Controlling Monopoly Power in a Double-Auction Market Experiment*

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Abstract

There is robust evidence in the experimental economics literature showing that monopoly power is affected by trading institutions. In this paper, we study whether trading institutions themselves can shape agents' market behaviour through the formation of anchors and reference points. We recreate experimentally five different double-auction market structures (perfect competition, perfect competition with quotas, cartel on price, cartel on price with quotas, and monopoly) in a within-subject design, varying the order of markets implementation. We investigate whether monopoly power endures the formation of reference prices emerged in previously-implemented market structures. Results from our classroom experiments suggest that double-auction trading institutions succeed in preventing monopolists from exploiting their market power. Furthermore, the formation of reference points in previously-implemented markets negatively impacts on monopolists' power in later market structures.

Keywords: Double Auctions; Perfect Competition; Monopoly, Market Imperfection; Spillovers; Classroom Experiments.

JEL code: C90, D41, D42, D43, D44

1 Introduction

The quest for controlling market power has paved the way to the modern experimental economics literature. Since the seminal works by Chamberlin [1948] and Smith [1962], scholars have tried to show that the power of agents operating in markets can be sensitive to the trading mechanisms devised. For example, Smith and Williams [1981] conducted a series of laboratory market experiments designed to investigate whether the rules of market trading mechanisms might discipline a monopolist. It turned out that public posting of uniform prices in a Posted Offer Auction eliminates the incentive to offer discounts on marginal units that arises in a Double Auction.

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In experimental markets with the same number of buyers and sellers, trading prices and traded quantity quickly converge to the competitive equilibrium price and quantity under Double Auction. Furthermore, the efficiency reached by double-auction markets closely approximates that reached at the competitive equilibrium. As shown by Smith [1962] and subsequent experimental research on competitive markets (see, e.g., Friedman and Rust [1993]; Attanasi et al. [2020]), the convergence and efficiency properties of double-auction markets with human traders are robust to modifications of trading periods length. In particular, only few trading periods are needed to get traded quantity and price to converge to the competitive equilibrium levels and the market to reach full efficiency. This empirical result is also confirmed by thorough theoretical analysis (see, e.g., Chatterjee and Samuelson [1983], Wilson [1985], Gresik and Satterthwaite [1989], Satterthwaite and Williams [1989], and Cripps and Swinkels [2006]).

As for monopolistic markets, prices set by monopolists under double-auction trading mechanisms are significantly lower than those the theory predicts, converging towards perfect-competition levels (see Holt et al. [1986], Smith and Williams [1989], and Davis and Williams [1991]). On the other hand, a recent experimental work has also provided conflicting evidence. In search for evidence proving that double-auction markets are able to control over monopoly and monopsony power, Muller et al. [2002] find that double-auction trading mechanisms provide an ineffective constraint to market power and do not succeed in preventing agents with market power from exploiting their advantage. Similar results are reported in Ledyard and Szakaly-Moore [1994], Brown-Kruse et al. [1995], and Godby [2000, 2002].

While the choice of the trading mechanisms has a significant impact on monopolistic market equilibrium, it is not clear how the presence of behavioural tendencies, combined with that of particular trading mechanisms may affect monopoly power. It is common wisdom in the experimental literature that subjects use formerly traded prices as *reference points*, namely, the regular price that they expect to pay for a given good (Thaler [1985], Isoni et al. [2011], Bordalo et al. [2012], Putler [1992]). Seminal works in the experimental economics literature have proven the ubiquitous presence of such anomalies in subjects' behaviour, even in repeated trading interactions. The *shaping hypothesis* proposed by Loomes et al. [2003] for example, states that in repeated auctions in which prices have no information content, there is a tendency for agents to adjust their bids towards the price observed in the previous market period. Tufano [2010] shows that market behaviour is not anomaly-free, strengthening Loomes and coauthors' results. Also out-of-the-lab studies of auctions have shown that game history and subjects' experience do matter in the analysis of price convergence, bids and sold quantity. Pownall and Wolk [2013] show that experience significantly lowers the level of bids suggesting that bidders change their bidding behavior throughout time, eventually eliminating previous overbidding. These studies confirm that market behaviour is not the product of the true underlying preferences but rather of context-dependent preferences.

Drawing from this experimental evidence, we design a double-auction classroom experiment with undergraduate students in Economics to understand whether the implementation of double-auction trading institutions creates a constraint over monopoly power and whether such effect is modulated by the formation of reference points created in previous markets. In particular, we hold double-auction trading under different market structures – perfect competition with and without quotas, cartel with and without quotas, monopoly – and vary, across treatments, their implementation order. With this, we aim at investigating whether monopoly power depends on subjects' experienced prices under previously-implemented market structures.

We derive our experimental hypotheses by informing a standard equilibrium model with behavioral insights from the experimental literature on anchoring effects (Kahneman et al. [1982], Tversky and Kahneman [1992], and Kristensen and GaÌrling [1997]). First, we study sellers' behavior in each of the five market structures separately. Then, we model the evolution of market outcomes (trading prices and trading quantities) according to the order of implementation of the five market structures. In our theoretical framework, we assume that sellers are heterogeneous in their bargaining toughness when negotiating with buyers (see, e.g., Attanasi et al. [2013]) and that, by moral balancing theory (Nisan and Horenczyk [1990]), they keep account of their self-image of tough bargainers as market structures unfold.

In line with the predictions of our behavioral model, our results provide indications that, under double-auction trading, prices prevailing in monopolistic markets are far lower than those predicted by the theory. On average, prices in monopoly start out relatively low since the first period, to then decrease as the experiment unravels. Moreover, if the monopoly comes after other market structures, the formation of reference prices in prior market structures weakens the monopolist's market power. In particular, when subjects in the experiment first trade under perfect competition, prices are lowest than when either cartel or no market precedes the monopoly.

Our work and results are relevant in the light of recent economic directions pointing towards the erosion of competition in markets and a steady rise of monopoly power (Eggertsson et al. [2018]). Recent work in economics has focused on future trends of monopolistic power, firm concentration and profit increase. For example, the share of total U.S. stock market value reflecting monopoly power rose from negligible levels in 1985 to around 80 % in 2015 and it seems to grow steadily (Kurz [2017]). Other authors have reported evidence of increasing firms' market power and concentration along with rising pure profits (Dorn et al. [2017], Grullon et al. [2019]). In such circumstances, policymakers are often called to intervene and regulate markets by either favoring competition or granting monopoly power to privates. The reasons why policymakers may prefer granting a monopoly are several. Economies of scale are one among others, with utility companies representing a relevant example in this regard. The government may also grant sole ownership of inventions through patent laws to help eliminate the market failure that is likely to occur in the markets for those goods. In evaluating policies in favour of coercive monopoly, regulators should account for the role of trading institutions as well as for behavioural fallacies typical of agents operating in markets. Such factors together inevitably affect market outcomes. In this effort, our work contributes to the growing body of experimental and theoretical literature complementing standard economic models with bounded rationality and psychological biases to better evaluate the impact of public policies (see, e.g., Gabaix et al. [2016], Gabaix [2020]).

The remainder of the paper is as follows: Section 2 discusses the experimental design; in Section 3 we present our model and theory-driven hypotheses; Section 4 reports the experimental results. Lastly, Section 5 concludes.

2 Experimental design

2.1 Market structures

Following Smith [1962] and subsequent standard practices in market classroom experiments (see, e.g., Holt [1996], Cason and Friedman [2008]; Attanasi et al. [2016]), we recreate an experimental, computerized double-auction laboratory market.

Table 1 describes the main features of each market structure of our design. We implement overall a total of five market structures in a within-subject design.

Table 1: Market structures

Market	No. Buyers	No. Sellers	No. Markets	Q per Seller
Monopoly	6	1	4	6
Perf. Comp.	24	4	1	24
Perf. Comp. - quotas	24	4	1	6
Cartel	24	4	1	24
Cartel - quotas	24	4	1	6

In each experimental session, $n = 28$ subjects are randomly assigned to the role of seller or buyer: 4 of them are sellers and the remaining 24 are buyers. Subjects keep the same role for the whole experiment. They play the five market structures in Table 1. Every market structure is played for 3 periods and a single trading period lasts 120 seconds.[1] At the beginning of the experiment, subjects only know that the experiment consists of five phases (market structures), with instructions of each new phase distributed only prior to that phase. Further details can be found in the instructions reported in Appendix C.

In each trading period, sellers' costs and buyers' valuations of a homogeneous good are exogenously given: each buyer is endowed with a valuation v_i, which varies across buyers, while the four sellers face the same production cost c. Therefore, each buyer only knows her own valuation and the fact that all sellers face the same production cost; each seller knows the cost of all sellers and the fact that buyers' valuations are heterogeneous. Valuations are described by the step function with values $v_i \in \{20, 18, 16, 14, 12, 10\}$ (see Figures A.1-A.3 in Appendix A). More precisely, in each trading period there are 4 buyers with the same v_i (i.e., 4 buyers with $v_1 = 20$, 4 buyers with $v_2 = 18$, ..., 4 buyers with $v_6 = 10$). The cost c is set at 12 for every seller. Valuations are re-shuffled and randomly re-assigned to buyers at each trading period.

For each seller-buyer transaction, the profit of seller S_j ($j = 1, 2, 3, 4$) is given by the difference between the trading price and his production cost, formally $\Pi_{S_j} = p - c$; the profit of buyer B_k ($k = 1, 2, ..., 24$) is given by the difference between the assigned

[1] Note that, although there is not a per period time constraint in the pioneering study of Smith [1962], a per period time limit has later become a quite standard feature of market classroom experiments, especially in computerized ones: see Wells [1991] for double-auction mechanisms and Holt [1996] and Ruffle [2003] for other trading mechanisms. This is a necessary feature in order to experimentally allow intramarginal inefficiency, which has been shown to be a relevant source of inefficiency in electronic markets (see, e.g., Cason and Friedman [1996]). Intramarginal inefficiency is also a reliable measure of subjects' learning across trading periods, as we show in the data analysis of Section 4.

valuation and the trading price, formally $\Pi_{B_k} = v_{ik} - p$. Negative profits are not allowed. In particular, although sellers (resp., buyers) are allowed to trade at their cost (resp., valuation), we require sellers (resp., buyers) to earn a positive profit for each traded unit. Transferring positive profits from one trading period to another is not allowed (every time a new period starts, subjects' profits are reset to zero).

Due to the short duration of trading periods, sellers' asks and buyers' bids are constrained to be integer numbers between 0 and 30 experimental points, i.e., the minimum positive profit is equal to 1 point. In each trading period, each buyer can buy at maximum one unit of the good; in line with our research objective, sellers are allowed to sell more than one unit of the good.

Trading is done through a double-auction mechanism. During the trading period, subjects are always shown the current highest bid and lowest ask. Every subject can improve on the existing situation (*improvement rule*): a buyer can submit a bid only if higher than the current highest bid (ascending auction), and a seller can submit an ask only if lower than the current lowest ask (descending auction). When a buyer and a seller reach an agreement, the buyer exits the market, the standing bids and asks are removed, and new bids and asks can be submitted without considering the previous trading price (*market clearing rule*). The trading price are disclosed on the screens of all subjects in chronological order together with the IDs of the buyer and seller reaching that agreement.

All of the above is independent of the market structure. Let us now discuss in detail each of the five **market structures** presented in Table 1.

Monopoly. The 28 subjects in the experimental session are randomly allocated to 4 markets, with 1 seller and 6 buyers per market. Each market is characterized by the same supply function – the seller owning 6 units of the good at a cost of $c = 12$ each –, and the same demand function – with each of the six buyers being assigned one of the six possible valuations $v_i \in \{20, 18, 16, 14, 12, 10\}$. In each of the four monopolistic markets the trading mechanism is Double Auction, so that price discrimination is allowed for each of the units traded within a period (see Figure A.1).

Perfect Competition. In each of the 3 trading periods, there are 4 sellers with $c = 12$, and 24 buyers with each buyer being randomly assigned one of the six v_i: 4 buyers have $v_1 = 20$, 4 have $v_2 = 18$, 4 have $v_3 = 16$, 4 have $v_4 = 14$, 4 have $v_5 = 12$, and 4 have $v_6 = 10$. Each seller owns 24 units of the homogeneous good, with which he can face alone all the buyers' demand. With this, the competitive market is characterized by 96 available units of the homogeneous good, with at most 24 of them being tradable (see Figure A.2).

