shubik (1978), Postlewaite and Schmeidler (1978), Amir *et al.* (1990), Peck *et al.* (1992), Amir and Bloch (2009), and Koutsougeras (2009).

[5]In the literature, there have been several attempts to incorporate externalities in a canonical price-taking model. See, for instance, Arrow and Hahn (1971), Shafer and Sonnenschein (1975), Hammond (1998), Florenzano (2003), del Mercato (2006), and Bonnisseau and del Mercato (2010).

sharing systems, is an insight that could not be gained without this experimental investigation and casts a shadow on the otherwise positive effects of vote trading in such systems.

These main findings of our work indicate that vote buying need not be ruled out in certain setups in which sharing of power is desired. Of course, one should be very careful when using a controlled experimental framework to understand real life contexts, and further experimental studies and approaches are necessary so that confidence in these results is strengthened or appropriately qualified. Field experiments would be a natural next step, but these first welfare results lay a promising groundwork.

Apart from welfare, our experimental study also sheds light on a number of other interesting aspects of vote trading. Notice that allowing individuals to trade votes does not mean that voters will actually decide to sell/buy votes. In all theoretical frameworks considered here, no trade is always a plausible eventuality: if nobody is expected to trade, then nobody has the incentive to offer or demand votes, and no trade is always an equilibrium. Hence, it is a real question whether human subjects will actually engage in trading their votes for money. We find that in an overwhelming 80% of cases trade actually took place (i.e., there was at least one seller and at least one buyer).[6] Moreover, the volume of traded votes, demand, and supply are shown to react in the expected manner when parameters of the trading environment change, thus strengthening the relevance of the main welfare results (i.e., it is very hard to argue that welfare changes are driven by other, non-economic forces when all the remaining economically relevant variables behave in the expected manner).

In what follows, we discuss the relevant literature (Section 2), we develop the general theoretical arguments and discuss the specific predictions for the environment we employ in our experiment (Section 3), we present our experimental setup (Section 4) and our results (Section 5), and, finally, we conclude with some ideas regarding further investigations (Section 6). The proofs of propositions and discussion about two additional treatments can be found in Appendices A and B, respectively.

2 Relevant literature

The literature on vote trading is not recent. Many scholars have debated the idea, since the endeavour to improve the quality of collective decision making is traditionally one of the main goals of economic theory.[7] Despite the above, it was only recently that a formal equilibrium analysis was provided by Casella *et al.* (2012), Casella and Turban (2014), Casella *et al.* (2014), and Xefteris and Ziros (2017) for certain intuitive trading contexts.

[6] In all of our experiments the theoretical prediction regarding the probability that vote trading actually takes place in a given round is about 84%, which is similar to the observed frequency.

[7] See, for instance, Ferejohn (1974), Koford (1982), and Philipson and Snyder (1996).

In particular, Casella *et al.* (2012) consider decentralised vote markets where individuals with privately known preferences place stochastic demands and supplies. The market for votes clears ex-ante in expectation, whereas in the case of imbalance between the realised demands and supplies, an anonymous rationing rule is used to allocate votes and money to market participants. The main result exhibits that, in equilibrium, each of the two voters with the most intense preferences (irrespective of party preferences) demands the majority of votes with some probability that depends on the realisation of types and the size of the electorate, and all other voters always sell their votes. Hence, if vote trading takes place, then a single voter acquires the majority of the votes. The literature also shows that if the number of voters is large (or if the distribution of electorate types is not very skewed), vote trading leads to welfare losses relative to plurality voting.

Casella and Turban (2014) consider competitive markets for votes in a setup where two groups of voters make decisions via majority rule. The authors provide sufficient conditions to guarantee the existence of an ex-ante equilibrium, in which the strongest supporter of each group demands votes, with the minority's buyer being more aggressive. For this reason, the probability of implementation of the minority's favourite policy is higher than the efficient level, and, thus, the market for votes always falls short of the first best. In a complementary approach, Casella *et al.* (2014) study trades which (i) take place in a decentralised competitive market and (ii) are coordinated by the two group leaders. The results exhibit that with decentralised trades, the minority's favourite policy is implemented with higher probability than the efficient level, which suggests that vote trading can be welfare reducing relative to no trade. On the other hand, with coordination through leaders vote trading has higher ex-ante total welfare than no trade; however, if the two groups are of different sizes, the minority wins with lower probability than the full-efficient level.

In Xefteris and Ziros (2017), vote trading under incomplete information is studied under alternative electoral rules, norms of exchange, and equilibrium concepts. First, decision-making power is not attributed as a whole to the majority winner, but, instead, is distributed between the two parties in a proportional manner. Second, trade follows the rules of strategic market games; thus, all traders are able to influence the prices of votes with their market actions. Third, almost strict Bayesian-Nash equilibrium is used as a solution concept. In such a framework, it is shown that trade occurs in every equilibrium of the game, that there always exists an equilibrium in which all individuals engage in vote trading (i.e., full-trade equilibrium), and that this equilibrium is unique in the class of full-trade equilibria. It is worth noting that the equilibrium outcomes allow for the dispersion of votes to many buyers, as all voters who have relatively more asymmetric valuations of the two parties offer their money in exchange for votes. Moreover, a positive perspective is offered, as it is proved that vote trading in power-sharing systems unambiguously improves social welfare.

As far as experiments on vote trading are concerned, the literature confirms existing theories, but solely in the context of majoritarian systems. Casella *et al.* (2012) tested their theoretical results with a continuous open-book multiunit double auction. The results showed that observed prices were higher than the ex-ante competitive equilibrium prices, but they fall with experience. On the other hand, the frequency of a single voter acquiring the majority of votes was lower than predicted, but it increased significantly with experience. Finally, social welfare was higher than expected, but still lower than with simple plurality voting, when the difference between the top valuations and all others was small. The experimental results in Casella *et al.* (2014) are also in line with theoretical predictions. In the decentralised trades scenario, demands for votes came from the highest-valuation voters of each group. Observed prices converged towards the equilibrium prices with decentralised market trades and with trades through leaders of equal-sized groups, but not with trades through leaders of different-sized groups. The data also showed that vote trading had the predicted effects on social welfare, since with decentralised markets there were too many minority wins. By contrast, with trade through group leaders, there were too few minority wins.

Our main goal is to complement these studies by studying similar questions in power-sharing systems and, hence, to provide a complete understanding of the comparative effects of vote trading across varying political institutions.[8]

3 Theoretical arguments

We consider a simplified model of vote trading: in particular, we consider a community with n individuals, denoted by $N = \{1, 2, ..., n\}$, with n odd, and two parties, $\mathcal{A}$ and $\mathcal{B}$. All individuals are identical with respect to their initial endowments, and each individual is assumed to have one vote and e units of money (numeraire).

Preferences and beliefs Concerning ordinal preferences, each individual $i \in N$ is characterised by her ordinal type, $t_i \in \{\mathcal{A}, \mathcal{B}\}$, where $t_i = \mathcal{A}$ if $\mathcal{A} \succ_i \mathcal{B}$ and $t_i = \mathcal{B}$ if $\mathcal{B} \succ_i \mathcal{A}$. As far as cardinal preferences are concerned, each individual $i \in N$ is characterised by her cardinal type/intensity parameter, $w_i \in \Xi = \{1 - \xi,\ 1, 1 + \xi\}$, for some $\xi \in (0, 1)$. For convenience, we sometimes refer to the cardinal type $1 - \xi$ as low type (L), the cardinal type 1 as medium type

[8]Let us also mention that there are various experimental approaches to vote trading in majoritarian systems that do not adopt the vote-market framework. For instance, McKelvey and Ordeshook (1980) used "votes for votes" exchanges in various scenarios in order to test whether subjects are able to coordinate towards Pareto efficient outcomes or outcomes offered by alternative cooperative solution concepts. More recently, Goeree and Zhang (2017) employed auction-type mechanisms—theoretically studied also by Lalley and Weyl (2014), Lalley and Weyl (2018), and Eguia and Xefteris (2018)—and showed that bidding for votes yields higher overall welfare and is particularly beneficial to moderate voters due to the redistribution of gains.

Of course, this is not the only class of experiments in political economics. Vote-related decisions in alternative contexts have been studied, for instance, by Levine and Palfrey (2007), Battaglini *et al.* (2010), Blais and Hortala-Vallve (2016), and Bouton *et al.* (2016). For an excellent review of related experiments see Palfrey (2009).

(M), and the cardinal type $1+\xi$ as high type (H).

The beliefs of individual $i \in N$ regarding the ordinal preferences of $j \in N \setminus \{i\}$ are modelled by a Bernoulli distribution with parameter $\frac{1}{2}$, and support $\{\mathcal{A}, \mathcal{B}\}$ and the beliefs of individual $i \in N$ regarding the intensity parameter of $j \in N \setminus \{i\}$ are given by a uniform distribution over Ξ.

Stages of the game The game consists of three stages: first, in the vote-trading stage, players trade votes for money according to the rules of some well-defined trading institution. Then, in the voting stage, each player casts all of the votes at her disposal to the party she chooses. Finally, the vote shares of the two parties and the payoffs of all players are computed.

Vote-trading stage We consider that vote trading follows the rules of a *strategic-market mechanism* (Shubik, 1973 and Shapley and Shubik, 1977).[9] There is a trading post where each individual chooses an action from the set $\{b, s, \varnothing\}$, where b stands for "buy votes by placing a fixed monetary bid $\beta > 0$", s stands for "sell her whole vote in exchange for money", and $\varnothing$ stands for "neither buy nor sell votes".[10] If we use B to denote the number of individuals who choose to buy votes and S to represent the number of individuals who choose to sell their votes, then in any strategy profile with $BS > 0$, the amount of extra votes that are allocated to each vote buyer is

$$h = S/B$$

and the extra amount of money that is allocated to each vote seller is

$$p = \beta B/S.$$

According to this allocation mechanism, the total number of votes offered for sale is distributed equally among individuals who chose to place monetary bids (vote buyers), whereas the total amount of the monetary bids are distributed equally among those who decided to sell their votes (vote sellers). Hence, if vote trading takes place (i.e., $BS > 0$), then an individual who submits a buying (selling) order gets an additional amount of votes (money) with probability one. If there are no vote sellers, the monetary bids are returned to the individuals who submitted them; whereas if there are no vote buyers, the submitted votes are returned to the individuals who offered them.[11]

[9] In Appendix A we show that our analysis and main results remain valid when considering alternative trading institutions.

[10] Standard market games are usually strategically richer than the considered vote-trading model, as they allow traders to choose the amount of their purchasing bids. Requiring that all bids are of the same amount is made to ensure tractability of our equilibrium analysis. Notice, though, that this assumption does not affect in any way our central findings.

[11] There are a few points that should be stressed here about our trading institution. First, votes are perfectly divisible, and, hence, a vote buyer might end up having a non-integer number of votes. This is not important for our results; we could instead consider indivisible votes at some extra cost in notation. Second, the allocation of votes and money is directly affected by the market actions of all individuals. Third, the term p can be interpreted as the market-clearing price, and, hence, the explicit price-formation mechanism exhibits how individuals can affect prices of votes with their submitted (buying or selling) orders. Finally, after this stage, the sum of votes and the sum of monetary units of all individuals are intact (n and ne, respectively).

Note that, in the current setup, two strategic-market mechanisms can differ only with respect to the value of the monetary bid, $\beta > 0$. Thus, whenever we refer to a specific strategic-market mechanism, we essentially refer to a particular value of β. Finally, given that any admissible setup is fully characterised by a triplet (n, ξ, β), we call such a collection of values a *parametrisation* of the model.

Voting stage In the second stage, each voter attributes her votes to any party she decides to.

Electoral systems and payoffs In the third stage, players' payoffs are computed. In particular, if we denote by V_{t_i} the vote share of the preferred party of individual i and by m_i the monetary units of individual i after the vote-trading stage, then in a power-sharing system the payoff of this individual is

$$u_i = V_{t_i} \times w_i + m_i,$$

and, under majority rule, it is given by

$$u_i = \theta_{t_i} \times w_i + m_i, \text{ where } \theta_{t_i} = \begin{cases} 1 & \text{if } V_{t_i} > 1/2, \\ \frac{1}{2} & \text{if } V_{t_i} = 1/2, \\ 0 & \text{if } V_{t_i} < 1/2. \end{cases}$$

That is, power-sharing systems are such that a voter's payoff from the result of an election is proportional to the vote share of her preferred party, while majoritarian systems attribute all power to the party that collects the majority of votes. While the specific description of these two popular classes of electoral systems admittedly abstracts from several of their real-world features (e.g., coalition formation, minority rights, etc.), it presents an arguably fair representation of their main different characteristic: the degree to which political outcomes are expected to be proportional to parties' vote shares. For this reason, this way of modelling power-sharing and majoritarian systems has been widely adopted by the literature (e.g., Iaryczower and Mattozzi, 2013; Herrera *et al.*, 2014).