Cartel. It is similar to Perfect Competition apart from the four sellers going through a pre-trading stage called "communication stage" in which each of them is asked to privately report his target trading price within $\{0, 1, ..., 30\}$ points, as the price he would like to apply to all his units in the following three trading periods. The experimenter collects the price proposal of each seller, computes the average of the four prices, and disclose it to the four sellers, suggesting that such average price is the only one that they should offer in each trading period.[2] Buyers are

[2]Note that, to preserve sellers' anonymity by avoiding noisy communication among them, and to have the same bargaining rules in each Cartel experiment, sellers cannot chat or send proposals

informed about the rules of the communication stage, but not about the outcome. The communication stage is intended to allow sellers to form a price cartel. However, sellers are told that they are not committed to offer in the following double-auction trading periods either their own or the average proposed price in the communication stage. Therefore, no additional constraint on trading is imposed with respect to Perfect Competition (see Figure A.3).

Perfect Competition with quotas and **Cartel with quotas**. Under both Perfect Competition and the Cartel structures, we distinguish between a "regular" market and one in which restrictions on the quantity endowed to sellers, called "quotas," are applied. In particular, in the latter each seller is only endowed with 6 units of the homogeneous good, with which he can face alone 1/4 of the buyers' demand. With 4 sellers in the market, the total supply of 24 units is equal to the maximum quantity buyers can buy. This leads to other two market structures, with quotas: one under Perfect Competition (Figure A.2 with $\bar{Q} = 24$) and another under the Cartel structure (Figure A.3 with $\bar{Q} = 24$).

2.2 Experimental Procedures and Treatments

Experimental sessions were run in the Laboratory of Experimental Economics of Strasbourg (LEES) by two of the paper authors. The experiment was computerised using the online platform www.econplay.fr. Individual cubicles ensured subjects' anonymity and the absence of communication during the experiment.

In total 1008 students participated in the experiment (336 per year), in 36 different sessions (12 sessions per year) with 28 students in each session. Each session was followed by a tutorial in Microeconomics, where the teacher (same as the experimenter) introduced the (standard) theoretical predictions of Section 3.1 to students, and then analysed and discussed the experimental data in the light of these predictions. The sessions took place throughout three consecutive academic years (November–December, 2014–2016). Subjects were equally balanced in gender (45% female) and homogeneous in other features: age (almost all students were 18-20 years old), nationality (90% of the were French) and field of study (Economics and Management). As it is common in classroom experiments, we did not use monetary rewards to incentivise subjects. Previous studies have shown that classroom experiments, especially with undergraduate students in Economics, are good at replicating textbook and theoretical predictions (see, e.g., Holt [1996, 1999], Finley et al. [2019]).

The experiment was implemented according to 12 treatments, with 3 sessions (Microeconomic classes) for each treatment, the latter being shown in Table 2. The 3 sessions of the same treatment were implemented in 3 non-consecutive classes. As Table 2 reports, in each of the 12 treatments students were presented, at a within-subject level, the five market structures described in Section 2.1: Perfect Competition (Comp), Perfect Competition with quotas (Comp-q), Cartel (Cartel), Cartel with quotas (Cartel-q), and Monopoly. The treatments differed at a between-subject level according to the order of presentation of the five market structures.

Given that each market structure was proposed for 3 consecutive trading periods, each treatment was characterized by 15 trading periods, with instructions of each new market structure being shown on the computer screen only at the end of

among them.

the previous 3 trading periods. Each trading period lasting 120 seconds, the experimental session average duration was about 40 minutes, including the reading of instructions. An example of the computer screen of buyers and sellers during a trading period is reported in the Appendix (Figure A.4 refers to the screen of buyer B_6 and Figure A.5 refers to the screen of seller S_1, both in the first trading period of a market under Perfect Competition).[3]

Table 2: Order of presentation of the five market structures

Treatments	Timeline				
	1	**2**	**3**	**4**	**5**
(1) CoCaMo	Comp	Comp-q	Cartel	Cartel-q	Monopoly
(2) CoMoCa	Comp	Comp-q	Monopoly	Cartel	Cartel-q
(3) CaCoMo	Cartel	Cartel-q	Comp	Comp-q	Monopoly
(4) CaMoCo	Cartel	Cartel-q	Monopoly	Comp	Comp-q
(5) MoCoCa	Monopoly	Comp	Comp-q	Cartel	Cartel-q
(6) MoCaCo	Monopoly	Cartel	Cartel-q	Comp	Comp-q
(7) CoCaMo-q	Comp-q	Comp	Cartel-q	Cartel	Monopoly
(8) CoMoCa-q	Comp-q	Comp	Monopoly	Cartel-q	Cartel
(9) CaCoMo-q	Cartel-q	Cartel	Comp-q	Comp	Monopoly
(10) CaMoCo-q	Cartel-q	Cartel	Monopoly	Comp-q	Comp
(11) MoCoCa-q	Monopoly	Comp-q	Comp	Cartel-q	Cartel
(12) MoCaCo-q	Monopoly	Cartel-q	Cartel	Comp-q	Comp

Note: 3 sessions per treatment. 'Co', 'Ca', and 'Mo' stand for Perfect Competition, Cartel and Monopoly, respectively. The 'q' symbol following the name of a market structure indicates implementation of quotas within that market.

Referring to Table 2, we report the main features of our order manipulation at a between-subject level:

- The first group of six treatments of Table 2 (first six rows of the table) share the common feature of implementing structures without quotas first, followed by those with quotas, while in the second group (last six rows of the table) the order without-with quotas is switched.
- Treatment 1 and treatment 7 (first row of each group of six treatments) indicates an order of markets presentation with decreasing structural level of competition (respectively, CoCaMo and CoCaMo-q).
- Treatment 6 and treatment 12 (last row of each group of six treatments) indicates an order of markets presentation with increasing structural level of competition (respectively, MoCaCo and MoCaCo-q).

[3]Figures A.4-A.5 show a moment of the trading period where 5 units are already traded (thus, $24 - 5 = 19$ units are still available for purchase and $96 - 5 = 91$ are still available for sale), seller S_1 has sold 2 of these units, buyer B_6 has not bought yet, the current highest bid is 15 (made by buyer B_{10}), and the current lowest ask is 16 (made by seller S_4).

- The remaining four rows of each group of six indicate treatments with an order of markets presentation leading to non-monotonic structural levels of competition.
- Row-to-row pairwise comparison between treatments in the first and the second group of six allows us to test for the effect of quotas introduced vs. removed within the same market.

3 Experimental Hypotheses

In Section 3.1, we study sellers' behavior in each of the five market structures separately. In Section 3.2, we enrich the standard equilibrium models we introduce in Section 3.1 with behavioral insights from the experimental literature on anchoring effects, in order to model the evolution of market outcomes (trading prices and trading quantities) according to the order of implementation of the five market structures.

3.1 A model of sellers' competition

Our theoretical analysis focuses on sellers' market-dependent behavior. We assume buyers' market-independent behavior because of extensive experimental evidence showing no impact of buyers' behavior on market indexes in double-auction markets like ours, where buyers can only buy one good unit with exogenously assigned valuation for that unit (see, e.g., Holt [1999] and follow-up experimental works).[4] Furthermore, competition among sellers is boosted by design in our experiment. In fact, traders are told by the experimenter that buyers' valuations are heterogeneous, while sellers' cost is homogeneous and hence known among sellers. Therefore, two sellers trading at the same price know they made the same profit, and a buyer making the same bid to two different sellers knows that both have the same leeway to accept that bid.

With this, we put forward a model of sellers' competition in non-monopolistic markets which relies on a feature of market equilibrium: the variance across the four sellers' traded quantities within a period increases according to the level of competitiveness induced by the market structure. Such a variance is null by construction in equilibrium under Monopoly. Recall that there are always 4 sellers in each experimental session, operating under the same experimental conditions in 4 distinct markets under Monopoly, and in the same market in the remaining market structures. We begin by providing a theoretical analysis of the 4 monopolistic markets.

Monopoly. The experimental implementation of the 4 monopolistic markets allows price discrimination by the monopolist: each monopolist can extract the maximum surplus from the four buyers with $v_i > c$. Given unit cost $c = 12$, valuations $v_i \in \{10, 12, 14, 16, 18, 20\}$, the discrete set of possible prices $\{0, 1, ...30\}$,

[4] In particular, Attanasi et al. [2020] show that increasing the market size by four times (from 10 to 40 or from 20 to 80 traders) does not affect buyers' behavior. This especially applies to our market structures since, when moving from Monopoly to any of the other four market structures, the number of buyers (and sellers) increases by four times.

and the experimental requirement for both sellers and buyers to make at least 1 point of profit, the vector of equilibrium prices in each of the four monopolistic markets will be $(19, 17, 15, 13)$, with equilibrium traded quantity $q^*_{Mo} = 4$ (with $66\% = 4/6$ buyers trading) and the monopolist's surplus equal to 16, i.e., 4 points per traded unit, as reported in Figure A.1. In fact, given the timing of price discrimination within a trading period, the monopolist first trades with $v_1 = 20$, the buyer with highest v_i, and makes the last trade with $v_4 = 14$, the buyer with lowest $v_i > c$. Therefore, the average price applied by the monopolist is decreasing in the traded quantity in a period: it is equal to 19 for $q_{Mo} = 1$, 18 for $q_{Mo} = 2$, 17 for $q_{Mo} = 3$, and 16 for $q_{Mo} = 4$. We define $p^*_{Mo} = 16 = (19 + 17 + 15 + 13)/4$ the average equilibrium price in each of the four monopolistic markets. Considering the four markets together, the equilibrium quantity is $Q^*_{Mo} = 4 \cdot q^*_{Mo} = 16$. Note that, to avoid loss of reputation in terms of bargaining power from the first to the third trading period, the monopolist will never trade with a buyer at a price $p_{Mo} = c = 12$. This would increase the per period traded quantity by allowing also $v_5 = 12$ to trade, although leaving the monopolist's surplus unaffected and decreasing the buyers' expected trading price in the next period. Finally, due to the monopolist's learning of the maximum surplus he can extract from each buyer in his market, behaviour will converge to (Q^*_{Mo}, p^*_{Mo}) as trading periods unfold.

We now study the four non-monopolistic market structures, starting from the one with the most competitive market rules.

Perfect Competition. The demand and supply functions in Figure A.2, together with the discrete set of possible prices $\{0, 1, ...30\}$, and the experimental requirement for both sellers and buyers to make at least 1 point of profit, lead to an equilibrium quantity and price under Perfect Competition of $(Q^*_{Co}, p^*_{Co}) = (16, 13)$,[5] i.e., 66% of buyers (16/24) trade in equilibrium, which is the same equilibrium quantity of the four monopolistic markets considered together, i.e., $Q^*_{Co} = Q^*_{Mo}$. Figure A.2 also represents the sellers' total surplus, equal to 16, i.e., 1 point per traded unit. The seller's per-unit surplus is 3 points lower than under Monopoly, because of the average mark-up: $p^*_{Mo} = p^*_{Co} + 3$. The four sellers considered together under Perfect Competition would obtain the same surplus as the unique seller would get in each of the four monopolistic markets. As for individual behavior, each seller sells on average 4 of his 24 units, although any supply vector $(q^*_j)^4_{j=1}$ with $q^*_j \in \{0, 1, ..., 16\}$ and $\sum_{j=1}^4 q^*_j = 16$ is an equilibrium. Therefore, it is possible that all $Q^*_{Co} = 16$ is traded in equilibrium by only one, only two or only three of the four sellers. More precisely, across the 969 possible equilibrium vectors of sellers' traded quantities $(q^*_1, q^*_2, q^*_3, q^*_4)$ there is only one equalizing the four quantities. This leads to substantial sellers' competition in traded quantities within a period, along with the law of demand, i.e., with sellers trading more quantities who will do it at a lower average price. In particular, to increase his market share, a seller will also trade at price $p_{Co} = c = 12$, thereby allowing also $v_5 = 12$ to trade. Trading at no-profit leaves the seller's individual surplus unaffected but decreases the buyers' and the other three sellers' expected trading price in the next period. The latter is an anchoring effect

[5] Indeed, p^*_{Co} lies in the interval $[12, 14]$. Asks and bids being constrained to integer numbers, this interval shrinks to $\{12, 13, 14\}$. Given $c = 12$ for each seller and valuations in $\{10, 12, 14, 16, 18, 20\}$, $p^*_{Co} = 13$ is the only price where each traded unit makes a positive profit for both trading parts.

across trading periods of the same market structure which may boost the average trading price below p^*_{Co} in the third period.

Cartel. The equilibrium quantity and price depend on whether sellers reach a mutual agreement on a unique price to maximise the sellers' total surplus and share it equally. Recall that the mutual agreement in the experiment is made available to the four sellers as the (unique) average of the four trading prices privately reported in the (pre-trade) communication stage.[6] Thus, collusive strategies among the four sellers should lead them to privately report (and coordinate on) the price they would impose under a monopoly with unique price. The quantity-price combination maximising the monopolist's total surplus under a unique price is $(Q^*_{Ca}, p^*_{Ca}) = (8, 17)$, i.e., only 33% of buyers (8/24) trade in equilibrium, with each seller only selling on average 2 of his 24 units (equilibrium supply vector $(q^*_j)^4_{j=1}$ with $q^*_j \in \{0, 1, ..., 8\}$ and $\sum^4_{j=1} q^*_j = 8$). Figure A.3 shows that in this case the sellers' total surplus equals to 40 overall (5 points per traded unit on average), although this is lower than under monopoly with price discrimination due to lower equilibrium quantity. However, in our setting agreements are not binding and so undercutting cannot be prevented, since sellers are free to set any price they want to. Thus, there is an individual incentive to deviate from the collusive outcome to increase the seller's traded quantity and individual surplus. Therefore, sellers should not be able to maintain the cartel agreement mentioned above, with the uniperiodal quantity-price combination converging to the one of Perfect Competition, i.e., $(Q^*_{Co}, p^*_{Co}) = (16, 13)$ as trading periods unfold. Therefore, the average trading price in this market lies in the interval (p^*_{Co}, p^*_{Ca}), tending to p^*_{Co} from period 1 to period 3. Again, sellers trading more quantities will do it at a lower average price, since tit-for-tat behaviour after betrayal of the cartel agreement will lead a seller to decrease his ask in order to attract further buyers to sell more. As under Perfect Competition, to increase his market share and/or to retaliate against other sellers after cartel betrayal, a seller will also trade at price $p_{Co} = c = 12$, thereby further reducing the average trading price and generating an anchoring effect across the three trading periods which may boost the average trading price below p^*_{Co} in the third period.

Perfect Competition with quotas and **Cartel with quotas**. The introduction of quotas does not affect the market equilibrium values in either Perfect Competition or Cartel. In fact, given a quota of 6 units per seller, the total supply of 24 units is sufficient to guarantee $Q^*_{Co} = 16$ and $Q^*_{Ca} = 8$, respectively. However, the equilibrium supply vector $(q^*_j)^4_{j=1}$ is constrained to $q^*_j \in \{0, 1, ..., 6\}$, with $\sum^4_{j=1} q^*_j = 16$ under Perfect Competition (Figure A.2) and $\sum^4_{j=1} q^*_j = 8$ under the Cartel (Figure A.3). Therefore, given that none of the four sellers is able to satisfy alone all the equilibrium market demand in any of the two market configurations, the lower pressure on the supply side may lead to a decrease in the traded quantity and increase the trading price, with average $p_{Co-q} > p_{Co}$ under Perfect Competition with quotas and average $p_{Ca-q} > p_{Ca}$ under Cartel with quotas. This effect should be greater in the Cartel with quotas ($p_{Ca-q} > p_{Co-q}$), since sellers can account for the individual rationing when reporting their (higher) target trading price in the

[6]Note that, different from Monopoly, sellers are not given the possibility to coordinate on price discrimination strategies, since this collusion device would be hard to implement in the experiment and for sellers to maintain.

(pre-trade) communication stage and when trying to maintain it through the three trading periods. However, due to non-binding cartel agreement, also in this case the seller's average trading price should converge to p_{Co-q} as trading periods unfold. Finally, the introduction of quotas leads to a significantly lower number (i.e., 149) of possible equilibrium vectors of sellers' traded quantities $(q_1^*, q_2^*, q_3^*, q_4^*)$ and the need of at least three out of the four sellers to trade in order to provide the competitive market equilibrium quantity $Q_{Co}^* = 16$. Therefore, despite not changing the market equilibrium quantity, quotas reduce competitive pressure among sellers. This in turn reduces both the negative correlation between sold quantity and average trading price at seller individual level and the fraction of sellers trading at zero profit with the aim of increasing their market share. The latter is prevented by individual rationing, which incentivises each seller to try to obtain a positive profit on each of the 6 allowed traded units.

Table 3 summarizes our predictions as for the average trading price, its correlation with the traded quantity, and the number of zero-profit trades in each of the five market structures. As for the average trading price, we introduce two parameters $\eta, \nu > 0$ with $\eta + \nu < 3$. Parameter η accounts for the positive differences $(p_{Co-q}^* - p_{Co}^*)$ and $(p_{Ca-q}^* - p_{Ca}^*)$ due to the effect of quotas. Parameter ν accounts for the positive differences $(p_{Ca}^* - p_{Co}^*)$ and $(p_{Ca-q}^* - p_{Co-q}^*)$ due to the (non-binding) cartel agreement during the pre-trade communication stage. The constraint $\eta + \nu < 3$ highlights that the two effects considered together are not enough to lead to a monopolistic configuration. Note that, because of our learning hypothesis, the predictions shown in Table 3 should especially hold in the third period of each market structure. In fact, the implementation of three trading periods for each market structure in our design is meant to allow subjects to learn across periods.

Table 3: Predictions on market structures comparison ($\eta, \nu > 0$ with $\eta + \nu < 3$)

Market Structures	Average p	Correlation with Q	Trades at $p = 12$
Monopoly	16	High	None
Comp	13	High	Many
Comp-q	$13 + \eta$	Low	Few
Cartel	$13 + \nu$	High	Many
Cartel-q	$13 + \eta + \nu$	Low	Few

All of the above leads to our first three theory-driven experimental hypotheses, which concern sellers' behavior in market structures regardless of the order of presentation in the twelve treatments of Table 2.

The first experimental hypothesis concerns the negative relationship between a seller's traded quantity and average trading price in the five market structures of our experiment (second column of Table 3). This negative relationship is the main theoretical feature of optimal monopolistic behavior.

Hypothesis 1. Average trading price in a monopolistic market decreases with the monopolist's traded quantity. The same holds for each seller under both Perfect Competition and Cartel. The introduction of quotas mitigates this negative relationship.

The second experimental hypothesis (last column of Table 3) concerns trading with zero profit as a seller's strategy to increase his market share under Perfect Competition and as a punishment of co-players' deception of the Cartel agreement. Conversely, we have shown that monopolists have no incentive to trade at their unit cost, and that in non-monopolistic markets the introduction of quotas mitigates such incentive.

Hypothesis 2. The fraction of zero-profit trades is higher for sellers under both Perfect Competition and Cartel than under Monopoly. The introduction of quotas mitigates these two positive differences.

Third, we want to check that equilibrium prices under each market are in line with our predictions, summarized in the second column of Table 3. If so, we ought to observe *weak monotonicity* of average trading prices moving from Perfect Competition to Cartel and from Cartel to Monopoly, with the introduction of quotas smoothing these two increases.

Hypothesis 3. Average trading prices increase or do not decrease by going from Perfect Competition to Monopoly, formally:

$$p_{Co} \leq p_{Co-q} \leq p_{Ca} \leq p_{Ca-q} \leq p_{Mo} \tag{1}$$

In the next section, we focus on the effects of the order of presentation of the five market structures on monopolists' power in the within-subject design of Table 2.

3.2 The effect of price anchoring on monopolists' power

Here we introduce a model that links prices emerged in non-monopolistic market structures with prices emerging in later implemented monopolistic markets. In fact, as reported in Table 2, Monopoly has been implemented in 4 treatments as first market, in other 4 treatments as third market, and in the remaining 4 treatments as fifth market. In the latter two groups of treatments, sellers' behavior in their own monopolistic market may be influenced by inter-seller competition in previously-implemented non-monopolistic markets.[7]

To model this impact, we rely on the psychological literature of cognitive biases (see Kahneman et al. [1982] and follow-up studies) and, in particular, on the role of anchors in negotiations. Tversky and Kahneman [1992] have shown that when negotiating about an object, a deliberate reference point can strongly affect the range of possible offers and counteroffers. Indeed, in the negotiation process, anchoring serves to determine a commonly accepted starting point for the subsequent negotiations. As soon as one side of negotiators states their first price offer, the (subjective) anchor is set. In this regard, several experimental studies have proved that traders'

[7]Note that subjects were told from the very beginning of the experiment that they were going to play a sequence of five different market structures. With a finite horizon of five market structures (i.e., no uncertainty about the number of repetition) and a different market structure (i.e., a different repeated game) in each repetition, the Folk theorem for infinitely repeated games does not apply.

initial offers have a stronger influence on the outcome of negotiations than subsequent counteroffers (see, e.g., Kristensen and GaÌrling [1997]). This way, the process of offer and counteroffer leads to mutually beneficial agreements distorted toward the first anchor. Attanasi et al. [2016, 2020] show that this anchoring effect especially holds under double-auction mechanisms within the same market structure – perfect competition – repeatedly played for at least three periods.

Building on this literature, we propose a model of price anchoring where the formation of reference prices which emerged in previously-implemented non-monopolistic markets influences sellers' perceived power – and thus how much tough they can act toward buyers – in later implemented monopolies. This model is based on three assumptions.

First of all, the theoretical analysis of Section 3.1 has shown that the equilibrium price in each of the four non-monopolistic market structures is lower than the average equilibrium price in monopoly with price discrimination. Therefore, rewriting Eq. (1), we assume that, if any, the effect of price anchoring on prices emerging in later implemented monopolistic markets is negative, i.e., it ultimately decreases the average price under Monopoly:

$$p_{Mo} > \max\{p_{Co}, p_{Co-q}, p_{Ca}, p_{Ca-q}\} \tag{2}$$

Second, in line with Attanasi et al. [2013], we assume that agents are heterogeneous in their bargaining toughness in negotiations. By moral balancing theory (Nisan and Horenczyk [1990]), individuals keep account of their self-image over time. Therefore, a seller asking for higher trading prices when acting as a monopolist should also display a similar bargaining toughness when competing with other sellers. With this, we expect that the average trading price a seller is able to rip under monopoly correlates with the one he is able to rip in each of the four non-monopolistic market structures. Eq. (3) models this correlation. We denote with p_{Mo} the trading price under Monopoly. With $p_{No\text{-}Mo}$ we indicate the trading price in the four *No*n-*Mo*nopolistic markets, with $No\text{-}Mo \in \{Co, Ca, Co\text{-}q, Ca\text{-}q\}$. p_{max} represents the highest trading price a seller is able to rip which is equal to the highest buyer's valuation $v_5 = 20$ regardless of the market structure. Eq. (3) represents the average trading price a seller is able to rip under Monopoly as a convex linear combination between the average trading price he is able to rip in any of the four non-monopolistic markets and the highest possible trading price. The weight $\sigma \in [0, 1]$ also represents the correlation between p_{Mo} and $p_{No\text{-}Mo}$, i.e., the seller's keeping of his self-image of bargaining toughness across market structures.

$$p_{Mo} = \sigma \cdot p_{No\text{-}Mo} + (1 - \sigma) \cdot p_{max} \tag{3}$$

Note that σ in Eq. (3) is independent from the order of presentation of market structures in the 12 treatments of Table 2. Indeed, our third assumption models the effect of order of presentation of market structures. In line with the literature on price anchoring at the beginning of this section, we assume that in each treatment of Table 2 it is the first implemented market structure that acts as anchor on the next four market structures of the timeline. In fact, when making decisions, anchoring is a cognitive bias accounting for the human tendency to rely too heavily on the first piece of information offered (the "anchor"). This initial piece of information biases decision makers' expectations subconsciously. In our design the initial piece of information is represented by (publicly disclosed) trading prices in the three periods of the first implemented market.