Equilibrium notion Given that sincere voting (weakly) dominates any other behaviour in the voting stage, we do not model it formally and simply assume that each voter attributes all her votes to the party she prefers. This essentially leaves us with an ex-ante symmetric single-stage game of incomplete information and, hence, a suitable equilibrium concept is symmetric Bayesian Nash equilibrium in pure strategies (i.e., two players may choose different actions only if their cardinal preference types are different).

General results In order to properly state the main results regarding the welfare properties of the two electoral systems, we need the following auxiliary definitions.

Definition 1 *A **vote-trading equilibrium** (or an equilibrium with vote trading) is such that trade takes place with positive probability.*

Definition 2 *A **no-trade equilibrium** is such that trade takes place with probability zero.*

Definition 3 ***Collective welfare** is the sum of the individuals' ex-ante (i.e., before types are drawn) expected payoffs.*

Definition 4 *For every n, use $\hat{\xi}_n \in (0,1)$ to denote the threshold value below which the majoritarian alternative (i.e., the outcome preferred by the majority of voters) is guaranteed to coincide with the utilitarian one (i.e., the alternative that maximises the sum of individual payoffs). Whenever the parametrisation (n, ξ, β) is such that $\xi < \hat{\xi}_n$, we say that the preference intensities are **similar**.*

Definition 5 *Given an electoral system and a parametrisation (n, ξ, β), vote trading is **welfare improving** if every vote-trading equilibrium leads to (weakly) higher collective welfare compared to the no-trade equilibrium.*

Notice that the no-trade equilibrium always exists. Indeed, if all players are expected to use action $\varnothing$, then every player is indifferent among all actions, and, thus, playing $\varnothing$ is a best response. We are now ready to present the main difference between power-sharing and majoritarian institutions, as far as the welfare consequences of vote trading are concerned.

Theorem 1 *In power-sharing systems, vote trading is welfare improving for every parametrisation. In majoritarian systems, vote trading is not welfare improving if the preference intensities are similar.*

Proof. Fix a parametrisation (n, ξ, β) and use $g : \Xi \to \{b, s, \varnothing\}$ to denote a strategy. We define (i) $EV_{t_i}(g|x)$, the expected vote share of the party preferred by i when i employs action x and the other players employ strategy g, and (ii) $Em_i(g|x)$, the expected amount of money to be allocated to i when i employs action x and the other players employ strategy g.

In a power-sharing system the expected payoff of player i when vote trading is not allowed is given by $[(1 + \frac{n-1}{2})/n]w_i + e = (\frac{1}{2} + \frac{1}{2n})w_i + e$. Moreover, in every vote-trading equilibrium, g^*, it must be the case that $EV_{t_i}(g^*|g^*(w_i))w_i + Em_i(g^*|g^*(w_i)) \geq EV_{t_i}(g^*|\varnothing)w_i + Em_i(g^*|\varnothing)$, for every $w_i \in \Xi$. But note that $Em_i(g|\varnothing) = e$ for every g, by definition of what $\varnothing$ entails (i.e., of what refraining from trade means) and that $EV_{t_i}(g|\varnothing) = (1 + \frac{n-1}{2})/n = \frac{1}{2} + \frac{1}{2n}$ for every g, by the fact that all other players employ the same strategy g. That is, in every vote-trading equilibrium, g^*, we must have $EV_{t_i}(g^*|g^*(w_i))w_i + Em_i(g^*|g^*(w_i)) \geq (\frac{1}{2} + \frac{1}{2n})w_i + e$. Hence, all types should enjoy an interim expected payoff that is at least as high as the interim expected payoff without trade. Therefore, the ex-ante expected payoff of every player is also at least as high as the ex-ante expected payoff without trade, establishing that vote trading is welfare improving.

Concerning majoritarian systems, fix n, and note that when $\xi < \xi_n$, the majoritarian outcome maximises the sum of the players' payoffs for every possible realisation of the players' type. Hence, minority victories are suboptimal from a utilitarian perspective. If a vote-trading equilibrium exists, then it should lead to minority victories with positive probability, in turn leading to lower collective welfare compared to when trading is not allowed. ■

The implications of this theorem are very strong: it essentially dictates that as long as vote trading is voluntary and subjects have the option to refrain from trade, vote trading cannot lead to welfare inferior outcomes in power-sharing systems. Perhaps more importantly, the argument employed for the proof establishes that, in these systems, even at the interim stage (i.e., after types are drawn), every player expects a (weakly) higher payoff when vote trading is allowed compared to when it is not, independent of her type. This is because any player can abstain from participating in vote trading and, given the symmetric priors assumption (equally likely to support party $\mathcal{A}$ or $\mathcal{B}$), vote trades amongst the rest of voters are equally likely to favour either alternative.[12]

As far as majoritarian systems are concerned, the theorem states that there exist cases in which allowing voters to trade votes for money in majoritarian elections can lead to losses in aggregate welfare.[13] This provides a clear comparative perspective on these two popular electoral systems, as far as vote markets are concerned, and qualifies the implications of vote trading with respect to the different ways in which vote shares are translated into political power.[14] Observe, though, that the theorem does not rule out that vote trading in majority systems may result in gains in collective welfare when preference intensities are sufficiently heterogeneous. In fact, Casella *et al.* (2012) have already argued that, in the context of an ex-ante competitive equilibrium analysis, the welfare consequences of vote trading in majoritarian elections crucially hinges on the distribution of preference intensities. In what follows, we consider a specific parametrisation of our model and an intuitive class of equilibria in order to describe when vote trading delivers welfare gains, as well as when it leads to losses, in majoritarian systems.

[12]While the arguments supporting this theorem utilise the assumption that ordinal preferences are assigned with even probability, as in Casella *et al.* (2012), and that cardinal preferences are drawn from a uniform distribution, it can be shown that the positive effect of vote buying on welfare in power-sharing systems extends to more general distributions of preferences. Moreover, the employed trading institution is not key for our results. In Appendix A, we define a broad class of vote-trading institutions, including the strategic-market mechanisms, and argue that Theorem 1 holds as stated in a more general setup.

[13]Notice that the formal condition provided for welfare losses due to trade is only a sufficient condition, not a necessary one. As we will see in the more specific analysis that follows, trade has a negative effect on collective welfare in many more cases.

[14]There are electoral systems with an in-between degree of disproportionality: voters' utilities are continuous, but not linear, in the vote share of their preferred party. By allowing any level of electoral rule disproportionality (e.g., in the fashion of Herrera *et al.*, 2016) one obtains a smooth transition from the positive welfare effects of vote trading in proportional power-sharing systems to the (typically) negative ones encountered in majoritarian systems.

3.1 A simple setting

Here we explore a specific case that encapsulates the main features of our model and paves the way for our laboratory experiment. We focus on a society consisting of five individuals and explore the properties of the *few-buyers equilibrium*: the situation in which types H buy votes, and types M and L sell their votes.[15] A first step is to prove that there exist strategic-market mechanisms (i.e., values of β) that provide such an equilibrium.

Proposition 1 *For any given electoral system and any given* $\xi \in (0, 1)$*, there exist strategic-market mechanisms that support the few-buyers equilibrium.*

Proof. In Appendix A.

When a certain share of society is expected to sell their votes and the rest to buy votes, then one can find suitable values of β that make type H players prefer to buy, and the rest of the types of players prefer to sell their votes. This fact is enough to establish existence of a few-buyers equilibrium in each of the electoral systems.

We now turn our attention to welfare.

Proposition 2 *In power-sharing systems, the few-buyers equilibrium delivers a strictly higher collective welfare compared to the no-trade equilibrium for every* $\xi \in (0, 1)$*. In majoritarian systems, there exists* $\bar{\xi} \in (0, 1)$ *such that the few-buyers equilibrium delivers a strictly lower (higher) collective welfare compared to the no-trade equilibrium when* $\xi < \bar{\xi}$ $(\xi > \bar{\xi})$*.*

Proof. In Appendix A.

The first part of this proposition follows almost directly from Theorem 1. The second part of the proposition, though, provides a better description of the cases in which vote trading is (un)desirable in majoritarian systems. Our finding is fully in line with Casella *et al.* (2012) who—despite the fact that they employ different trading assumptions (ex-ante competitive equilibrium)—also argue that, in majoritarian systems vote trading has negative (positive) welfare effects when preference intensities are very homogeneous (heterogeneous). Importantly, this common conclusion of these distinct approaches to vote trading in majoritarian systems establishes that the trading institutions are not central to the main welfare properties of vote trading in majoritarian systems; instead, *it is the dispersion of preference intensities that matters most.*

The main difference between the two electoral systems is that when voters are sufficiently homogeneous in how much they value the electoral result, then gains from trade are negative under majority rule and positive—albeit, small—in a power-sharing system. Otherwise, voters in

[15]We limit attention to such configurations only to better connect our theoretical arguments with the particular experimental setup. It is important to stress that one can provide similar results for the case of the many-buyers equilibrium as well: the situation in which types H and M players buy votes, and type L players sell their votes.

both systems profit more from trading when they are more likely to disagree on the importance of the election. We need to stress that the maximum possible gains from trade (i.e., the gains from trade when $\xi = 1$) are much larger in power-sharing systems than in majoritarian systems. That is, while it is theoretically possible that vote trading benefits voters in majoritarian systems, this gain might be too small to merit serious consideration in an applied context. Especially when the policy maker is uncertain about the dispersion of preference intensities (assume her beliefs about ξ are given by a uniform distribution on the unit interval), then it can be shown that the expected effect of vote trading on collective welfare is strictly negative.

Finally, from the proof of Proposition 2, we have calculated the value of $\bar{\xi}$ for a society of five individuals to be $\bar{\xi} = 0.76737$. Given this, we notice that $\bar{\xi} > \hat{\xi}_5 = 0.2$.[16] That is, a vote-trading equilibrium may lead to lower collective welfare even when some minority victories are desirable from a utilitarian perspective. This establishes that the negative effect of vote trading in majoritarian systems is much more frequent than suggested by the arguments supporting Theorem 1 and is not limited to the cases in which all minority victories are suboptimal.

4 The experiment

Our experimental setup is designed to be as close as possible to our theoretical model. The four main treatments are differentiated with respect to the electoral system and the relative dispersion of preference intensities. More specifically, we consider elections that are conducted via either a power-sharing or a majoritarian system, in communities with distributions of types that have either high or low dispersion of preference intensities. In all treatments, we consider a common strategic-market mechanism of vote trading (same bid β). The choice of the parameter values has a number of interesting properties: first, a vote-trading equilibrium exists in all treatments. In fact, the equilibrium is the same for all treatments, it is in pure strategies (types with low and medium intensities sell and high intensity type buys), and it is the unique equilibrium that induces full trade (i.e., all types either sell or buy). Second, the equilibrium is such that in the majoritarian system vote trading leads to lower collective welfare than no trade when dispersion is low and to higher collective welfare than no trade when dispersion is high. In Appendix B, we present results for two additional treatments with different trading mechanisms. A detailed description of the experimental design is presented in the following subsection.

[16]The threshold $\hat{\xi}_5 = 0.2$ is where the majority's lowest aggregate payoff (3 voters with $w_i = 1 - \xi$) is equal to the minority's highest aggregate payoff (2 voters with $w_i = 1 + \xi$).

4.1 Experimental setup

The experiment took place at the Laboratory for Experimental Economics at the University of Cyprus (UCY LExEcon). A total of 360 subjects were recruited in 24 sessions, with 15 subjects in each session. The main part of the experiment consisted of four treatments, with five sessions in each treatment. Two more sessions were conducted for each of two additional treatments, which are discussed separately in Appendix B. Average total payment was approximately 13.6 euros and the experiment lasted about 80 minutes. The experiment lasted 50 rounds, prior to which there were 5 practice rounds that familiarised the subjects with the experimental environment.[17] The experiment was designed on z-Tree (Fischbacher, 2007).

Communities and groups (Ordinal preferences) In each of the 50 rounds, the 15 subjects of the session were grouped into communities of 5 members, with communities varying in each round. In the beginning of the round, each subject was endowed with *1 vote and 11 tokens* and was randomly selected with equal probability to be a supporter of either the PURPLE or the BROWN group. Preferences over groups were randomly reassigned in each round through independent draws. Being a supporter of a group meant that the subject would receive additional tokens depending on the performance of the group on the voting stage. The exact meaning of "performance" depended on the electoral system, majority or power sharing, and is discussed below in detail, together with the rationale behind the choice of other parameter values.

Types (Cardinal preferences) In addition to her preferred group, in each round, each member of the community was randomly assigned a type of preference intensity. Henceforth, when mentioning the term *type*, we refer to the intensity parameter that characterises the subject's cardinal preferences, with a typical type denoted by w. In line with our theoretical analysis, each distribution consisted of three possible types—low (L), medium (M), and high (H)—each of which had the same probability of being drawn. We used two different sets of types with different levels of dispersion. Namely, we used (i) $w \in \{10, 50, 90\}$ and (ii) $w \in \{30, 50, 70\}$.[18] Only one distribution of types was used in each session. Types were randomly drawn from a uniform distribution in each round, with the draws being independent across rounds, across community members, and with respect to the draws of ordinal preferences over groups.

In each round, a subject knew the group she was supporting and her realisation of w, but she did not know the preferred groups and the types of the other members of her community. Yet, it was made clear to the subjects that the process through which the preferred group and the type of

[17]Final earnings were determined by the sum of earnings from the 50 rounds of the experiment's main part. Practice rounds were not taken into account for determining final earnings. Payment included 5 euros as a participation fee. There were also two pilot sessions with 15 and 10 subjects respectively.

[18]Following the notation of Section 3, these would correspond to $\xi = 4/5 > 0.76737 = \bar{\xi}$ and $\xi = 2/5 < 0.76737 = \bar{\xi}$ respectively, with all preference intensities being multiplied by 50. It is apparent that multiplying both all the preference intensities and the value of β with the same number leaves our results unaffected.

each subject were selected was identical to their own, as well as that the realised values had been chosen independently for each subject and across rounds.

Vote trading Prior to voting, the members of each community were allowed to trade their votes for tokens, and vice versa. In each round, a subject had to choose between (i) buying votes, (ii) selling her own vote, or (iii) neither selling nor buying votes. In all four main treatments, we consider a strategic-market mechanism—as defined and described in Section 3—with a monetary bid $\beta = 11$. Therefore, a subject who wanted to buy votes had to give away her whole initial endowment of tokens for this round and her earnings would depend solely on the performance of her preferred group in the election. If there were no buyers or no sellers, then no trade was taking place and subjects were keeping their 1 vote and 11 tokens, irrespective of their choices.

Voting stage The vote-trading stage was followed by a voting stage where the number of votes that a subject possessed was automatically counted in favour of the group she supported. Note that there was no possibility of abstention from voting; therefore, during the voting stage, a total of five votes were cast by the members of each community.

Earnings The earnings of a subject in a round were equal to the amount of tokens she had after the vote-trading stage plus the additional tokens she received from the outcome of the elections. After each round, subjects could see the number of votes that were cast in favour of their group and their individual earnings. In addition to these, they could also see whether trade took place and, in case it did, how many additional votes each buyer acquired and how many tokens each seller received.

Electoral systems The core features of the two systems were defined in Section 3. Let S and B denote the number of sellers and buyers in a round, V the vote share of a typical subject's preferred party, and a the action from the set $\{b, s, \varnothing\}$ the subject chose, where b stands for "buy", s for "sell", and $\varnothing$ for "neither buy nor sell".

Then, in a power-sharing system a subject's earnings, given w, V, S, B, β, and an initial endowment of 11 tokens were as follows:[19]

$$E_{PS} = V \times w + m, \text{ where } m = \begin{cases} 0 & \text{if } a = b \text{ and } SB > 0, \\ 11 + \beta B/S & \text{if } a = s \text{ and } SB > 0, \\ 11 & \text{if } a = \varnothing \text{ or } SB = 0. \end{cases}$$

In a majoritarian system, an additional point that required clarification was the way in which profits from the election would be distributed if both groups ended up with the same number of votes. In those cases, we used a random equiprobable draw among the two groups, which

[19]Although in all our main treatments we consider $\beta = 11$, we keep β as a parameter in the following expressions in order to stress that its value may differ from the tokens that voters have available at the beginning of each round. Results for a treatment in which this is the case are presented in Appendix B.

determined the winner of the election, thus preserving the nature of majoritarian systems that assign all power to the winner of the election. Draws were independent across rounds.

Therefore, the outcome of the election was essentially binary for each subject and denoted by Θ, as her preferred group could win ($\Theta = 1$) if either $V > 1/2$ or $V = 1/2$ and the group was selected by the random tie-breaking draw, or lose ($\Theta = 0$) if either $V < 1/2$ or $V = 1/2$ and the other group was selected by the random tie-breaking draw. As a result, in a majoritarian system a subject's earnings from each action, given w, Θ, S, B, β, and an initial endowment of 11 tokens, were as follows:

$$E_M = \Theta \times w + m, \text{ where } m = \begin{cases} 0 & \text{if } a = b \text{ and } SB > 0, \\ 11 + \beta B/S & \text{if } a = s \text{ and } SB > 0, \\ 11 & \text{if } a = \varnothing \text{ or } SB = 0. \end{cases}$$

Treatments We employed a 2×2 setup with four treatments (see Table 1) in which we varied the two major parameters of interest: (i) the electoral system and (ii) the distribution of possible types. More specifically, we considered two possible systems, a power-sharing system and a majoritarian system, and two types of distributions, one with high dispersion across types and another with low dispersion across types (types drawn uniformly at random from $\{10, 50, 90\}$ and from $\{30, 50, 70\}$, respectively). For each of these treatments, we conducted five experimental sessions.

In each session of a treatment, we used a different sequence of draws of community pairings, types and ordinal preferences over groups, which were randomly generated according to the processes described above. Yet, the same five sequences of draws were used in all treatments, thus each sequence was used in one session of each treatment.[20]

Treatment	Electoral System	β	Type Dispersion	Type Set	Sessions	Subjects
PSH	Power Sharing	11	High	$\{10, 50, 90\}$	5	75
PSL	Power Sharing	11	Low	$\{30, 50, 70\}$	5	75
MH	Majoritarian	11	High	$\{10, 50, 90\}$	5	75
ML	Majoritarian	11	Low	$\{30, 50, 70\}$	5	75

Table 1: The four main treatments of the experiment.

Vote-trading equilibria All treatments admit a unique equilibrium with vote trading: the few-buyers equilibrium, an equilibrium in which all types of voters engage in trade, with low and medium types of voters selling their votes and high types buying votes.[21] Henceforth, we will refer to this particular equilibrium as ***the vote-trading equilibrium***. Of course, uniqueness refers

[20]This allows us to perform some relevant tests at a session level that require paired observations.
[21]Analytical calculations can be found in Appendix A.

to equilibria with vote trading, since a no-trade equilibrium, in which all types use action $\varnothing$, always exists. Importantly, the described vote-trading equilibrium leads to lower collective welfare (compared to no trade) in Treatment ML, slightly higher collective welfare in Treatment MH, and higher collective welfare in both treatments with a power-sharing system, PSH and PSL (see Table 2).

Due to our interest in the relative (individual or collective) welfare when trading is allowed compared to when it is not, we henceforth use the term ***net earnings from trade*** to describe the difference between real earnings and the counterfactual earnings that subjects would get if everybody refrained from trade and simply voted sincerely for their preferred alternative (which is also a dominant strategy when vote trading is not allowed). For brevity, we refer to the latter as ***earnings under no trade***.

At the type level, in Treatments PSH and PSL all types are better off in the vote-trading equilibrium compared to no trade.[22] By contrast, in Treatments MH and ML the low type is better off, whereas the other two types are worse off. The difference in the relative magnitude of gains/losses is what determines the sign of the difference in collective welfare. Indeed, even in the case of MH where collective welfare increases, this does not occur through a Pareto improvement of earnings for all types. A detailed overview of expected net earnings from trade—i.e., expected earnings from the vote-trading equilibrium compared to no trade—for each treatment and each type is presented in Table 2.

The results in Table 2 also suggest that higher dispersion leads to a Pareto improvement in expected net earnings from trade, as both low and high types are strictly better off in PSH compared to PSL and in MH compared to ML. The same holds when comparing different treatments with the same type dispersion but different electoral systems (PSH vs. MH and PSL vs. ML). Yet, this does not mean that higher ex-ante expected earnings from trade are necessarily a result of a Pareto improvement for all types. For instance, in PSL, ex-ante expected earnings are higher than in MH, yet low types would expect higher earnings in MH than in PSL.

The selection of values of preference intensities in the different treatments was intended to highlight the theoretical implications of different type dispersion levels, mainly on majority systems, without making the environment trivial and uninteresting. More specifically, on the one hand, we wanted one value of ξ to be sufficiently high (above $\bar{\xi}$) in order to ensure positive expected net earnings in the majoritarian system, yet we did not want this value to be so high that low types would be essentially indifferent about the outcome of the elections. The implication of this is that the expected net earnings from trade in MH are just marginally positive, which makes the prediction that subjects will benefit from trade in that treatment relatively sensitive. On the other

[22]Recall that, although Theorem 1 is stated with respect to collective welfare, in power-sharing systems vote trading increases welfare even at the interim level (i.e., conditional on a player's type).

Treatment	Expected Net Earnings from Trade (Vote-Trading Equilibrium vs. No Trade)			
	Ex–Ante	Low	Medium	High
PSH	+3.2	+4.6	+1.4	+3.6
PSL	+1.6	+3	+1.4	+0.4
MH	+0.1	+3.9	–2.1	–1.5
ML	–1.6	+0.9	–2.1	–3.5

Table 2: Expected net earnings from trade for each treatment, ex-ante (before types are drawn) and conditional on type. Values rounded to the first decimal.

hand, we wanted the other value of ξ to be sufficiently low (below $\bar{\xi}$) to ensure negative expected net earnings in the majority system, yet we did not want this to be too low, as tiny values of ξ make profits from trade practically impossible. Overall, our parameter selection allows trade to increase or reduce earnings in both electoral systems, depending of course on the parameter realisation of each round and on subjects' behaviour.

Indeed, in all treatments, even if subjects were playing according to an ex-ante individually welfare improving vote-trading equilibrium, there existed realisations of types and ordinal preferences that would lead to negative net earnings from trade. Thus, observing lower individual earnings than those the no trade condition would yield should be expected to happen in several rounds. Moreover, for the same reason, even if all citizens were choosing a trade-inducing action (buy or sell), we would expect to observe occasions in which no trade could take place. For instance, this would be the case if all subjects in a round were playing according to the vote-trading equilibrium and were assigned the high type, meaning all subjects would want to buy and no trade would take place. More specifically, in all four treatments, under the vote-trading equilibrium, trade is expected to take place with probability $1 - \left[\left(\frac{2}{3}\right)^5 + \left(\frac{1}{3}\right)^5\right] \approx 0.84$.

4.2 Testable hypotheses

In this section, we state the major testable hypotheses that follow from our theoretical analysis. A preliminary question is whether trade will actually take place, as a no-trade equilibrium always exists, and, in fact, in one of the treatments (ML) it would yield superior aggregate results compared to the vote-trading equilibrium. Therefore, an important initial observation would be to observe the extent to which subjects decided to engage in vote trading.

Nevertheless, it should be noted that while no trade is an equilibrium, it is a relatively weak prediction as, when other subjects are expected not to trade, then one is essentially indifferent between choosing a trading option and no trade. On the other hand, when all other players are expected to trade according to the vote-trading equilibrium, then trading according to the vote-trading equilibrium strategy is a unique best response. Thus, it is less likely to observe very strong coordination towards no-trade equilibria.

Hypothesis 0 *Vote trading takes place in all treatments.*

The main set of hypotheses concerns the welfare implications of vote trading in different electoral systems. Our theory makes a strong claim regarding an unambiguously positive effect of vote trading in power-sharing systems and an ambiguous effect in majoritarian ones. We test this claim both on aggregate terms, across all subjects, as well as at a subject level.