This third assumption extends Eq. (3) by providing our model of price anchoring in Eq. (4):

$$p_{Mo} = (\sigma + \mathbb{1}_{\mathbb{A}} \cdot a) \cdot p_{No\text{-}Mo} + (1 - \sigma - \mathbb{1}_{\mathbb{A}} \cdot a) \cdot p_{max} \tag{4}$$

with $a \in [0, 1-\sigma]$ and indicator function $\mathbb{1}_{\mathbb{A}}$ being equal to 0 in treatments 5, 6, 11, and 12 of Table 2 (where Monopoly is played as first market), and equal to 1 in the remaining eight treatments.[8] In the latter treatments, parameter a accounts for the boosting of the weight of $p_{No\text{-}Mo}$ on p_{Mo}. In that case, the average trading price a seller obtains in the non-monopolistic market implemented at the beginning of the treatment anchors the average trading price he can obtain under Monopoly and by Eq. (2) lowers it.

We elaborate two experimental hypotheses in the light of our model of anchoring of Eq. (4). The first hypothesis focuses on monopolistic prices, and especially whether a seller's monopolistic power is affected by the order through which the market has been implemented.

Hypothesis 4. Monopoly power endures anchoring effect: prices observed under Monopoly in treatments where this is implemented as first market are higher than those observed in treatments where Monopoly is implemented after non-monopolistic markets.

It remains an empirical exploratory question to understand whether the later the implementation of Monopoly in the timeline of Table 2, the more pervasive is the anchoring effect of the first competitive market index. Intuitive reasoning would suggest that a longer history of competition should lead to a stronger anchor on future behavior in monopolistic settings. However, lacking extant experimental and empirical evidence on this issue, our model of Eq. (4) is deliberately silent as for the comparison between treatments 1-2, between treatments 3-4, between treatments 7-8, and between treatments 9-10. In each of these pairwise comparisons, Monopoly is implemented as either third or fifth market structure, with the first implemented (non-monopolistic) market being held constant.

The second hypothesis coming from Eq. (4) concerns the ability of monopolists to price-discriminate depending on the order of presentation of this market in the treatment timeline.

Hypothesis 5. Monopolists are able to price-discriminate only when the Monopoly is played as first.

[8] In particular, it is *No-Mo*=*Co* in treatments 1-2, *No-Mo*=*Ca* in treatments 3-4, *No-Mo*=*Co-q* in treatments 7-8, and *No-Mo*=*Ca-q* in treatments 9-10. In the four treatments where Monopoly is played as first market, we consider as reference non-monopolistic market for Eq.(4) either the third one or the last one in the sequence of Table 2, depending on the treatment comparisons, as it will become clear in the data analysis of Section 4 (see, e.g., Table 9).

Differently from Hypothesis 4, in our Hypothesis 5 we focus on the dispersion of price distributions. A more disperse distribution of prices is indicative of higher price discrimination under Monopoly. Recall that the predicted behaviour in the four non-competitive markets leads to convergence to a unique price (see Section 3.1). In this regard, the anchor to previously-implemented non-monopolistic markets is represented by a significantly lower price dispersion.

4 Results

In order to test our predictions, we present the results in two steps. We first study sellers' market-dependent behavior, in line with what discussed in Section 3.1 (Hypothesis 1 through Hypothesis 3). Secondly, we analyze the effect of price anchoring on monopolists' power, as discussed in Section 3.2, by comparing prices prevailing under Monopoly when this market is played after Perfect Competition, Cartel or both (Hypothesis 4 and Hypothesis 5).[9]

Hypothesis 1. Price-quantity relation. We begin by testing whether average trading prices in monopolistic markets decrease with the monopolist's traded quantity. To do so, we aggregate our data from monopolistic markets, irrespective of their implementation order, and estimate the correlation between prices and quantities. Our data reports a strong negative relation between these two variables (Spearman's $\rho = -0.54$, *p-value* < 0.001). We then extend the same test on the remaining markets. In both Perfect Competition and Cartel markets we find strong evidence of a negative relation (under Perfect Competition: $\rho = -0.10$, *p-value* $= 0.04$; under Cartel: $\rho = -0.11$, *p-value* $= 0.02$). When focusing on markets with quotas, we find that their introduction mitigates the negative relation both under Perfect Competition ($\rho = -0.02$, *p-value* $= 0.74$) and under Cartel ($\rho = -0.09$, *p-value* $= 0.08$). Therefore, our data provides evidence in support of Hypothesis 1. Trading prices are negatively correlated with traded quantity across all markets, and the introduction of quotas mitigates such a relation.

Hypothesis 2. Zero-profit trades. We now test whether zero-profit trades are more likely under both perfectly competitive and cartel markets than monopolistic market structures. We compare the proportions of trades closed at a price of 12 across market structures. Our data show that zero-profit trades are more likely under Perfect Competition (proportion test on difference $\pi_{Co} - \pi_{Mo} = 0.14$, *p-value* $<$ 0.001) and Cartel ($\pi_{Ca} - \pi_{Mo} = 0.09$, *p-value* < 0.001) than under Monopoly. Furthermore, zero-profit trades are still more likely under both Perfect Competition and Cartel markets even upon the introduction of quotas. Yet, as predicted, the difference relative to Monopoly becomes smaller ($\pi_{Co-q} - \pi_{Mo} = 0.02$, *p-value* $= 0.02$; $\pi_{Ca-q} - \pi_{Mo} = 0.02$, *p-value* $= 0.02$). Therefore, we can conclude that Hypothesis 2 is essentially verified.

Hypothesis 3. Weak monotonicity of prices. To test the monotonicity of prices according to Hypothesis 3, we consider prices of market structures played as

[9] Raw experimental data and all the statistical codes are available from the authors upon request.

first in the treatment timeline of Table 2. For example, we gather prices of perfectly competitive markets from each sequence starting with Perfect Competition (CoCaMo, CoMoCa, CoCaMo-q, and CoMoCa-q) and once this is done for each market structure, we test inequalities between market structures. Table 4 presents the summary statistics of trading prices observed in each of the five market structures played as first in the experiment. Figure 1 shows corresponding price distributions broken down by trading periods. Given that no significant difference is found between Comp and Comp-q (t-test, $p\text{-}value = 0.588$) and between Cartel and Cartel-q (t-test, $p\text{-}value = 0.942$), Figure 1 only shows the distribution of trading prices for the three market structures without quotas: Comp, Cartel and Monopoly. Trading prices under Perfect Competition are in line with the theoretical prediction (Figure 1, panel Comp): they are, on average, slightly above the prediction $p^*_{Co} = 13$, and converge to predicted equilibrium level as market interactions approach to the last trading period (see Table B.1 in Appendix B).

The average trading price under Monopoly is lower than the one predicted by the theory in the case of price discrimination (null hypothesis: $p^*_{Mo} = 16$, t-test, $p\text{-}value < 0.01$). This result strengthens the evidence of Double Auction as a trading institution able to control over monopoly power (Smith and Williams [1989]). Furthermore, the average monopolistic price is lower than predicted since the very first period (Figure 1, panel Monopoly), and then slightly declines, although not significantly, in trading periods 2-3 (Table B.1; $p_{Mo|t=1} = 14.81$, $p_{Mo|t=3} = 14.50$).

By looking at Figure 1 (panel Cartel), it is straightforward to see how the average Cartel price in period 1 is closer to the theoretical prediction of maintained Cartel agreement ($p_{Ca|t=1} = 15.42$). It then shifts towards the equilibrium price of perfect competition in subsequent periods, especially in period 3 ($p_{Ca|t=3} = 13.56$). In line with our predictions, it thus emerges that although sellers reach a mutual agreement on a (higher) trading price in the first trading period, they are not able to maintain it across periods (Huck et al. [2001]).

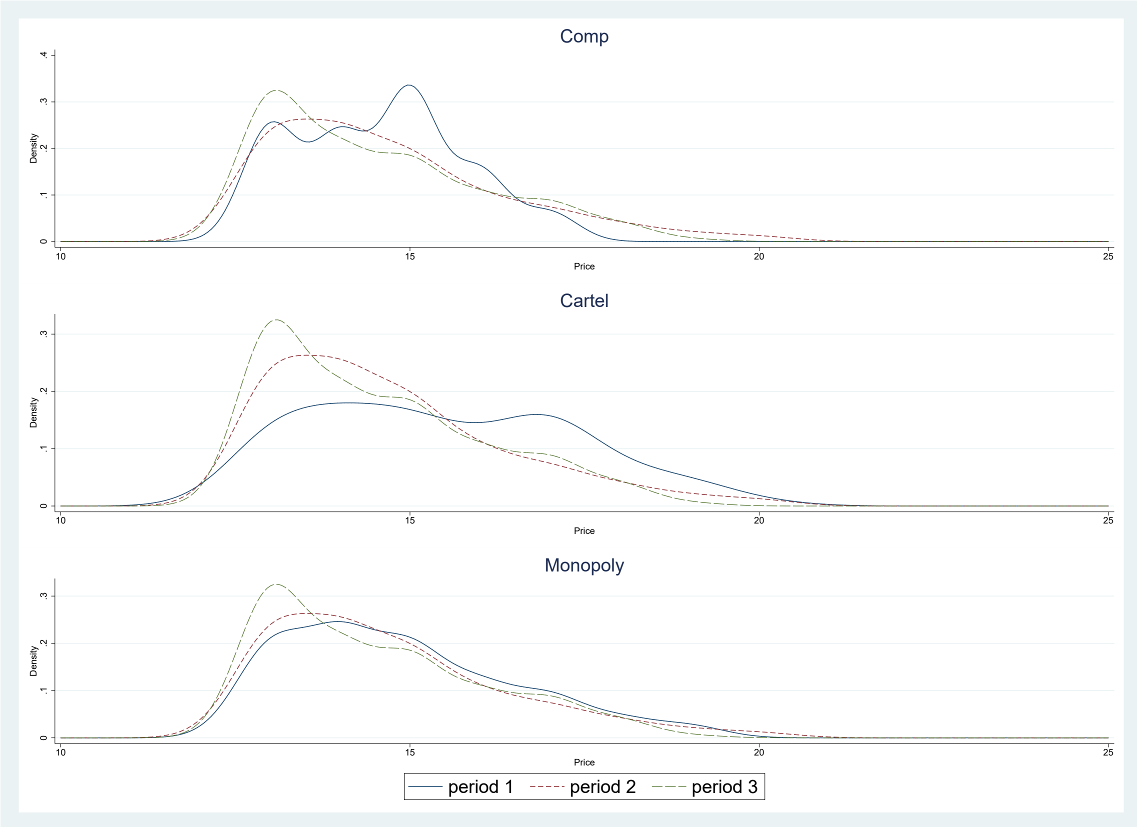
Table 4: Summary statistics of trading prices for market structures played as first (pooled across the three trading periods)

	p_{Co}	p_{Co-q}	p_{Ca}	p_{Ca-q}	p_{Mo}
Mean	14.00	13.81	14.36	14.32	14.63
Max	20	18	20	19	20
Min	12	12	12	12	12
St. dev.	1.28	1.09	1.65	1.24	1.70
N (trades).	275	284	277	261	444

To provide further evidence of price monotonicity, we pool observations of the three trading periods within each market structure played as first in the treatment timeline of Table 2. Table 5 displays the results of clustered-error regression models that test the difference between the average trading price obtained in two different markets when they are played as first in the experiment.[10] These statistics confirm the non-binding nature of the sellers' agreement in the Cartel, since prices observed

[10] This is equivalent to performing a simple t-test but we opt for running a regression model to account for the clustered structure of our data and correct standard errors accordingly. The model

Figure 1: Distribution of trading prices broken down by periods in Comp, Cartel and Monopoly when played as first



Note: Density distributions using kernel estimator.

in Perfect Competition and in Cartel are not significantly different. Furthermore, prices in all competitive markets (with or without quotas) are lower than prices observed under Monopoly. Finally, our data report no significant difference between Cartel markets (both with and without quotas) relative to Monopoly structures (Monopoly vs. Cartel, *p-value* = 0.186, and Monopoly vs. Cartel-q, *p-value* = 0.204). Yet, if we focus on period $t = 3$ only, the difference in prices $p_{Mo} - p_{Ca}$ is statistically significant (*p-value* < 0.001), as well as the difference $p_{Mo} - p_{Ca-q}$ (*p-value* < 0.001). These two differences are not significant in the first two trading periods. Thus, in line with our learning hypothesis, prices under Monopoly are higher than under any other market structure only when considering the last trading period.