The term ***average net earnings from trade*** refers to the net earnings from trade averaged over subjects and rounds. Thus, in those cases, the unit of observation is the net earnings from trade of a particular subject in a particular round. Analogously, the term ***subject average net earnings from trade*** refers to the net earnings from trade of a particular subject averaged over the 50 rounds of the experiment.

Hypothesis 1.1 *Average net earnings from trade are:*
(i) positive in a power-sharing electoral system (PSH, PSL),
(ii) positive in a majoritarian electoral system when type dispersion is high (MH), and
(iii) negative in a majoritarian electoral system when type dispersion is low (ML).

A positive answer to Hypothesis 1.1 would be an indication that vote trading in power-sharing systems is indeed ex-ante beneficial for the average voter. However, this claim should be made with caution, as the benefits of vote trading might not be unambiguously positive for all members of a society. Our theoretical model considers a homogeneous population in which decisions depend only on the intensity of one's preferences; however, heterogeneity in behaviour might favour particular individuals at the expense of others. Given that the subjects in our experiment participate in a substantial number of rounds, during which they face different combinations of ordinal and cardinal preferences, we also look at *each subject's* average net earnings from trade over the course of the whole experiment (Hypothesis 1.2). If behaviour is homogeneous and close to the vote-trading equilibrium, then most subjects in treatments with power-sharing systems (if not all of them) would be expected to gain from vote trading.

Hypothesis 1.2 *In a power-sharing electoral system (PSH, PSL), the* ***subject average*** *net earnings from trade over the course of the 50 rounds are positive for almost all subjects.*

A relatively intuitive feature of the environment is that the relative type dispersion increases potential gains from trade. Proposition 2 provides a cutoff value $\bar{\xi}$ that allows this comparison in majoritarian systems. Moreover, for the parameter values of our experiment, the expected net earnings in the vote-trading equilibrium show the same positive relationship (see Table 2). Thus, it is of interest to see whether this feature is also observed in the experimental data.

Hypothesis 1.3 *Average net earnings from trade are higher in treatments with higher type dispersion for both electoral systems (PSH vs. PSL and MH vs. ML).*

Testing Hypothesis 1.1 would say little about the distribution of expected gains or losses among different types. Yet, our theory suggests that in power-sharing systems, vote trading Pareto improves individual welfare of different types. In other words, there is no voter type for which expected net earnings from trade are negative. This is not expected to be the case under a majoritarian system, as low types are expected to gain from trading at the expense of other types.

Hypothesis 2 *Average net earnings from trade are:*
(i) positive for all types in a power-sharing electoral system (PSH, PSL),
(ii) positive for low types ($w = 10$, $w = 30$) in a majoritarian electoral system (MH, ML), and
(iii) negative for medium and high types ($w \in \{50, 90\}$, $w \in \{50, 70\}$) in a majoritarian electoral system (MH, ML).

The main motivation behind the idea of vote trading is to transfer more voting power, in exchange for some other valuable commodity, to those who care more about the outcome of an election. For this reason, it is expected that high types would be more likely to attempt to buy votes, whereas lower types would be more likely to attempt to sell. In fact, in the current setup with three types, any vote-trading equilibrium should satisfy the condition that low types sell with positive probability and high types buy with positive probability. Even more so, in pure strategy vote-trading equilibria (like the unique equilibrium in all treatments of our experimental setup), low types always sell, and high types always buy. Given this, the next hypothesis arises naturally.

Hypothesis 3.1 *In all treatments (PSH, PSL, MH, and ML):*
(i) the likelihood of vote selling decreases with type, and
(ii) the likelihood of vote buying increases with type.

One could wonder here whether the relative dispersion of types also plays a role. The vote-trading equilibrium we have presented prescribes for each type the same strategy in all treatments. This also means that the expected demand for and supply of votes is the same across all treatments. However, intuition would suggest that a higher similarity of preference intensities (lower type dispersion) would induce more similar behaviour across types. This could be tested in a number of ways, yet we state our hypothesis to be in accordance with the equilibrium prediction and to capture the choices of all types.

Hypothesis 3.2 *Both the demand for votes and the supply of votes remain unaffected by the type dispersion and the electoral system (PSH vs. PSL, MH vs. ML, PSH vs. MH, and PSL vs. ML).*

There are a number of additional topics that one could be interested in, including the evolution of subjects' behaviour over time or the heterogeneity of individual choices. These, however, are not directly implied by our theoretical results. Thus, although not stated here, our analysis contains some additional results on observed behaviour that are, arguably, of independent interest.

5 Experimental results

In this section, we test the hypotheses described in Section 4.2 and present some additional observations that arise from our experiment. Before stating the results, it is important to make a few clarifications on the procedures we follow.

First, our setup induces dependency among all observations of each session, as all participants interact with each other in some rounds. We intend to take this dependency into account in different ways, trying to be as conservative as our dataset allows in each case. This is a delicate task, as we only have five sessions (clusters) in each treatment, which might substantially affect the validity of techniques that behave well asymptotically as the number of clusters becomes large. To tackle this problem, we mainly employ the Wild Cluster Bootstrap method, which has been shown to behave well with as few as five clusters (Cameron *et al.*, 2008; MacKinnon and Webb, 2018; Roodman *et al.*, 2019; Kline and Santos, 2012).[23]

In all our results, we consider the relevant one-sided tests. Thus, we use the bootstrap to construct the one-sided confidence set at the 95% level and calculate the associated p-values. Given that our hypotheses make predictions about the direction of certain effects (positive/negative), it is natural to use one-sided tests in those cases. This might seem slightly more unconventional when reporting confidence sets and respective p-values for estimated values of regression coefficients (other than the intercept), yet we use the same way of presentation for consistency given that this choice is not essential for any of our results.[24] We consider a result *significant* if the p-value of the respective one-sided test is lower than 5%. For simplicity, we refer to a parameter value as *positive* or *negative* if the null hypothesis of the relevant one-sided is rejected at the 5% significance level; otherwise, we refer to it as *neither positive nor negative*. Confidence sets, p-values and relevant statistics are reported for all tests related to the main results. In some cases, we also perform some tests that use as unit of observation the average value of a variable across all subjects and rounds of a given session. This leaves us with one independent observation per session, and the power of those tests is obviously limited given the small number of sessions per treatment.

Result 0 *Vote trading takes place in approximately 80% of the rounds of each treatment.*

Table 3 presents the observed frequencies with which trade took place in each of the four main

[23]For most of the results, we consider linear regressions with standard errors clustered at the session level, which is the most conservative choice here, and we use the Wild Cluster Bootstrap method to obtain the confidence sets and the p-values. We consider 4999 repetitions of the bootstrap and we use the six-point distribution proposed by Webb (2014) for the distribution of wild weights, since the standard Rademacher weights would limit the number of unique observations we could draw from, given the number of clusters we have. Note that, Wild Cluster Bootstrap can handle different cluster sizes, which allows us to use it also under some additional restrictions, as for instance when considering only rounds in which trade actually took place. In some cases, where we deem appropriate, we also consider Wild Cluster Bootstrap on Probit regressions, as proposed by Kline and Santos (2012). For the implementation of both methods, we use the *boottest* command in Stata (Roodman *et al.*, 2019).

[24]All results containing the two-sided tests are readily available upon request.

treatments. At first glance, there seems to be a slightly higher trading frequency in the treatments with higher type dispersion (PSH and MH), however when comparing the frequencies of trade in each session across treatments, the differences are not statistically significant at any conventional level.[25]

Treatment	N	Trade Frequency	Buyers	Sellers	Price	Votes Bought
PSH	750	84.13	1.753	2.171	13.32	1.53
			(1.061)	(1.102)	(11.17)	(1.12)
PSL	750	81.73	1.667	2.116	13.07	1.51
			(1.026)	(1.110)	(10.13)	(1.13)
MH	750	83.47	1.645	2.523	11.45	1.76
			(1.060)	(1.121)	(9.92)	(1.22)
ML	750	78.93	1.495	2.456	11.43	1.74
			(1.052)	(1.077)	(10.21)	(1.16)

Table 3: Descriptive statistics regarding community-level observations: trade frequency, mean number of buyers, number of sellers, price, and votes bought, with standard deviations in parentheses. For prices and votes bought, averaging is only over rounds in which trade took place.

Result 1.1 *Average net earnings from trade are positive in treatments PSH and PSL, whereas they are negative in treatments MH and ML.*

We observe that vote trading leads to a significant increase of individual welfare in Treatment PSH and to a smaller increase in Treatment PSL, both of which are in line with theoretical predictions. On the other hand, it leads to a substantial decrease in individual welfare in Treatment ML and a smaller decrease in Treatment MH. The latter is the only observation that does not follow from theory, yet it is not unexpected given that in MH expected net earnings in the vote-trading equilibrium are only slightly positive. The detailed results are presented in Table 4. In both systems, the differences are substantial as (depending on the treatment) they lead to an average increase in earnings of up to 4% per subject per round in power-sharing systems and an average decrease in earnings up to 6% per subject per round in majoritarian systems.

The results are robust, and in fact they become even stronger, if we limit attention to rounds in which trade actually took place. The same is true if we consider net earnings averaged at the community level, in which case the unit of observation is the sum of net earnings of all subjects of a given community in a given round and monetary transfers cancel out. For community-level data, we also consider the sum of net earnings divided by the maximum community-level earnings that

[25] Wilcoxon signed-rank test: (PSH/MH) $z = 0.405$, $p = .6858$, (PSL/ML) $z = 0.674$, $p = .5002$, (PSH/PSL) $z = 1.214$, $p = .2249$, (MH/ML) $z = 1.089$, $p = .2763$. Mann-Whitney U test: (PSH/MH) $z = 1.064$, $p = .2873$, (PSL/ML) $z = 0.731$, $p = .4647$, (PSH/PSL) $z = 1.152$, $p = .2492$, (MH/ML) $z = 1.163$, $p = .2448$. For Wilcoxon signed-rank test, we consider sessions with common sequences of draws (on preferences, types and groups) as paired.

Treatment	Net Earnings from Trade	95 % Confidence Set		t-statistic	p-value
	(avg. per subject per round)	Lower	Upper		
PSH	+1.193	+0.7573	·	6.0549	.0088
PSL	+0.452	+0.0730	·	2.4026	.0398
MH	–1.128	·	–0.4124	–3.1278	.0258
ML	–2.139	·	–1.4660	–6.1639	.0088

Table 4: Average net earnings from trade. Confidence sets are constructed using the Wild Cluster Bootstrap method, with data clustered at the session level. The p-values correspond to the relevant one-sided tests. The results contain all rounds, even those in which trade did not take place.

could be reached and the percentage net earnings—i.e., net earnings divided by earnings under no trade—with the results remaining unaffected in both cases.[26]

We also look at average net earnings from trade at the session level. We average individual earnings in all 50 rounds of the session and all subjects participating in the session. This gives us five independent observations per treatment and allows us to conduct standard statistical tests. We find that in all five sessions of Treatment PSH and in four out of five sessions of PSL, session average net earnings are positive, whereas in all sessions of Treatment ML and in four out of five sessions of MH, they are negative.[27] Despite the small number of sessions, this last result suggests that the positive (negative) effect in power-sharing (majoritarian) systems is relatively robust across sessions and is not driven by results in some particular session, with the effect being more prevalent in PSH and ML.

Result 1.2 *In both treatments with a power-sharing system, PSH and PSL, vote trading leads to the majority of subjects having positive subject average net earnings from trade over the 50 rounds.* ***However****, it leads to a substantial number of subjects having negative subject average net earnings from trade over the 50 rounds. Furthermore, the distribution of subject average net earnings is shifted to the left compared to the distribution that would be observed if subjects were playing according to the vote-trading equilibrium.*

Result 1.2 highlights that the benefits of vote trading should be evaluated with caution, as they may not be homogeneously distributed across all individuals. Note that, despite that the vote-trading equilibrium yielding higher ex-ante expected net earnings to all individuals, the realisation of types and preferences over groups might lead some of them to negative net earnings even if all subjects were to play equilibrium strategies.

This observation becomes even more noticeable in the experimental data, as the following two

[26] The detailed results of all robustness checks are readily available upon request.

[27] Wilcoxon signed-rank test: (PSH) $z = 2.023$, $p = .0431$, (PSL) $z = 1.753$, $p = .0796$, (MH) $z = -1.753$, $p = .0796$, (ML) $z = -2.023$, $p = .0431$. One-sided t-test: (PSH) $t = 6.0549$, $p = .0019$, (PSL) $t = 2.4026$, $p = .0371$, (MH) $t = -3.1278$, $p = .0176$, (ML) $t = -6.1639$, $p = .0018$.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment	N	Higher Subject Average Earnings over 50 Rounds (out of 75)			Kolmogorov-Smirnov	
		Actual/No Trade	*Equilibrium/No Trade*	*Actual/Equilibrium*	D	p-value
PSH	75	59	72	16	.4533	.000
PSL	75	38	57	20	.2667	.010
MH	75	21	28	37	.1333	.518
ML	75	18	13	43	.1867	.147

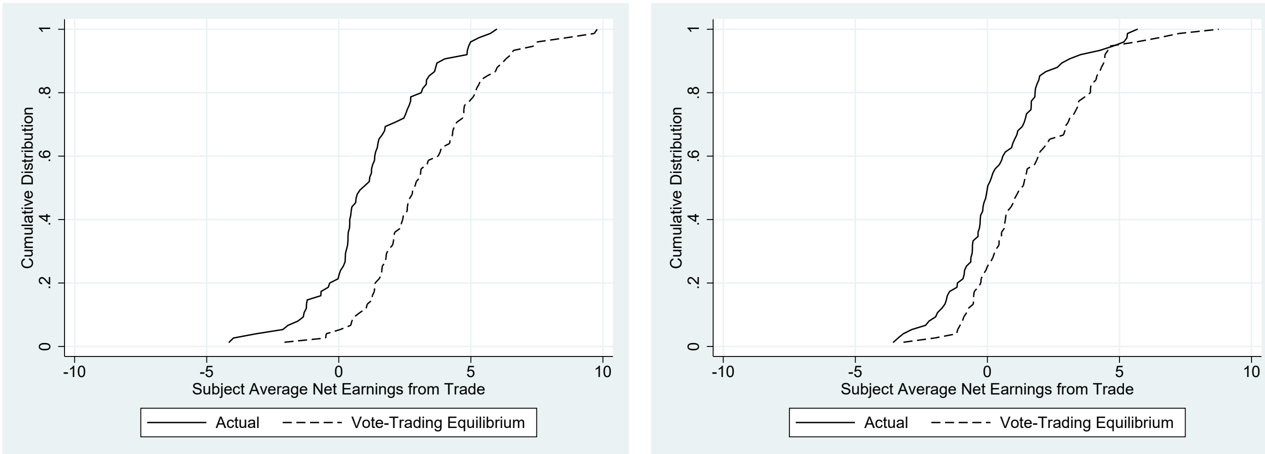
Table 5: Results are based upon the subject average earnings over 50 rounds. Columns 3-5 report the number of subjects who (3) obtained higher earnings in the experiment than they would without trade, (4) would obtain higher earnings in vote-trading equilibrium than they would without trade, and (5) obtained higher earnings in the experiment than they would in vote-trading equilibrium, for the draws used in the experiment. Columns 6 and 7 present the results of the Kolmogorov-Smirnov test between the distributions of actual subject average net earnings and those the vote-trading equilibrium would yield.

results suggest: first, the number of subjects who actually receive negative net earnings from trade over the 50 rounds of the experiment is substantially higher compared to what the vote-trading equilibrium would predict (see Table 5, columns 3 and 4). Second, if we compare the cumulative distributions of subject average net earnings to those that vote-trading equilibrium would yield, we find them to be significantly different. Figure 1 makes it clear that the distribution of actual subject average net earnings is first-order stochastically dominated by the one that the vote-trading equilibrium would yield. Subject to the limitation of assuming independence across subjects, the Kolmogorov-Smirnov test suggests that the difference between the two distributions is statistically significant, with the distribution of actual subject average net earnings containing smaller values (see Table 5, columns 6 and 7). Similar analysis of the two treatments with majoritarian system (MH and ML) shows no significant differences.

Result 1.3 *Given the electoral system, average net earnings from trade are higher in treatments with higher type dispersion.*

We find higher dispersion to be associated with significantly higher net earnings from trade (Table 6). More specifically, in power-sharing systems higher type dispersion amplifies the positive effects of trading, whereas in majoritarian systems it reduces its negative impact. Intuitively, all else equal, vote trading would be expected to lead towards higher average net earnings for higher levels of dispersion, as buying votes would be relatively more desirable for higher types, and selling votes would be more desirable for low types. This is what we observe in the experiment.

The above experimental results are enough to back up the theoretical implications of Theorem 1. To be sure, we showed that, under the employed trading institution, in majoritarian systems vote trading can lead to lower welfare, whereas in power-sharing systems it leads to higher welfare. However, as we argue more formally in Appendix A, the welfare-improving result regarding power-



(a) Treatment PSH

(b) Treatment PSL

Figure 1: Cumulative distribution functions of actual subject average net earnings over the 50 rounds of the experiment (solid) and of subject average net earnings that would be achieved under the vote-trading equilibrium (dashed).

Compared Treatments	Coefficient *(High Dispersion)*	95% Confidence Set Lower	Upper	t-statistic	p-value
PSH/PSL	+0.7411	+0.2345	·	2.8842	.0126
MH/ML	+1.0107	+0.1250	·	2.1419	.0302

Table 6: Linear regression of net earnings from trade on the level of type dispersion (high dispersion=1) by electoral system. Confidence sets are constructed using the Wild Cluster Bootstrap method, with data clustered at the session level. The p-values correspond to the relevant one-sided tests. The results contain all rounds, even those in which trade did not take place.

sharing systems is, in theory, true for many other trading institutions. Of course, we cannot perform experiments for every trading institution, but it is important to explore at least some alternatives. For this reason, in Appendix B we present results of some additional treatments where we focus on power-sharing systems and vary the trading institutions. We consider an alternative strategic-market mechanism ($\beta = 3$ instead of $\beta = 11$) and a price-taking institution and confirm the positive welfare effects of vote trading in power-sharing systems (see Results R1, R2a, and R2b in Appendix B).

Result 2.1 *In treatments PSH and PSL, average net earnings from trade are:*
(i) positive for low types ($w = 10$ *and* $w = 30$)*, and*
(ii) neither positive nor negative for medium or high types ($w \in \{50, 90\}$ *in PSH and* $w \in \{50, 70\}$ *in PSL*).

As our main theoretical result suggested, we find evidence that vote trading in power-sharing systems leads to a Pareto improvement of individual welfare (see Table 7). The experimental results

Treatment	Type (w)	Net Earnings from Trade (avg. per subject per round)	95 % Confidence Set Lower	Upper	t-statistic	p-value
PSH	L - 10	+4.1115	+3.0940	·	8.0444	.0090
PSH	M - 50	–0.3988	·	+0.4458	–1.0179	.1864
PSH	H - 90	–0.0846	·	+0.3438	–0.4497	.3239
PSL	L - 30	+1.2215	+0.3541	·	2.6757	.0196
PSL	M - 50	+0.3617	–0.3867	·	1.0382	.1620
PSL	H - 70	–0.2053	·	+0.7138	–0.5055	.3137

Table 7: Average net earnings from trade per type for treatments PSH and PSL. Confidence sets are constructed using the Wild Cluster Bootstrap method, with data clustered at the session level. The p-values correspond to the relevant one-sided tests. The results contain all rounds, even those in which trade did not take place.

Treatment	Type (w)	Net Earnings from Trade (avg. per subject per round)	95 % Confidence Set Lower	Upper	t-statistic	p-value
MH	L - 10	+2.9431	+2.4000	·	9.6190	.0074
MH	M - 50	–2.9143	·	–2.0410	–5.1721	.0120
MH	H - 90	–3.3344	·	–1.3380	–3.4684	.0114
ML	L - 30	+0.5350	–0.6560	·	0.9002	.2318
ML	M - 50	–2.9802	·	–1.7720	–4.7140	.0092
ML	H - 70	–3.9108	·	–3.0300	–8.3337	.0068

Table 8: Average net earnings from trade per type for treatments MH and ML. Confidence sets are constructed using the Wild Cluster Bootstrap method, with data clustered at the session level. The p-values correspond to the relevant one-sided tests. The results contain all rounds, even those in which trade did not take place.

are less optimistic than the theoretical predictions for medium and high types, as in those cases both treatments yield net earnings not significantly different from zero. On the other hand, low types seem to benefit consistently from trading. Overall, all types seem to underachieve compared to the earnings that vote-trading equilibrium would allow them to reach. We elaborate on this observation more below, but the reason seems to be that the relatively low frequency of selling compared to buying led to high average prices (see Table 3 and Table 9). Given that low types predominantly sell, and high types predominantly buy (see Result 3.1), high prices are expected to favour mainly low types at the expense of higher ones. The result remains qualitatively unaffected if we consider only rounds in which trade took place.

Result 2.2 *In treatments MH and ML, average net earnings from trade are:*
(i) positive for low types when dispersion is high ($w = 10$ *in MH*),
(ii) neither positive nor negative for low types when dispersion is low ($w = 30$ *in ML*), *and*
(iii) negative for medium and high types ($w \in \{50, 90\}$ *in MH and* $w \in \{50, 70\}$ *in ML*).

Vote trading in majoritarian systems was expected to be particularly harmful for medium and high types. This is strongly confirmed by the data (see Table 8). Both medium and high types lose heavily from trading, whereas low types have significant gains in MH and possibly some slight, but not significant, gains in ML. The result does not change if we exclude rounds in which trade did not take place. Results 2.1 and 2.2 are fairly robust to considering average net earnings per type over a whole session as a single observation, instead of using individual observations for each subject and round.[28]

Result 3.1 *Likelihood of buying increases with type and likelihood of selling decreases with type.*
Result 3.2a *Likelihood of buying or selling is not altered by type dispersion.*
Result 3.2b *Subjects are more likely to sell votes in a majoritarian system.*

We report results from linear regressions that include all treatments and control for type, type dispersion, and electoral system (see Table 9). The results are identical if we consider each treatment separately, if we consider pairs of treatments with the same level of dispersion, or if we consider the same electoral system. The results are also robust to using a Probit model in place of a linear model for the initial estimation, following the Score Based Method of Wild Bootstrap (Kline and Santos, 2012), which is adequate for non-linear models.[29]

The results presented in Table 9 suggest a strongly significant effect of the electoral system on the frequency of selling decisions, while there does not seem to exist an effect of type dispersion on either of the decisions. Overall, there seems to be a higher resiliency of subjects to give up their votes in power-sharing systems, which can be explained by the fact that selling a vote in a majority system, even if it is bought by a supporter of the opposite group, is often not pivotal and, as a result, inconsequential to the election outcome. By contrast, in power-sharing systems, selling to a supporter of the rival group always worsens the outcome of the election for the seller's preferred group.

In addition to these, we also look at average differences among consecutive types (medium/low, high/medium) in frequencies of buying, selling, and holding at the session level. The results for buying and selling are still supported to a large extent. An interesting observation is that the frequency with which subjects hold their vote without attempting to buy more votes follows a non-monotonic pattern, as it is consistently observed more often for medium types compared to

[28]Wilcoxon signed-rank test: (PSH - L) $z = 2.023$, $p = .0431$, (PSH - M) $z = -0.944$, $p = .3452$, (PSH - H) $z = -0.405$, $p = .6858$, (PSL - L) $z = 2.023$, $p = .0431$, (PSH - M) $z = 1.214$, $p = .2249$, (PSH - H) $z = -0.674$, $p = .5002$, (MH - L) $z = 2.023$, $p = .0431$, (MH - M) $z = -2.023$, $p = .0431$, (MH - H) $z = -2.023$, $p = .0431$, (ML - L) $z = 0.944$, $p = .3452$, (ML - M) $z = -2.023$, $p = .0431$, (ML - H) $z = -2.023$, $p = .0431$. One-sided t-test: (PSH - L) $t = 8.0389$, $p = .0006$, (PSH - M) $t = -1.1090$, $p = .1648$, (PSH - H) $t = -0.4544$, $p = .3366$, (PSL - L) $t = 2.6645$, $p = .0281$, (PSL - M) $t = 1.1082$, $p = .1650$, (PSL - H) $t = -0.5315$, $p = .3116$, (MH - L) $t = 9.6054$, $p = .0003$, (MH - M) $t = -5.3128$, $p = .0030$, (MH - H) $t = -3.4885$, $p = .0126$, (ML - L) $t = 0.8967$, $p = .2103$, (ML - M) $t = -4.6941$, $p = .0047$, (ML - H) $t = -8.3956$, $p = .0006$.