To further investigate price differences across periods and shed light on learning effects, we run several regression models including all treatment dummies as well as period controls.[11] The results are reported in Table 6 and are consistent with the tests reported in Table 5. We regress the observed trading prices on market structure

regresses the prices of the first market to a constant and a market dummy flagging the second market structure in a given comparison.

[11]Recall that sellers face the same marginal cost c (see Section 2.1). Thus, all sellers have the same reservation price, which is why we do not include it in the regression models as a control.

Table 5: t-test of equality of trading prices in markets played as first, using a clustered-error regression model

H_0	β	P-value	Result
$p_{Mo} = p_{Ca-q}$	-0.31	0.204	Not-Rejected
$p_{Mo} = p_{Ca}$	-0.30	0.186	Not-Rejected
$p_{Mo} = p_{Co-q}$	-0.81	0.006	Rejected
$p_{Mo} = p_{Co}$	-0.62	0.032	Rejected
$p_{Ca-q} = p_{Ca}$	0.01	0.942	Not-Rejected
$p_{Ca-q} = p_{Co-q}$	-0.50	0.126	Not-Rejected
$p_{Ca-q} = p_{Co}$	-0.31	0.322	Not-Rejected
$p_{Ca} = p_{Co-q}$	-0.52	0.094	Rejected
$p_{Ca} = p_{Co}$	-0.33	0.267	Not-Rejected
$p_{Co-q} = p_{Co}$	0.19	0.588	Not-Rejected

Note: Subscript of p specifies the market considered. Column β reports estimates associated with the market dummy capturing the difference between the two considered markets.

fixed effects, considering Monopoly as a benchmark.[12] Coefficients of all fixed effects associated with perfectly competitive markets (Co and Co-q) in Model 1 are negative and significant at any conventional level. Prices under Perfect Competition are on average lower than under Monopoly of about -0.628 (*p-value* < 0.05). Similar results are reported when comparing with-quota competitive markets to Monopoly (-0.818, *p-value* < 0.01). While in Cartel markets (both with and without quotas) average prices are on average lower than those prevailing under Monopoly, these differences are not significant, consistently to what reported above in Table 4 (-0.296, *p-value* $= 0.184$ for Cartel; -0.313, *p-value* $= 0.202$ for Cartel with quotas). Furthermore, we control for possible trends along the three trading periods, by including the variable *Period* (Model 2). Such a variable controls for possible trends throughout trading periods 1 to 3 of each market. As a result, the differences between Monopoly and all perfectly competitive market structures yet remain significant upon the inclusion of such trend control. Lastly, consistently with what discussed at the beginning of this section, overall prices decrease over periods as tradings unravel (estimates associated with *Period* equal to -0.454, *p-value* $< .001$). As a confirm, when analyzing prices separately in each period, we find that all market structures display similar prices in the first period (Model 3) with the exception of Perfect Competition with quotas (prices lower on average of about -0.695, *p-value* < 0.05). However, as market tradings unfold, the price difference between Monopoly and any other market widens (Models 4-5), becoming highly significant in the last period (magnitude ranging from -0.734 to -0.998). Finally, we report no significant evidence of difference between estimates associated with Cartel (*Ca, Ca-q*) and Perfect Competition (*Co, Co-q*) in Model 5 as well as in the other models.[13]

[12] To better account for the hierarchical nature of the data, as recommended by Moffatt [2015], we run both clustered-error models and mixed-effects models, obtaining similar results. For consistency reasons, we report the former in Table 6, and the latter in Table B.2 of Appendix B.

[13] Tests on parameters equality display all p-values being higher than any conventional level. Results are available upon request.

Table 6: Regression models of all market prices

	(1) Price	(2) Price	(3) Price$\|t$=1	(4) Price$\|t$=2	(5) Price$\|t$=3
Co	-0.628*	-0.632*	-0.317	-0.505	-0.998***
	(-2.21)	(-2.18)	(-0.96)	(-1.32)	(-3.96)
Co-q	-0.818**	-0.850**	-0.695*	-0.830*	-0.961**
	(-2.87)	(-2.98)	(-2.32)	(-2.38)	(-3.26)
Ca	-0.296	-0.320	0.616	-0.529*	-0.945***
	(-1.34)	(-1.42)	(1.76)	(-2.22)	(-4.70)
Ca-q	-0.313	-0.326	0.164	-0.318	-0.734***
	(-1.29)	(-1.31)	(0.49)	(-0.95)	(-3.73)
Period		-0.454***			
		(-7.46)			
Constant	14.63***	15.57***	14.81***	14.61***	14.50***
	(89.00)	(71.47)	(73.32)	(76.16)	(87.80)
N (trades)	1542	1542	478	516	548

Notes: t-test in parentheses. OLS model with clustered errors.
* $p-value < 0.05$, ** $p-value < 0.01$, *** $p-value < 0.001$

In line with subjects' learning toward the equilibrium, it follows that, when looking at prices prevailing in the last trading period, our results provide evidence in support of Hypothesis 3 of weak monotonicity:

$$p_{Co} = p_{Co-q} = p_{Ca} = p_{Ca-q} < p_{Mo} \tag{5}$$

Further evidence supporting our learning approach is shown in Table B.3 of Appendix B, reporting the results on intramarginal inefficiency across markets. In fact, the fraction of sellers and buyers not trading in a given period both decrease as periods unfold, in all markets but Perfect Competition. Intramarginal inefficiency decreases from period 1 to period 3 when pooling all market structures, both in terms of sellers not trading and in terms of buyers not trading within a period (for sellers: 4.31% vs. 2.64% in periods 1 vs. 3, yet the difference between the two negligible fractions is not significant, *p-value*=0.24; for buyers: 24.75% vs. 22.06% in periods 1 vs. 3, *p-value*= 0.079; Wilcoxon-signed rank test). These results highlight the learning and efficiency properties of the double-auction trading mechanism.

Hypothesis 4. Anchoring effect on Monopoly – Spillovers of previous markets on Monopoly. We now pass on investigating whether monopolistic prices are affected by the formation of reference prices in previously-implemented market structures. To do so, we provide evidence of anchoring effects at both market and individual level.

The market-level analysis compares prices from all Monopolies played in the first position (MoCoCa, MoCaCo, MoCoCa-q, and MoCaCo-q) to those played in the middle (CoMoCa, CaMoCo, CoMoCa-q, and CaMoCo-q) or at the end (CoCaMo, CaCoMo, CoCaMo-q, and CaCoMo-q) of the treatment timelines of Table 2. In Table 7, we present the results from pairwise comparisons of trading prices observed under Monopoly implemented as first to those implemented later in the treatment timeline. Results in Table 7 show that monopolistic prices are significantly lower when the Monopoly is implemented after more competitive market structures (either Perfect Competition or Cartel). Additionally, we observe that starting the experiment with Perfect Competition or with Cartel does not produce the same spillover effect on trading prices in a later played Monopoly. Indeed, if agents start trading under Perfect Competition, prices in Monopoly structures implemented in the middle of the sequence are significantly lower than those prevailing in the case of Cartel implemented as first structure (t-test between p_{CoMo} and p_{CaMo}, *p-value* < 0.01).

Table 7: t-test on Monopoly played as first vs. after other market structures, using a clustered-robust error regression model.

H_0	β	P-value	Result
$p_{Mo} = p_{CoMo}$	-0.94	0.003	Rejected
$p_{Mo} = p_{CaMo}$	-0.77	0.013	Rejected
$p_{Mo} = p_{CoCaMo}$	-0.65	0.032	Rejected
$p_{Mo} = p_{CaCoMo}$	-0.81	0.014	Rejected

Note: p_{Mo} refers to trading prices of Monopoly played as first in the timeline of a treatment. p_{CoMo} (resp., p_{CaMo}) refers to trading prices of Monopoly played in the middle of a treatment, after Perfect Competition (resp., Cartel). p_{CoCaMo} (resp., p_{CaCoMo}) represents the trading prices of Monopoly played at the end of a treatment, after Perfect Competition and Cartel (resp., Cartel and Perfect Competition). Column β reports the estimates from our clustered-error regression models associated with the dummy variable flagging the Monopoly played after some other structure(s). We merged data from market structures with and without quotas since the effect on later played Monopoly is the same and structures with and without quotas do not differ in prevailing prices.

Table 8 reports the results of regression models on trading prices under Monopoly, varying for the order of implementation and for the type of this order (i.e., after Competition or after Cartel, if Monopoly is played in the middle of the treatment; after Competition and then Cartel or after Cartel and then Competition, if it is played at the end of the treatment timeline of Table 2).[14] We consider four dummy variables, i.e., one for each of these order-type combinations of implementation, and Monopoly played as first market is the reference for comparisons. Models 1-2 clearly report that monopolistic prices endure the effect of previously-played market structures, irrespective of the inclusion of *Period* to control for time trends. When comparing anchoring effects, the highest negative impact on monopolistic prices is found when Monopoly is played in the middle of the treatment after Perfect Competition (trading prices are lower of more than 0.94 points). A lower but still significant negative effect is found when Monopoly is played in the middle of the treatment after Cartel (trading prices are lower of about 0.78 points). However, we report no significant difference between the effect of these two markets (Model

[14]We report in Table B.4 of Appendix B the results from the corresponding mixed-effects models.

Table 8: Regression models of Monopoly prices after other market structures

	(1) *Mo* Price	(2) *Mo* Price	(3) *Mo* Price$\|t=1$	(4) *Mo* Price$\|t=2$	(5) *Mo* Price$\|t=3$
Co	-0.938***	-0.949***	-1.136***	-0.782**	-0.927***
	(-4.80)	(-4.83)	(-4.81)	(-3.05)	(-4.21)
Ca	-0.772***	-0.781***	-0.650*	-0.725**	-0.955***
	(-3.73)	(-3.76)	(-2.46)	(-2.95)	(-4.71)
CoCa	-0.648**	-0.659**	-0.714**	-0.627*	-0.632**
	(-3.00)	(-3.04)	(-2.77)	(-2.27)	(-2.84)
CaCo	-0.812***	-0.821***	-0.650*	-0.906***	-0.901***
	(-3.85)	(-3.86)	(-2.36)	(-3.78)	(-4.07)
Period		-0.177***			
		(-4.40)			
Constant	14.63***	15.00***	14.81***	14.61***	14.50***
	(89.31)	(78.23)	(73.58)	(76.40)	(88.09)
N (trades)	1501	1501	478	495	528

Notes: t-test in parentheses. OLS model with clustered errors.
* *p-value* < 0.05, ** *p-value* < 0.01, *** *p-value* < 0.001

1, $Co = -0.938$ vs. $Ca = -0.772$, F-test of the difference, *p-value* = 0.317). When Monopoly is introduced at the end of the treatment, we find similar results irrespective of the market order that precedes it. Indeed, while variable *CaCo* has a higher negative effect relative to *CoCa* in all model specifications except Model 3, this difference is not statistically significant (lowest *p-value* = 0.206 in Model 1, F-test of the difference $CaCo = -0.901$ vs. $CoCa = -0.632$). Overall, Monopoly prices are lower when this is preceded by either competitive market structure (*Co* or *Ca* only) than when Monopoly is preceded by both (*CaCo* or *CoCa*). Yet, we find no significant result supporting this evidence (F-test of the difference between {*Ca*, *Co*} vs. {*CaCo*, *CoCa*}, *p-value* > 0.10 in all pairwise comparisons). All results remain unchanged when analysing the data disentangling by period (Models 3-5).

On top of providing market-level evidence showing how Monopoly power endures the effect of price anchoring due to previously-implemented market structures, we now look closer at sellers' behavior at the individual level.

We start by investigating how prices have changed for given sellers when they play a Monopoly after a sequence of competitive or cartel market structures. To do so, we consider treatments of Table 2 where Monopoly is implemented as third or fifth market. For example, in *CoMoCa*, subjects have played first two competitive markets (without and with quotas) and then played under Monopoly before ending the session with two cartel markets. We call these sequences of markets as the *anchor-sequences*, including sequences where Monopoly is implemented as fifth market. Considering only these sequences, we calculate the difference in each seller's average price between firstly-implemented non-monopolistic markets and later-implemented

Monopoly (δ_a in Table 9). Consistently with our previous analyses (Table 8) and our theoretical framework (Section 3.2, Eq. (4)), we expect that sellers adjust Monopoly prices downwards after having experienced competitive market structures. The results reported in the left panels of Table 9 (column δ_a) show that individual price changes are even negative for most of the anchor-sequences, with monopolistic prices being often lower than prices prevailing in the first implemented market structure. Indeed, later implementation of Monopoly seems to make sellers lose their mark-up power entirely, irrespective of whether it is implemented as third structure in the sequence (Table 9, upper panel) or as fifth (Table 9, lower panel).