[29](Buy) - High Dispersion: $p = .1754$, Power Sharing: $p = .1102$, Type: $p = .0000$. (Sell) - High Dispersion: $p = .3135$, Power Sharing: $p = .0114$, Type: $p = .0000$.

	Coefficient	95 % Confidence Set Lower	Upper	t-statistic	p-value
Buying					
High Dispersion	+0.0301	–0.0216	·	1.1815	.1664
Power Sharing	+0.0344	–0.0206	·	1.2538	.1462
High Dispersion × Power Sharing	–0.0128	·	+0.0453	–0.4380	.3559
Type	+0.1877	+0.1546	·	9.9005	.0000
Constant	–0.0785	·	–0.0086	–1.9799	.0340
Selling					
High Dispersion	+0.0133	–0.0404	·	0.4771	.3275
Power Sharing	–0.0680	·	–0.0184	–2.6717	.0140
High Dispersion × Power Sharing	–0.0024	·	+0.0577	–0.0764	.4665
Type	–0.1808	·	–0.1478	–9.6744	.0000
Constant	+0.8547	+0.7851	·	21.7904	.0000

Table 9: Linear regressions of per round individual buying and selling decisions on dispersion (high dispersion=1), electoral system (power sharing=1), and type (L=1, M=2, H=3). Confidence sets and p-values are obtained using the Wild Cluster Bootstrap method, with data clustered at the session level. The p-values correspond to the relevant one-sided tests. The results contain all rounds, even those in which trade did not take place.

either high or low ones.[30]

Additional findings In the final part of this section, we provide some additional data-driven observations, which might further improve our understanding of the behaviour of experimental subjects.

Result 4 *There is no significant difference in net earnings from trade, likelihood of buying or likelihood of selling among supporters of different groups in any treatment.*

In the current setup, the group a subject supports in each round should in principle be completely irrelevant to her behaviour. Indeed, we find no significant differences in either the subjects' net earnings or in their choices, conditional on their preferences over groups. In fact, the only significant difference appears in the buying decisions of subjects in treatment ML, and even in this case, if we look at differences at the type level no type seems to behave significantly differently.[31]

[30] Wilcoxon signed-rank test: [Buy] (M/L - PSH, MH, ML) and (H/M - PSH, MH, ML) $z = 2.023$, $p = .0431$, (M/L - PSL) $z = 1.1214$, $p = .2249$, (H/M - PSL) $z = 1.753$, $p = .0796$ [Sell] (M/L - PSH, PSL, MH, ML) and (H/M - PSH, MH) $z = -2.023$, $p = .0431$, (H/M - PSL) $z = -1.753$, $p = .0796$, (H/M - ML) $z = -1.483$, $p = .1380$ [Hold] (M/L - PSH, PSL) and (H/M - PSH, MH) $z = -2.023$, $p = .0431$ (M/L - MH) $z = 1.483$, $p = .1380$, (M/L - ML) $z = 0.944$, $p = .3452$, (H/M - PSL) $z = -1.753$, $p = .0796$, (H/M - ML) $z = -1.214$, $p = .2249$.

[31] Linear regression of net earnings from trade on the preferred group. Confidence sets and p-values obtained through Wild Cluster Bootstrap method, with errors clustered at session level. For buying and selling decisions we run a Probit regression on the preferred group and calculate p-values based on the Score Based Method of Wild Bootstrap, with errors again clustered at the session level. We report the p-values of the respective one-sided tests. (Net Earnings from Trade) - PSH: $p = .2991$, PSL: $p = .4221$, MH: $p = .2262$, ML: $p = .3947$. (Buy) - PSH:

Result 5a *Net earnings from trade are significantly higher in late rounds (>25) in Treatment PSL and do not change between early and late rounds in any of the other three treatments.*
Result 5b *Prices are significantly lower in late rounds (>25) in treatments with high type dispersion, because subjects buy significantly less and sell significantly more.*

Our theory covers the case of a unique election round, although experimental subjects participate in multiple consecutive rounds of elections. This might alter their behaviour both because of learning and because of changes in their beliefs regarding other subjects' choices. For this reason, we test whether there are substantial differences in earnings and choices between early (≤ 25) and late (> 25) rounds. We find a significant increase of net earnings from trade only in Treatment PSL, which is driven by the improved performance of high types.[32] This improved performance can be explained by a consistent observation across treatments, which is that subjects sell more often and buy less often in late rounds (Table 10),[33] with this being more prominent for low types. However, except for Treatment PSL, high types buy less often, which prevents them from capitalising on the lower prices (Table 10) and thus increasing their earnings accordingly.

Treatment	Net Earnings *(Individual)*	Buy *(Individual)*	Sell *(Individual)*	Price *(Community)*
PSH	+0.1810 (.3157)	–0.0453 (.0086)	+0.0544 (.0230)	–2.0490 (.0122)
PSL	+0.3718 (.0126)	–0.0416 (.0104)	+0.0357 (.0124)	–1.8509 (.0630)
MH	+0.0053 (.4903)	–0.0501 (.0256)	+0.0832 (.0140)	–1.7319 (.0450)
ML	+0.1707 (.3655)	–0.0368 (.0306)	+0.0491 (.0374)	–0.8811 (.1354)

Table 10: Linear regressions of net earnings from trade, choice to buy, choice to sell and price, on late versus early rounds (late round=1 if round>25), with the unit of observation being a subject in a round by treatment. P-values are in parentheses. Confidence sets and p-values are obtained using the Wild Cluster Bootstrap method, with data clustered at the session level. The p-values correspond to the relevant one-sided tests. The results contain all rounds, even those in which trade did not take place.

Result 6 *Given the level of type dispersion, votes are more concentrated in power-sharing systems*

$p = .3803$, PSL: $p = .3271$, MH: $p = .3581$, ML: $p = .0252$, ML/L: $p = .1386$, ML/M: $p = .0750$, ML/H: $p = .3781$. (Sell) - PSH: $p = .2697$, PSL: $p = .4673$, MH: $p = .4013$, ML: $p = .1488$.

[32]Same regression of net earnings from trade on late versus early rounds as in Table 10, for Treatment PSL, by type (p-value in parentheses): PSL/L: –0.8782 (.1370), PSL/M: +0.4954 (.2462), PSL/H: +1.3254 (.0284).

[33]The Probit model gives similar results (p-value in parentheses): (Buy) PSH: –0.1224 (.0086), PSL: –0.1145 (.0104), MH: –0.1387 (.0258), ML: –0.1061 (.0322), (Sell) PSH: +0.1384 (.0230), PSL: +0.0913 (.0124), MH: +0.2089 (.0140), ML: +0.1231 (.0374).

compared to majoritarian systems. Given the electoral system, type dispersion does not significantly affect the concentration of votes.

In our last result, we focus on the distribution of votes among voters in the presence of vote trading. In this setup, vote trading leads, by design, to a higher concentration of votes to fewer members of the society. In theory, the level of concentration we would expect to observe should not vary across treatments. We measure concentration using the Herfindahl Index, $HI = \sum_i s_i^2$, where s_i is the share of votes voter i possesses after vote trading. It turns out that concentration is relatively higher in power-sharing systems and is not really affected by type dispersion.[34]

6 Conclusion

In this paper, we study vote trading in power-sharing and majoritarian systems. We argue, by using both theoretical and experimental results, that allowing for such an activity leads to unambiguous welfare improvements in the former and has negative or—at best—mildly positive effects in the latter, depending on the dispersion of voters' preference intensities. Our experimental data show that in power-sharing systems the increase in welfare from vote trading is statistically significant across all employed intensity distributions. Importantly, this positive effect of vote trading in such systems is robust to alternative trading institutions (see Appendix B). In majoritarian systems, our data demonstrate that vote trading decreases welfare, with the decrease being more substantial when voters are similar enough in how much they care about the election's result.

Apart from aggregate welfare, the experiment allows us to explore the extent to which the actual behaviour in committees corresponds to other interesting implications of our theory and to pin down potential caveats and limitations. Indeed, we find that trading votes for money generates winners and losers in power-sharing systems even in the long run, unlike what formal analysis predicts. Hence, while in aggregate, societies that use power-sharing systems stand to gain from vote trading, it is not true that all citizens will end up better off. Moreover, those who consistently gain from vote trading—in both electoral systems—are individuals who care the least about the outcome of the election, whereas individuals with strong preferences do not gain much or even lose from trading. Combined, these observations might provide an explanation as to why vote trading is difficult to implement, a central implication of this paper.

Of course, we still need to explore a number of alternative directions that could further enhance our understanding of vote markets. We study some simple trading institutions and a setup that

[34] Linear regressions of concentration on the level of type dispersion (high dispersion=1) by electoral system and on the electoral system (power-sharing=1) by level of type dispersion. Confidence sets and p-values are obtained using the Wild Cluster Bootstrap method, with data clustered at the session level (p-values in parentheses). (Electoral System) PSH/MH: –0.0411 (.0374), PSL/ML: –0.0281 (.0418), (Dispersion) PSH/PSL: +0.0113 (.1332), MH/ML: +0.0243 (.1734).

features many desirable properties, but they both, certainly, abstract from important issues that would be relevant in contexts of applied interest. This includes the heterogeneity of budget constraints and other wealth effects, such as the non-linearity or non-separability of the voters' utility or the existence of an information aggregation dimension (Piketty, 1994). These observations open interesting avenues for future work. We believe that a natural key extension is to consider vote trading in common value environments. Another interesting path forward would be to extend our analysis to additional decision rules, beyond power-sharing and majoritarian ones; further investigations related to other widely used decision rules (e.g., supermajority rules, or systems of disproportionate representation), for which the impact of vote trading on collective welfare is not obvious, would be of great interest.

Appendix A: Proofs and additional theoretical arguments

A broad class of vote-trading institutions

We describe here a class of vote-trading institutions for which Theorem 1 holds as stated. We use $y_i = (v_i, m_i)$ to denote the allocation of v_i votes and of m_i monetary units to individual i, and Y to denote the set of all possible individual-level allocations. Moreover, we use $\Omega = \{((v_1, m_1), (v_2, m_2), ..., (v_n, m_n)) \in Y^n \text{ s.t. } \sum_{i \in N} m_i = ne, \sum_{i \in N} v_i = n \text{ and } v_i \geq 0 \text{ for every } i \in N\}$ to denote the set of all possible allocation profiles.

Individuals face a common strategy set $X = \{\varnothing\} \cup \bar{X}$, where $\bar{X} = \{x_1, x_2, ..., x_k\}$ is the set of the vote-trading options (for some $k \geqslant 0$) and $\varnothing$ stands for the refrain-from-trade option (if a player i selects $\varnothing$, then $(v_i, m_i) = (1, e)$ independently of what the other players choose). They also face a symmetric allocation rule $Q_{k,n} : X^n \to \Delta\Omega$, where $\Delta\Omega$ is the set of lotteries over Ω. By symmetric we mean that if $x' \in X^n$ is a permutation of $x \in X^n$ such that $x_i = x'_j$ for some pair $(i, j) \in N^2$, then i ends up with y in x with the same probability that j ends up with y in x', for every $y \in Y$. A pair $(X, Q_{(\#X-1),n})$ that conforms with these assumptions is called a *vote-trading institution.*

Hence, vote trading is *decentralised*—the allocations of votes and money follow endogenously from the players' decisions—and *regulated*—the permitted actions and their consequences follow a specific vote-trading institution. Note that these conditions are permissive and several trading institutions satisfy them, including both price-making (the strategic-market mechanisms of our main analysis, the strategic-market mechanisms that allow players to bid arbitrary monetary amounts, etc.) and price-taking environments (e.g., the trading mechanism with predetermined prices presented in Appendix B).