Obviously, not all the difference δ_a is due to the anchor effect a of Eq. (4), as it should be clear by comparing Eq. (4) with Eq. (3) of our model. To isolate the anchor effect from possible confounders (e.g., the correlation σ between non-monopolistic and monopolistic behavior at the seller's level), we construct a control difference that we compare with δ_a. In particular, we consider market sequences in which Monopoly is implemented as a first market structure (*control-sequences*, hereafter) and calculate the difference between the prices under Monopoly and under the market that comes later in the sequence (δ_c in Table 9). The results reported in the right panels of Table 9 (column δ_c) show that monopolistic prices are always higher than prices prevailing in later-implemented market structures, regardless of considering the third market structure (upper panel) or the fifth market structure (lower panel) in the treatment timeline.

We then match control-sequences with anchor-sequences such that the first and the third (resp., fifth) implemented markets are switched in the upper (resp., lower) panel of Table 9. For example, as Table 9 shows, we match CoMoCa with MoCoCa in the upper panel (Monopoly played as third structure), CoCaMo with MoCaCo in the lower panel (Monopoly played as fifth structure), etc. Notice that we use control-sequences as a counterfactual to test if there is a substantial difference relative to the associated anchor-sequence. This approach consists of a between-subjects comparison of within-subjects differences. Results in the last column of Table 9 (Δ_{a-c}) display a negative and significant difference between the two mark-up δ_a and δ_c in all of the eight pairwise comparisons. This evidence confirms that monopolistic prices are lowered when non-monopolistic markets are played before Monopoly, regardless of the type of these markets (Comp, Comp-q, Cartel, or Cartel-q).

Finally, we move to the study of sellers' toughness. As shown in Section 3.2, we derive a model of price anchoring in which the formation of reference prices in previous markets affects sellers' perceived power – i.e., their bargaining toughness (Kristensen and GaÌrling [1997], Attanasi et al. [2016]). By exploiting our within-subjects design, we perform a second kind of analysis to estimate an indicator of sellers' toughness as the weight in a convex combination of two other market prices, in line with the formalization of Eq. (3). Drawing on Eq. (4) and rearranging it, we can express a sellers' average trading price under Monopoly as a function his average trading price in non-monopolistic markets, depending on the sequence:

$$\begin{cases} \sigma + a = \dfrac{p_{max} - p_{Mo}}{p_{max} - p_{No\text{-}Mo}}, & \text{if anchor sequence} \\ \sigma = \dfrac{p_{max} - p_{Mo}}{p_{max} - p_{No\text{-}Mo},} & \text{if control sequence} \end{cases} \tag{6}$$

Table 9: Average price differences between consecutive markets.

Monopoly played as third structure				
Anchor	δ_a	*Control*	δ_c	Δ_{a-c}
CoMoCa	$p_{Mo} - p_{Co} = -0.20$	MoCoCa	$p_{Mo} - p_{Co} = 0.01$	-0.20^{+}
CoMoCa-q	$p_{Mo} - p_{Co-q} = 0.68$	MoCoCa-q	$p_{Mo} - p_{Co-q} = 2.51$	-1.94***
CaMoCo	$p_{Mo} - p_{Ca} = -0.18$	MoCaCo	$p_{Mo} - p_{Ca} = 1.76$	-1.94***
CaMoCo-q	$p_{Mo} - p_{Ca-q} = -0.95$	MoCaCo-q	$p_{Mo} - p_{Ca-q} = 0.87$	-1.82***

Monopoly played as fifth structure				
Anchor	δ_a	*Control*	δ_c	Δ_{a-c}
CoCaMo	$p_{Mo} - p_{Co} = -0.11$	MoCaCo	$p_{Mo} - p_{Co} = 2.23$	-2.34***
CoCaMo-q	$p_{Mo} - p_{Co-q} = 0.68$	MoCaCo-q	$p_{Mo} - p_{Co-q} = 1.81$	-1.13***
CaCoMo	$p_{Mo} - p_{Ca} = -0.21$	MoCoCa	$p_{Mo} - p_{Ca} = 0.22$	-0.43***
CaCoMo-q	$p_{Mo} - p_{Ca-q} = -0.60$	MoCoCa-q	$p_{Mo} - p_{Ca-q} = 2.21$	-2.81***

Notes: The difference $\Delta_{a-c} = \delta_a - \delta_c$. Mann-Whitney tests: $^{+}$ *p-value* < 0.10, * *p-value* < 0.05, ** *p-value* < 0.01, *** *p-value* < 0.001.

Based on this equation, we can calculate the values of $\sigma+a$ and σ algebraically by considering different sequences of market structures. For each seller, $\sigma+a$ is obtained from anchor-sequences (as in Table 9) as the ratio between the distances from the highest possible trading price p_{max} of the average trading price under Monopoly and the first-implemented market in the treatment. The same calculation is performed for σ in control sequences, by considering prices from both Monopoly and third- (or fifth-) implemented markets (as in Table 9). Table 10 reports the average values of our parameters of interest. Consistently with our previous analysis, we compare anchor-sequences with control-sequences and we test if the difference between $\sigma + a$ in anchor-sequences and σ in control-sequences is significantly greater than zero (using Mann-Whitney tests).

The results reported in Table 10 can be interpreted in a straightforward way. A value of $\sigma + a = 0.96$ (first row, first column of the upper panel) shows that, on average, sellers in the sequence CoMoCa heavily anchor to prices carried out in competitive markets when charging Monopoly prices later on in the sequence. A high value of σ (0.93) reflects a strong tendency of sellers to offer prices that are very similar to third- (or fifth-) implemented structures. The difference between these two estimates (i.e., $a = 0.03$), is a proxy of the extent to which Monopolists endures the anchoring effect. Results from our data support our hypothesis across all market sequences. Prices in later-implemented monopolistic structures strongly depend on sellers' toughness established in previously-implemented markets. Indeed, estimates of a are significantly positive in all of the eight pairwise comparisons. Sellers tend to anchor their offers to prices of deals carried out in previously-implemented markets ($p_{No\text{-}Mo}$ in Eq. 6). The value of a is lower than those obtained in the other market structures only in the case of the sequence CoMoCa. Yet, the estimate of a is significantly different from zero at a conventional significance level (10%).

Table 10: Estimates of σ and a using anchor and control sequences

Monopoly played as a third structure				
Anchor	CoMoCa	CoMoCa-q	CaMoCo	CaMoCo-q
$\sigma + a$	0.96	0.88	0.94	0.97
Control	MoCoCa	MoCoCa-q	MoCaCo	MoCaCo-q
σ	0.93	0.61	0.73	0.82
Difference (a)	0.03^{+}	0.27^{***}	0.21^{***}	0.15^{***}

Monopoly played as fifth structure				
Anchor	CoCaMo	CoCaMo-q	CaCoMo	CaCoMo-q
$\sigma + a$	0.91	0.88	0.93	0.98
Control	MoCoCa	MoCoCa-q	MoCaCo	MoCaCo-q
σ	0.69	0.73	0.92	0.65
Difference (a)	0.22^{***}	0.15^{***}	0.01^{*}	0.24^{***}

Note: Difference (a) reports the estimates of a and the results of a Mann-Whitney test; $^{+}$ *p-value* < 0.10 * *p-value* < 0.05, ** *p-value* < 0.01, *** *p-value* < 0.001

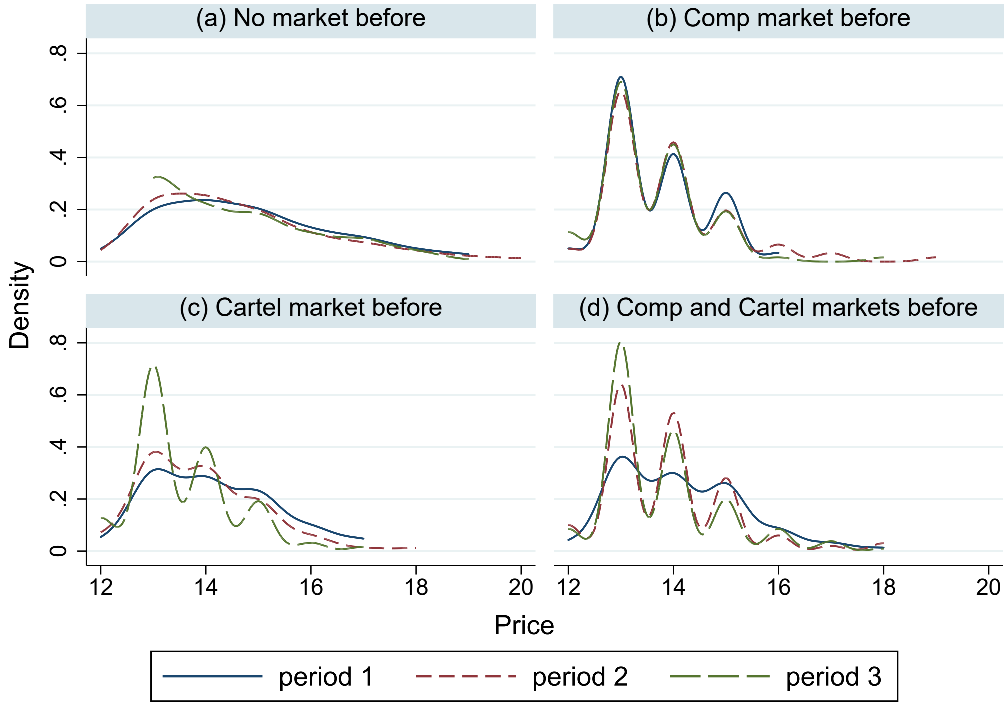
We find mixed evidence on the effect of a longer history of competition on the anchoring effect (a). The average estimate of a is the same between sequences in which Monopoly is implemented as third structure and those in which it is implemented as fifth one (0.16 vs. 0.15, *p-value*=0.88; Mann-Whitney test). We can finally conclude that our twofold evidence (at the market and seller level) supports Hypothesis 4, by suggesting that monopolists' power endures the negative effect of price anchoring formed in previous non-monopolistic market structures.

Hypothesis 5. Price discrimination in Monopoly. We finally focus on the ability of monopolists to discriminate among buyers with different maximum willingness to pay. Recall that in the test of Hypothesis 1 we find that, when Monopoly is played as first market structure in a treatment, monopolists set on average lower prices than those theoretically predicted in the case of price discrimination (see Table 3 and Figure 1). However, here we aim at studying differences in price dispersion under Monopoly according to the order-type combinations of its implementation in the treatment sequence.

Figure 2 depicts the distribution of monopolistic prices according to the fact that, in the treatment timeline of Table 2, Monopoly is introduced as first market (panel (a)), as third market after Perfect Competition (panel (b)), as third market after Cartel (panel (c)), or at the end of the sequence, after both these markets, independently of their order (panel (d)). Figure 2 shows that when Monopoly is played as first market, sellers are able to implement price discrimination among buyers. In fact, most of the prices $p > c = 12$ that could be afforded by the buyers given their budget constraint ($p \in \{13, 14, ..., 19\}$), are actually paid (see panel (a) of Figure 2).

When Monopoly is played after some other market structures, price discrimination becomes less obvious, especially in the second and third trading periods. That is, when buyers and sellers go through Perfect Competition, Cartel or both of them before being exposed to Monopoly, sellers – finally becoming monopolists – are much less able to exploit their market power.

Figure 2: Per-period density plots of Monopoly prices



In order to confirm these results, Table 11 reports price variances broken down by period and in each monopolistic structures differing in their order of implementation in a treatment. If price discrimination is favoured when Monopoly is played at the beginning of a treatment, we should observe a higher variance of monopolistic prices under this sequence than when Monopoly is later introduced.