The symmetric nature of the above allocation rules and of our equilibrium notion guarantees that the argument in the proof of Theorem 1 remains valid if one substitutes our benchmark strategic-market mechanism with any other vote-trading institution that belongs in the above class. This generalises our main result and establishes that the different welfare effects of vote trading in alternative electoral rules is not related to the employed vote-trading institution, but is only due to the innate characteristics of the voting systems.

Moreover, notice that the restriction to three types of cardinal preferences and to uniform beliefs over them are not central to the argument supporting Theorem 1. One can consider richer type spaces and more general distributions and derive, essentially, the same results.

Proof of Proposition 1

In power-sharing systems, when all other players employ the few-buyers strategies (i.e., individuals with $w_i = \{1-\xi, 1\}$ choose action s, and individuals with $w_i = 1+\xi$ choose action b), the expected payoff of an individual who chooses $\varnothing$ is $Eu_i(\varnothing) = 0.6w_i + e$, the expected payoff of an individual who chooses action s is $Eu_i(s) = \left(\frac{1}{3}\right)^4 \left(4\beta + \frac{1}{2}w_i\right) + 4\left(\frac{1}{3}\right)^3 \left(\frac{2}{3}\right)\left(\frac{3\beta}{2} + \frac{1}{2}w_i\right) + 6\left(\frac{1}{3}\right)^2 \left(\frac{2}{3}\right)^2 \left(\frac{2\beta}{3} + \frac{1}{2}w_i\right) + 4\left(\frac{1}{3}\right)\left(\frac{2}{3}\right)^3 \left(\frac{\beta}{4} + \frac{1}{2}w_i\right) + \left(\frac{2}{3}\right)^4 \left(\frac{3}{5}w_i\right) + e = \frac{421}{810}w_i + \frac{40}{81}\beta + e$, and the expected payoff of an individual who chooses action b is $Eu_i(b) = \left(\frac{1}{3}\right)^4 \left(\frac{3}{5}w_i\right) + 4\left(\frac{1}{3}\right)^3 \left(\frac{2}{3}\right)\left(-\beta + \frac{2.5}{4}w_i\right) + 6\left(\frac{1}{3}\right)^2 \left(\frac{2}{3}\right)^2 \left(-\beta + \frac{2}{3}w_i\right) + 4\left(\frac{1}{3}\right)\left(\frac{2}{3}\right)^3 \left(-\beta + \frac{3}{4}w_i\right) + \left(\frac{2}{3}\right)^4 \left(-\beta + w_i\right) + e = \frac{616}{810}w_i - \frac{80}{81}\beta + e$. For $\beta \in \left(\frac{13}{80}, \frac{13}{80}(1+\xi)\right)$, we can easily derive that $Eu_i(s) > \{Eu_i(\varnothing), Eu_i(b)\}$ for individuals with $w_i = \{1-\xi, 1\}$, and $Eu_i(b) > \{Eu_i(\varnothing), Eu_i(s)\}$ for individuals with $w_i = 1+\xi$. Thus, no individual deviates from the above profile of strategies.

In majoritarian systems, when all other players employ the few-buyers strategies, the expected payoff of an individual who chooses $\varnothing$ is $Eu_i(\varnothing) = \frac{11}{16}\left(\frac{2}{3}\right)^4 w_i + 2\left(\frac{2}{3}\right)^3\left(\frac{1}{3}\right) w_i + \frac{9}{2}\left(\frac{2}{3}\right)^2\left(\frac{1}{3}\right)^2 w_i + 2\left(\frac{2}{3}\right)\left(\frac{1}{3}\right)^3 w_i + \frac{11}{16}\left(\frac{1}{3}\right)^4 w_i + e = \frac{265}{432}w_i + e$, the expected payoff of an individual who chooses action s is $Eu_i(s) = \beta\left(\frac{1}{3}\right)\left(\frac{4}{3}\right)\left[1 + \left(\frac{1}{3}\right)^2\right] + \frac{1}{16}\left[11 + 3\left(\frac{1}{3} - 2\right)\left(\frac{1}{3}\right)\left[2 + \left(\frac{1}{3} - 2\right)\left(\frac{1}{3}\right)\right]\right] w_i + e = \frac{29}{54}w_i + \frac{40}{81}\beta + e$, and the expected payoff of an individual who chooses action b is $Eu_i(b) = e - \beta + \left(\frac{2}{3}\right)^4 w_i + 3\left(\frac{2}{3}\right)^3\left(\frac{1}{3}\right) w_i + \frac{9}{2}\left(\frac{2}{3}\right)^2\left(\frac{1}{3}\right)^2 w_i + \frac{11}{4}\left(\frac{2}{3}\right)\left(\frac{1}{3}\right)^3 w_i + \left(\frac{1}{3}\right)^4\left(\beta + \frac{11}{16}w_i\right) = \frac{1027}{1296}w_i - \frac{80}{81}\beta + e$. For $\beta \in \left(\frac{331}{1920}, \frac{331}{1920}(1+\xi)\right)$, we can easily derive that $Eu_i(s) > \{Eu_i(\varnothing), Eu_i(b)\}$ for individuals with $w_i = \{1-\xi, 1\}$, and $Eu_i(b) > \{Eu_i(\varnothing), Eu_i(s)\}$ for individuals with $w_i = 1+\xi$. Thus, no individual deviates from the above profile of strategies.

Proof of Proposition 2

In power-sharing systems, the difference between the expected payoff of a random individual in the few-buyers equilibrium and her expected payoff in the no-trade equilibrium is $\frac{1}{3}\left(\frac{421}{810}(1-\xi) + \frac{40}{81}\beta + e\right) + \frac{1}{3}\left(\frac{421}{810} + \frac{40}{81}\beta + e\right) + \frac{1}{3}\left(\frac{616}{810}(1+\xi) - \frac{80}{81}\beta + e\right) - (0.6 + e) = \frac{13}{162}\xi$, which is strictly positive for every $\xi \in (0,1)$.

In majoritarian systems, the difference between the expected payoff of a random individual in the few-buyers equilibrium and her expected payoff in the no-trade equilibrium is $\frac{1}{3}\left(\frac{29}{54}(1-\xi) + \frac{40}{81}\beta + e\right) + \frac{1}{3}\left(\frac{29}{54}1 + \frac{40}{81}\beta + e\right) + \frac{1}{3}\left(\frac{1027}{1296}(1+\xi) - \frac{80}{81}\beta + e\right) - \left(\frac{11}{16} + e\right) = \frac{331}{3888}\xi - \frac{127}{1944}$, which is strictly negative (positive) when $\xi < \bar{\xi} = 0.76737$ ($\xi > \bar{\xi} = 0.76737$).

Uniqueness of equilibrium with vote trading in main experimental treatments

First, we show that the few-buyers strategies—low types and medium types choose action s, and high types choose action b—form an equilibrium. In power-sharing systems, when all other players employ the few-buyers strategies, the expected payoff of an individual who chooses $\varnothing$ is $Eu_i(\varnothing) = 0.6w_i + 11$, the expected payoff of an individual who chooses s is $Eu_i(s) = \frac{421}{810}w_i + \frac{440}{81} + 11$, and the expected payoff of an individual who chooses b is $Eu_i(b) = \frac{616}{810}w_i - \frac{880}{81} + 11$. For $w_i = \{10, 30, 50\}$ we have $Eu_i(s) > \{Eu_i(\varnothing), Eu_i(b)\}$, and for $w_i = \{70, 90\}$ we have $Eu_i(b) > \{Eu_i(\varnothing), Eu_i(s)\}$. Thus, no type deviates from the above profile of strategies.

In majoritarian systems, when all other players employ the few-buyers strategies, the expected payoff of an individual who chooses $\varnothing$ is $Eu_i(\varnothing) = \frac{265}{432}w_i + 11$, the expected payoff of an individual who chooses action s is $Eu_i(s) = \frac{29}{54}w_i + \frac{440}{81} + 11$, and the expected payoff of an individual who chooses action b is $Eu_i(b) = \frac{1027}{1296}w_i - \frac{880}{81} + 11$. For $w_i = \{10, 30, 50\}$ we have $Eu_i(s) > \{Eu_i(\varnothing), Eu_i(b)\}$, and for $w_i = \{70, 90\}$ we have $Eu_i(b) > \{Eu_i(\varnothing), Eu_i(s)\}$. Thus, no type deviates from the above profile of strategies.

Next we will show that there is no other equilibrium with vote trading. The only candidates for equilibria are (i) the few-sellers profile of strategies where low types choose action s, and medium types and high types choose action b, and (ii) the few-sellers/few-buyers profile of strategies where low types choose action s, medium types choose action $\varnothing$, and high types choose action b.

The few-sellers profile of strategies is not an equilibrium in any of the two systems because there is a profitable deviation. In power-sharing systems, when all other players employ the few-sellers strategies, the expected payoff of an individual who chooses $\varnothing$ is $Eu_i(\varnothing) = 0.6w_i + 11$, the expected payoff of an individual who chooses action s is $Eu_i(s) = \frac{203}{405}w_i + \frac{1430}{81} + 11$, and the expected payoff of an individual who chooses action b is $Eu_i(b) = \frac{263}{405}w_i - \frac{715}{81} + 11$. For $w_i = 50$, we can easily derive that $Eu_i(s) > Eu_i(b)$. Hence, a medium-type individual deviates from the above profile of strategies. In majoritarian systems, when all other players employ the few-sellers strategies, the expected payoff of an individual who chooses $\varnothing$ is $Eu_i(\varnothing) = \frac{265}{432}w_i + 11$, the expected payoff of an individual who chooses action s is $Eu_i(s) = \frac{217}{432}w_i + \frac{1430}{81} + 11$, and the expected payoff of an individual who chooses action b is $Eu_i(b) = \frac{58}{81}w_i - \frac{715}{81} + 11$. For $w_i = 50$, we can easily derive that $Eu_i(s) > Eu_i(b)$. Hence, a medium-type individual deviates from the above profile of strategies.

Finally, the few-sellers/few-buyers profile of strategies is not an equilibrium in any of the two systems because there is a profitable deviation. In power-sharing systems, when all other players employ the few-sellers/few-buyers strategies, the expected utility of an individual who chooses $\varnothing$ is $Eu_i(\varnothing) = 0.6w_i + 11$, and the expected payoff of an individual who chooses action s is $Eu_i(s) = \frac{421}{810}w_i + \frac{715}{81} + 11$. For $w_i = 50$, we can easily derive that $Eu_i(s) > Eu_i(\varnothing)$. Hence, a medium-type individual deviates from the above profile of strategies. In majoritarian systems, when all other players employ the few-sellers/few-buyers strategies, the expected utility of an individual who chooses $\varnothing$ is $Eu_i(\varnothing) = \frac{271}{432}w_i + 11$, and the expected payoff of an individual who chooses action s is $Eu_i(s) = \frac{232}{432}w_i + \frac{715}{81} + 11$. For $w_i = 50$, we can easily derive that $Eu_i(s) > Eu_i(\varnothing)$. Hence, a medium-type individual deviates from the above profile of strategies.

Appendix B: Additional treatments

The main part of our experiment presents evidence in support of vote trading increasing individual welfare in power-sharing systems, whereas vote trading possibly (and more likely) decreases individual welfare in majoritarian systems. Moreover, improvement of individual welfare is obtained through a Pareto improvement of earnings for all types of preference intensities. The theoretical arguments presented in Appendix A suggest that the latter result is robust to alternative specifications of the trading mechanism.

For this reason, we provide results for two additional treatments, as robustness checks, in which we altered the trading mechanism compared to the main treatments, while retaining a power-sharing electoral system. All features of the environment, except of the trading mechanism, are the same as those described for Treatment PSH. The goal of this exercise is to test the extent to which the welfare improving results associated with the power-sharing system are robust to different trading mechanisms.

Treatment PSH3 In this treatment, we keep the same trading rules as in the main treatments and change only the monetary bid for buying votes to $\beta = 3$ tokens, while keeping the initial endowment to 11 tokens.

There is again a unique vote-trading equilibrium, which now is a *many-buyers equilibrium* (i.e., low types ($w = 10$) sell their votes, whereas medium and high types ($w \in \{50, 90\}$) buy votes). The intuition is that, in equilibrium, the decrease in the required investment for vote buying is sufficient to overcome the decrease in the supply of votes due to the fact that fewer types find it profitable to sell their votes. Therefore, we expect to observe a higher demand and a lower supply of votes in Treatment PSH3 compared to Treatment PSH. This is expected to lead to a decrease in the volume of votes traded—as this depends predominantly on the number of sellers—without observing a substantial difference in the trading frequency.

Treatment PSHPP In this treatment, we use a substantially different trading mechanism. More specifically, we consider a price-taking trading environment, in which votes can be bought in exchange for tokens at a *predetermined price* p, which is known to the subjects at the beginning of the round. We consider three distinct prices, $p \in \{9, 11, 13\}$, that appear in mixed order to the participants over the course of the 50 rounds.[35] Hence, there was no uncertainty about the price of a vote, since vote traders were not able to influence the price with their market actions, unlike all previous treatments. Individuals who chose to buy were also able to choose the maximum number of votes they would be willing to buy, which could be any quantity in $\{1, 2, 3, 4\}$, each at price p.[36]

Therefore, in a power-sharing system with predetermined prices, following the notation of Section 4 and letting b denote any buying decision (irrespective of the number of votes requested) and vb denote the number of votes actually bought by the subject, then earnings of the subject were as follows:

$$E_{PSHPP} = V \times W + m, \text{ where } m = \begin{cases} 11 - p \times vb & \text{if } a = b \text{ and bought } vb \in \{1, \ldots, 4\} \text{ votes,} \\ 11 + p & \text{if } a = s \text{ and vote was sold,} \\ 11 & \text{otherwise.} \end{cases}$$

A crucial difference of this trading mechanism is that it does not balance supply with demand by construction, even in the presence of both sellers and buyers, as the realised demand and supply might be different. In order to sort this imbalance, we employed the following allocation rule:[37] (i) if the number of votes for sale was equal to the number of votes demanded by buyers, then all the votes were sold, each seller would get extra p tokens, and each buyer would get the number of extra votes she had requested; (ii) if the number of votes for sale exceeded the number of votes requested by buyers, the computer would randomly select the sellers whose votes were sold, while the votes of the remaining sellers were returned to them; and (iii) if the number of votes for sale fell short of the number of votes requested by buyers, the computer would randomly select the buyers whose buying orders were executed, with the restriction that a buyer could get a second vote only if all buyers received at least one vote.

In this setup, assuming risk neutrality, for price $p = 9$ subjects with types $w \in \{10, 50\}$ would sell their votes, whereas subjects with $w = 90$ would request to buy up to four votes.[38] For prices higher than $p = 9$, none of the preference intensities (of the three available ones) is sufficient

[35] In fact, Treatment PSHPP employs a within-subject design with three sub-treatments, the results of which will be presented separately when appropriate.

[36] There were a total of 4 occurrences of a subject receiving negative earnings in a round, and no subject earned less than 1607 tokens over the course of 50 rounds. We refrained from imposing a no-bankruptcy rule at the round level to avoid complicating further the decision process of the subjects, given that bankruptcy was expected to occur very rarely for our selection of parameters. Negative earnings over the course of 50 rounds was essentially impossible given that the final earnings were determined by the sum of earning in all rounds.

[37] For cases where the realised demand and supply of votes do not coincide, our allocation rule can be thought of as the equivalent of the "rationing rule" that is used in many other price-taking environments. Importantly, although the rule we use might not seem the most intuitive one, it does not affect equilibrium behaviour.

[38] In fact, for $p = 9$ a subject with type $w = 90$ is exactly indifferent between buying and not buying because the expected benefit from buying an additional vote is $\frac{1}{2} \times \frac{w}{5} = 9$. Therefore, we can find a symmetric equilibrium that leads to ex-ante equality of expected demand and expected supply. The use of an equilibrium price that leads to market clearing in expectation can also be found in Casella *et al.* (2012), although different equilibrium concept and allocation rules are employed in their setup.

to make a subject wanting to buy votes. Therefore, under risk neutrality, there would be no equilibrium with vote trading for $p > 9$. However, there is good reason to expect trade to take place even for higher prices. In order to understand this, it is crucial to observe that the expected benefit from buying a vote is $w/10$, as the obtained vote is equally likely to have been owned initially by a supporter of the same group as the buyer or by a supporter of the other group. Thus, if a subject is risk averse, she would be willing to sacrifice part of her expected earnings in order to ensure that more votes would be cast in favour of her group, meaning that she would be willing to buy votes even at a price $p > 9$. This tendency towards overbidding is well-documented in the experimental literature on vote trading (Casella *et al.*, 2012) and elsewhere (Cox *et al.*, 1988 and Goeree *et al.*, 2002).

Having defined our additional treatments, we can now state the relevant hypotheses:

Hypothesis R1 *Average net earnings from trade are positive in both Treatments PSH3 and PSHPP.*

Hypothesis R2 *Average net earnings from trade are positive for all types in both Treatments PSH3 and PSHPP.*

Results Table 11 contains summary statistics of the two additional treatments. It is readily observable that the demand in all subtreatments of PSHPP is much higher than what theory (with risk-neutral agents) predicts. In fact, it seems that the supply of votes reaches almost the same levels as demand only at $p = 13$, which from a utilitarian perspective is a very high price to pay for a vote in this game. This suggests that a large fraction of all types of players was attempting to buy votes. This excessive demand impacts subjects' earnings, as we will see in the subsequent results.

It should be noted here that the small number of sessions for each treatment prevents us from being able to cluster standard errors at the session level, as we did in the main part of the analysis. Instead, we cluster of errors at the subject level (dependency of observations among the same subject over the course of 50 rounds, 30 clusters).[39] This is an obvious limitation, as in practice dependency may also exist among the members of the same community. Finally, although in this case the number of clusters is sufficiently large to allow the use of other techniques, we still use the Wild Cluster Bootstrap method for consistency.

Result R1 *Average net earnings from trade are positive in both Treatments PSH3 and PSHPP. When considering the three subtreatments of PSHPP separately, average net earnings from trade are positive only when* $p \in \{9, 11\}$.

[39] We have repeated the same exercise considering clustering at the community level (dependency of observations among the five subjects in a given round, 300 clusters), with the results being similar. Clustering at the subject level yields more conservative results due to the smaller number of clusters. For this reason, we omit the results with clustering at the community level from the text.

Treatment	Obs.	Trading Frequency	Buyers	Sellers	Demand	Price	Votes Bought
PSH3	300	82.33	2.240	1.733		4.68	1.16
			(1.086)	(1.089)		(3.38)	(0.96)
PSHPP	300	84.00	2.217	1.967			
			(1.242)	(1.204)			
PSHPP (9)	102	78.43	2.892	1.500	7.216	9	0.68
			(1.202)	(1.106)	(3.603)		(0.72)
PSHPP (11)	99	85.86	2.152	1.970	4.778	11	0.87
			(1.173)	(1.199)	(2.625)		(0.81)
PSHPP (13)	99	87.88	1.586	2.444	3.222	13	0.98
			(0.979)	(1.127)	(2.513)		(0.74)

Table 11: Descriptive statistics regarding community-level observations: trade frequency, average number of buyers, number of sellers, demand, price, and votes bought, with respective standard deviations in parentheses. For prices and votes bought, averaging is only over rounds in which trade took place.

Treatment	Clustering	Net Earnings from Trade	95 % Confidence Set		t-statistic	p-value
		(avg. per subject per round)	Lower	Upper		
PSH3	Subject	+0.8134	+0.3600	·	3.1073	.0032
PSHPP	Subject	+1.0387	+0.4457	·	3.0477	.0020
PSHPP (9)	Subject	+0.7529	+0.0128	·	1.7077	.0470
PSHPP (11)	Subject	+1.6283	+0.7573	·	3.2046	.0020
PSHPP (13)	Subject	+0.7434	–0.3337	·	1.1969	.1150

Table 12: Average net earnings from trade. Confidence sets are constructed using the Wild Cluster Bootstrap method, with data clustered at the subject level. The p-values correspond to the relevant one-sided tests. The results contain all rounds, even those in which trade did not take place.

The supporting evidence to Result R1 is presented in Table 12. Interestingly, for $p = 13$, the net earnings from trade are not significantly positive, which is not really unexpected given the high price buyers need to pay for each vote. We also observe the average net earnings in PSH3 to be lower than those in PSH, which occurs for two reasons: first, low types are compensated less for giving up their votes, and second, medium types are now also more likely to buy votes. Thus, additional votes are more often allocated to medium rather than high types.

Result R2a *In Treatment PSH3, average net earnings from trade are positive for low and high types* ($w \in \{10, 90\}$) *and neither positive nor negative for medium types* ($w = 50$).

Result R2b *In Treatment PSHPP, average net earnings from trade are positive for low types* ($w = 10$), *neither positive nor negative for medium types* ($w = 50$), *and negative for high types* ($w = 90$).

As we have already seen in the results of the main treatments, the benefits from vote trading are

Treatment	Type	Net Earnings from Trade	95 % Confidence Set		t-statistic	p-value
	(w)	(avg. per subject per round)	Lower	Upper		
PSH3	L - 10	+1.0090	+0.6155	·	4.4859	.0002
PSH3	M - 50	–0.0090	·	+0.5400	–0.0276	.4987
PSH3	H - 90	+1.4724	+0.2678	·	2.0994	.0258
PSHPP	L - 10	+4.4930	+3.6160	·	8.7851	.0000
PSHPP	M - 50	–0.1918	·	+0.5944	–0.4005	.3433
PSHPP	H - 90	–1.1959	·	–0.2622	–2.1025	.0238
PSHPP (9)	L - 10	+4.0000	+2.901	·	6.1622	.0000
PSHPP (9)	M - 50	–1.6857	·	–0.5689	–2.4594	.0082
PSHPP (9)	H - 90	–0.0552	·	+1.3900	–0.0646	.4707
PSHPP (11)	L - 10	+5.1039	+4.2080	·	9.7394	.0000
PSHPP (11)	M - 50	+0.1163	–0.9982	·	0.1740	.4337
PSHPP (11)	H - 90	+0.0000	·	+1.8800	0.0000	.4923
PSHPP (13)	L - 10	+4.4393	+2.9270	·	5.1742	.0000
PSHPP (13)	M - 50	+1.0793	–0.4316	·	1.1815	.1192
PSHPP (13)	H - 90	–3.6519	·	–1.8460	–3.3550	.0024

Table 13: Average net earnings from trade by type, for treatments PSH3 and PSHPP, as well as separately for the three subtreatments of PSHPP with the different prices, $p \in \{9, 11, 13\}$. Confidence sets are constructed using a Wild Cluster Bootstrap method, with data clustered at the subject level. The p-values correspond to the relevant one-sided tests. The results contain all rounds, even those in which trade did not take place.

not distributed equally among subjects of different types. Table 13 presents the net earnings from trade by type. Similar to the main treatments, we observe that subjects with low types are the main and consistent beneficiaries from trading, whereas subjects with medium and high types seem either not to be affected or to be affected differently depending on the trading environment. For instance, while in Treatment PSH, high types did not gain from trading, they did so in Treatment PSH3. By contrast, in PSHPP, and in particular for $p = 13$, these types seem to be negatively affected by trading. What is the driving force behind these diverse findings? We argue that trading institutions that impose constraints, whether explicitly or implicitly, that do not allow prices to become very high help high type agents gain from vote trading, too. For instance, by focusing on Treatment PSHPP, we observe that high type agents demand votes even at very high prices. In addition to this, recall that even in the main treatments (and despite the fact that strategic-market mechanisms can impose some control on the prices) we observe rather high prices, which plays a crucial role in suppressing the earnings of higher types. Medium types seem to be the least affected by trading, as expected. Yet, interestingly, they lose from trade in PSHPP when $p = 9$ because at this price they often try to buy votes, likely because they underestimate the probability of buying a vote from a supporter of their own group.

Note that, as was also the case in the main treatments, over the course of the experiment, many subjects earn less than they would have without vote trading (see Table 14).

Treatment	PSH3	PSHPP	PSHPP (9)	PSHPP (11)	PSHPP (13)
(out of 30)	20	22	19	21	17

Table 14: Number of subjects who earned more over the course of the experiment than they would under no trade. For PSH3 and PSHPP, comparison is over all 50 rounds, whereas for PSHPP (9)–(13), comparison is only over rounds with the specific price.

In addition to the welfare implications of trading, there is also strong evidence that in both treatments, frequency of vote buying (selling) increases (decreases) significantly with type, and in Treatment PSHPP, supply (demand) increases (decreases) significantly with price.

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