Table 11: Differences of variances in Monopoly prices between monopolies implemented at the beginning of a treatment or later, varying previously-implemented markets

	Variance difference			
Price	$t = 1$	$t = 2$	$t = 3$	Overall
$\Delta(\sigma_{CoMo})$	1.96***	2.20***	1.43***	1.93***
$\Delta(\sigma_{CaMo})$	1.29***	2.27***	1.43***	1.60***
$\Delta(\sigma_{CoCaMo})$ and $\Delta(\sigma_{CaCoMo})$	1.30***	2.23***	1.16***	1.53***

Notes: Δ reports the difference between the variance of p_{Mo} and that of every other market price. Levene's test on the difference Δ. * *p-value* < 0.05, ** *p-value* < 0.01, *** *p-value* < 0.001

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Pairwise-parametric tests on the variance of monopolistic price distributions show that trading prices under Monopoly played as first market have higher variance than under Monopoly played after any possible sequence of other market structures. All Δ reported in Table 11 are positive and different from zero (Levene's test, *p-value* < 0.01 in every case). Similar results also hold when we compare monopolistic structures within each period: prices prevailing under Monopoly played as first market display higher variance than the prices observed in any other later implemented monopolistic structures for each of the three trading periods considered separately (pairwise Levene's test, *p-value* < 0.01 in all the cases).

5 Conclusions

In this paper, we analyze different market structures with few sellers and many buyers, under the same trading institution: double auction. The paper contributes to the literature on trading mechanisms in general, and double auction in particular, by incorporating behavioral aspects that are not accounted for in standard models and testing behavioral-theory driven predictions through a laboratory experiment. In this regard, our contribution is threefold.

First of all, we strengthen previous experimental evidence showing that double-auction trading mechanisms can recreate perfectly competitive environments (Smith and Williams [1989, 1981], Davis and Williams [1991]). Indeed, prices prevailing in our perfectly competitive markets converge towards predicted equilibrium levels, despite the fact that the fraction of buyers in the market is six times the fraction of sellers. Similarly, when cartel opportunities are open to sellers, they do not reach mutual agreement on prices, consistently with previous experimental literature (Huck et al. [2001]).

Second, while there is evidence in the extant experimental literature showing that double-auction trading mechanisms cannot control over monopoly power (Muller et al. [2002], Ledyard and Szakaly-Moore [1994], Brown-Kruse et al. [1995], Godby [2002]), we provide evidence showing that monopoly power can be significantly resized under double-auction institutions. In fact, trading prices under monopoly are significantly lower than those predicted by the theory: double-auction trading institutions succeed in preventing monopolists to fully extract buyers' maximum willingness to pay.

Our third and most important finding concerns spillovers of previous market trading on prices prevailing in monopolistic markets. Monopolists' power is sensitive to past trading experience and to the formation of reference prices in previous (more competitive) market structures. Market spillovers play a fundamental role in weakening monopolists' ability to price discriminate in our double-auction setting. In fact, when a monopolistic market is not preceded by any other market structure, price discrimination seems more effective. However, perfectly competitive markets, as well as cartel structures, reduce the possibility of price discrimination in later-played monopoly. In other words, prices formed under perfect competition or through non-binding cartel agreements permeate buyers and sellers' behavior in later-played monopolies, with the result being that monopolists are less likely to price discriminate.

Our research also contributes to the growing body of literature dealing with experimental methods by highlighting the relevance of order effects in experiments on trading mechanisms. Recall, however, that our findings rely on a series of classroom experiments without monetary rewards, as it is common practice when trying to replicate textbook and theoretical predictions (see, e.g., Holt [1996, 1999], and Finley et al. [2019]). Despite our experimental requirement for subjects to earn a positive profit for each traded unit, we acknowledge that designing an incentive-compatible experiment (e.g., by paying sellers and buyers according to their profits in the experiment) might mitigate or boost the impact of the order effects detected in our study. Indeed, this seems to be a quite intriguing issue. On the one hand, monetary incentives might lead sellers' behavior to better adhere to market rules, with monopolists extracting all buyers' surplus up to 1 point of profit left to each intramarginal buyer. This would happen despite sellers' perception of a reduced market power due to previous participation in more competitive markets. On the other side, the impact of order effects might be boosted by monetary incentives. In fact, due to role asymmetry, social preferences as inequity aversion might emerge, leading buyers to reject those monopolists' offers that leave buyers with only 1 point of profit, consistently with evidence from ultimatum games (see Güth et al. [1982], and a plethora of follow-up studies). More precisely, the more buyers learn that sellers trade at substantially lower prices under previous markets, the less willing they are to bear perfect discrimination under monopoly – which they (have learned to) perceive as unfair. Furthermore, the latter effect would depend on the specific payment rule implemented to introduce monetary incentives (see Cox et al. [2015] and Charness et al. [2016]). In fact, randomly paying only one market structure at the end of the experiment could eventually boost order effects when monopoly is played as last market. We leave for future research the issue on the interaction between order effects and monetary incentives in experiments on trading mechanisms.

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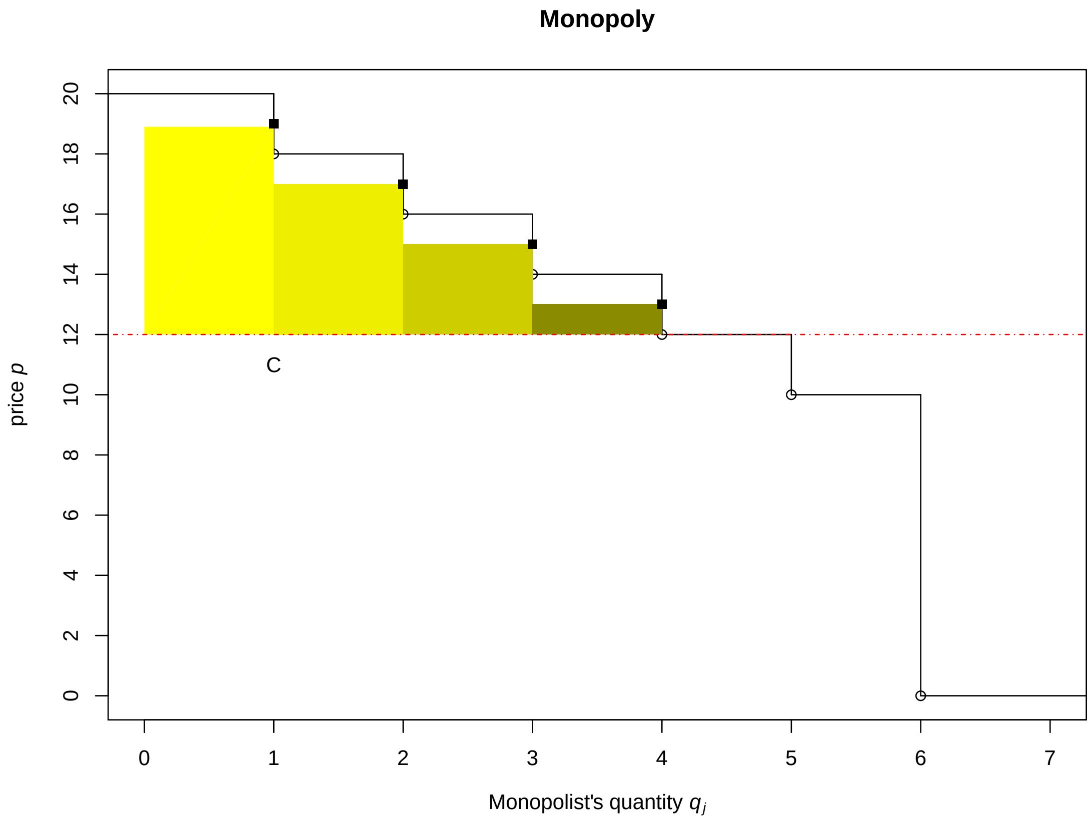
Appendix

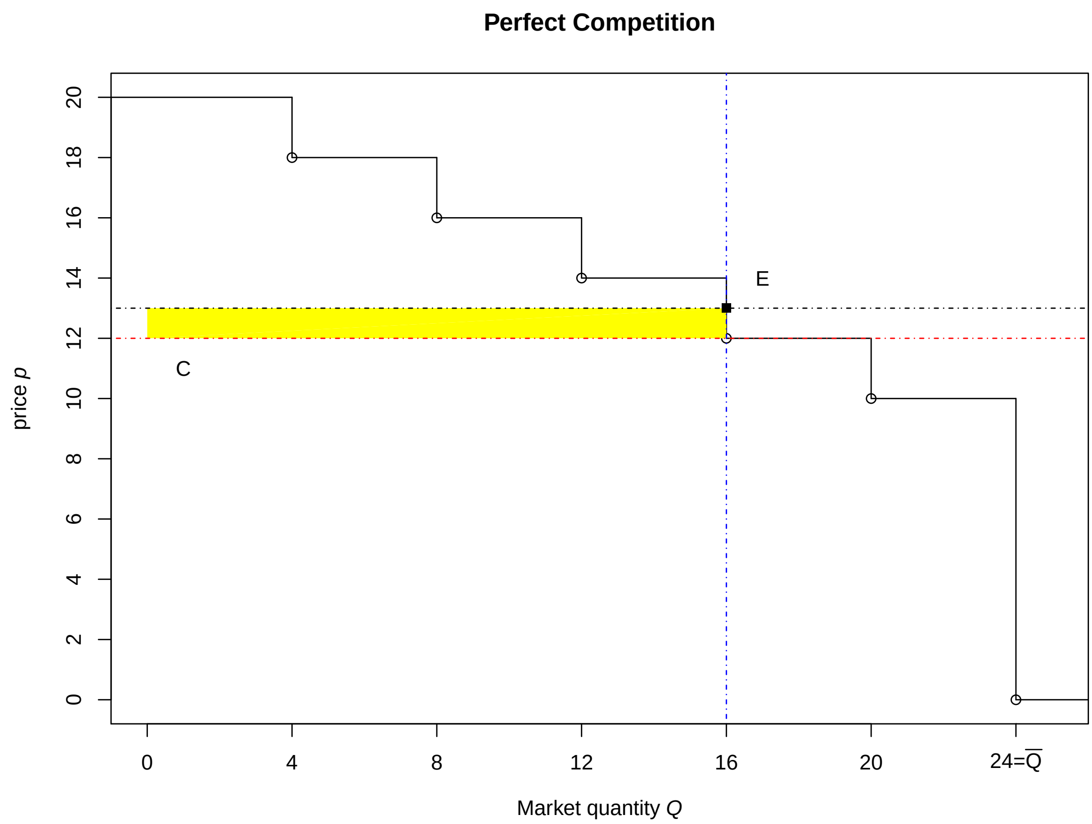
A Supplementary Figures

Figure A.1: Demand and Cost functions under Monopoly



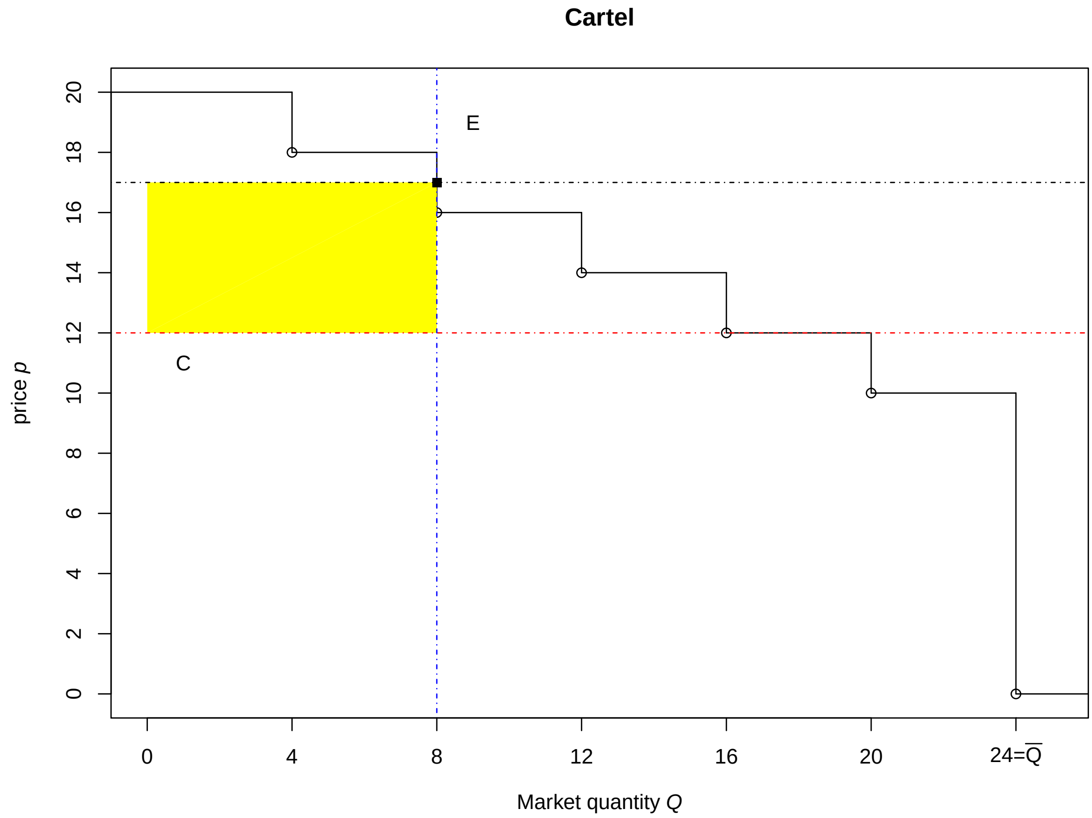
Note: the sum of colored areas represents monopolist j's surplus ($j = 1, 2, 3, 4$).

Figure A.2: Demand and Cost functions under Perfect Competition



Note: the yellow area represents the sellers' surplus.

Figure A.3: Demand and Cost functions under Cartel



Note: the yellow area represents the sellers' surplus.

Figure A.4: Example of a buyer's computer screen during the experiment.

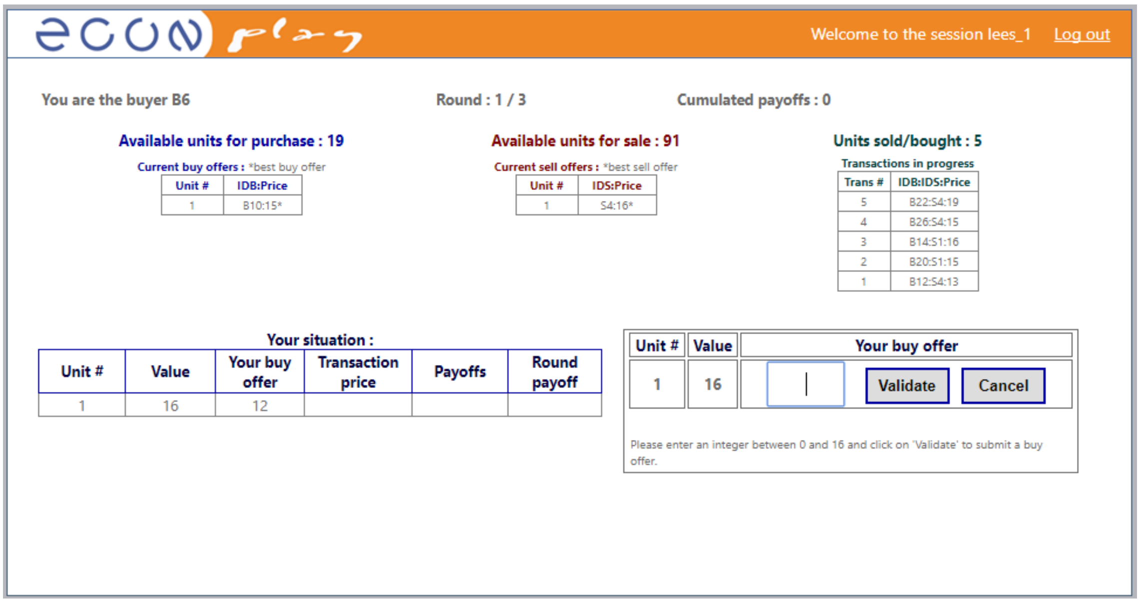
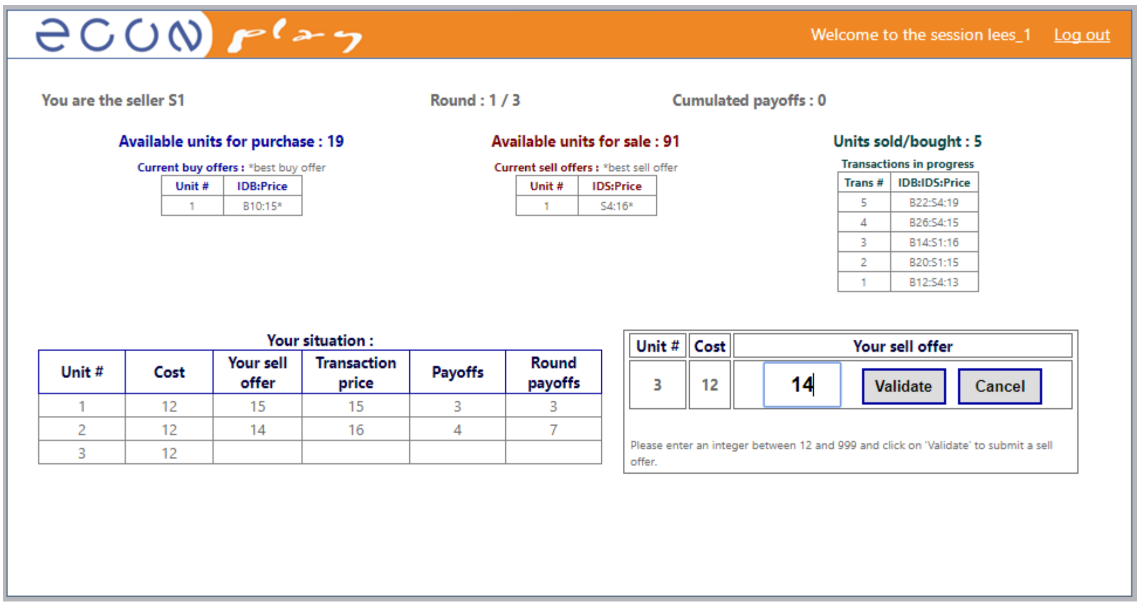


Figure A.5: Example of a seller's computer screen during the experiment.



B Supplementary Tables

Table B.1: Average trading prices for market structures played as first, disentangled by trading period $t = 1, 2, 3$

	p_{Co}	p_{Co-q}	p_{Ca}	p_{Ca-q}	p_{Mo}
$t = 1$	14.49	14.12	14.42	14.97	14.81
$t = 2$	14.10	13.78	14.08	14.30	14.61
$t = 3$	13.50	13.54	13.56	13.76	14.50

Table B.2: Mixed-effects regression of prices across markets

	(1) Price	(2) Price	(3) Price$\|t$=1	(4) Price$\|t$=2	(5) Price$\|t$=3
Comp	-0.742^{+}	-0.764^{+}	-0.379	-0.609	-1.121**
	(-1.71)	(-1.70)	(-0.90)	(-1.07)	(-2.88)
Comp-q	-0.945*	-0.990*	-0.797+	-0.886	-1.048**
	(-2.18)	(-2.21)	(-1.91)	(-1.56)	(-2.69)
Cartel	-0.410	-0.457	0.563	-0.619	-1.077**
	(-0.95)	(-1.02)	(1.34)	(-1.09)	(-2.76)
Cartel-q	-0.451	-0.478	0.105	-0.392	-0.865*
	(-1.04)	(-1.07)	(0.25)	(-0.69)	(-2.21)
Period		-0.474***			
		(-12.67)			
Constant	14.78***	15.78***	14.94***	14.70***	14.63***
	(94.52)	(88.95)	(83.67)	(70.31)	(99.76)
N (trades)	1542	1542	478	516	548

t-test in parentheses. Effects at the session, market and seller levels.

+ *p-value* < 0.10 * *p-value* < 0.05, ** *p-value* < 0.01, *** *p-value* < 0.001

Table B.3: Fractions of intramarginal sellers and buyers that do not trade, across markets

	Sellers			Buyers		
Market	$t = 1$	$t = 2$	$t = 3$	$t = 1$	$t = 2$	$t = 3$
Comp	4.17%	6.25%	5.56%	20.42%	20.00%	20.97%
Comp-q	2.78%	2.08%	1.39%	21.11%	23.61%	20.42%
Cartel	4.17%	9.03%	4.17%	22.08%	23.75%	20.00%
Cartel-q	8.33%	3.47%	1.39%	26.53%	26.39%	22.22%
Monopoly	2.08%	2.08%	0.69%	33.61%	31.25%	26.67%
Average	4.31%	4.58%	2.64%	24.75%	25.00%	22.06%

Table B.4: Mixed-effects regression models of Monopoly prices after other market structures

	(1)	(2)	(3)	(4)	(5)
	Mo Price	*Mo* Price	*Mo* Price$\|t$=1	*Mo* Price$\|t$=2	*Mo* Price$\|t$=3
Co	-1.000**	-1.016**	-1.269***	-0.856*	-0.961***
	(-3.26)	(-3.27)	(-4.07)	(-2.31)	(-3.34)
Ca	-0.896**	-0.911**	-0.758*	-0.791*	-1.038***
	(-2.92)	(-2.94)	(-2.45)	(-2.14)	(-3.62)
CoCa	-0.693*	-0.711*	-0.769*	-0.698	-0.639*
	(-2.25)	(-2.29)	(-2.46)	(-1.85)	(-2.21)
CaCo	-0.873**	-0.886**	-0.715*	-0.899*	-0.978***
	(-2.84)	(-2.85)	(-2.30)	(-2.43)	(-3.41)
Period		-0.201***			
		(-6.13)			
Constant	14.78***	15.21***	14.97***	14.71***	14.62***
	(82.90)	(78.85)	(80.90)	(67.96)	(87.35)
N (trades)	1501	1501	478	495	528

t-test in parentheses. Effects at the session, market and seller levels.

* *p-value* < 0.05, ** *p-value* < 0.01, *** *p-value* < 0.001

C Instructions

[*Treatment 1: CoCaMo (see Table 2)*]

The goal of this experiment is to make students familiarize with the concepts of monopoly and cartel.

General instructions The experiment consists of 5 consecutive sessions. In each of them, there are 4 sellers and 24 buyers of a fictitious good. At the beginning of the experiment the computer will inform you if you are assigned to the role of a seller or a buyer. Your role will remain the same throughout the whole experiment.

If you are a seller, you can make profits by selling a unit of the good to a buyer. On your screen, the cost of production of each unit of the good will be displayed. If you sell one unit of at a price P and the production cost of this unit is C, your profit for this unit will be equal to the difference P – C.

If you do not sell any unit of the good, your profit will be zero. You are not obliged to sell. For example, it can be that the price that has been proposed to you for a unit does not cover the production cost. In this case, you cannot sell that unit. The software allows you to sell the unit at your production cost. However, we require you to earn a positive profit for each sold unit.

If you are a buyer, you can buy a unit of the good from a seller. Your valuation for one unit of the good is indicated on your screen: it is the value that you attribute to a unit of the good. Therefore, if your valuation is V and you buy one unit at a price P, your profit will be V – P.

If you do not buy any unit of the good, your profit will be zero. You are not obliged to buy any unit. For example, if the selling price is higher than your valuation, you will not be able to buy the unit of the good. The software allows you to buy the unit at your valuation. However, we require you to earn a positive profit for each unit that you buy.

Each of the 5 sessions that follow consists of 3 trading periods.

Every trading period lasts 2 minutes (120 seconds). In each trading period:

- Each seller can sell several units of the good; each buyer can buy at maximum one unit of the good.
- The production cost is the same for each unit of the good across sellers; the value for each good unit can be different for each buyer.
- You can make offers, either to buy or sell, only using integer numbers within 0 and 30.

The unitary production cost for each seller does not change across trading periods, while the valuation for the same buyer changes across trading periods.

How to exchange: double auction During each trading period, you will have the possibility to submit an ask price (if you are a seller) or a bid (if you are a buyer) according to the same mechanism that we have explained to you during the first tutorial of the course (double auction).

The only difference relative to the first tutorial is that bids and ask prices will be made through a software installed in each of the 28 computers of the laboratory.

Now, we are going to illustrate how to use the software (Figure 1 for sellers and Figure 2 for buyers).

Session 1 (*Perfect Competition*)

There are 3 trading periods. In each period:

- Each of the 4 sellers can sell 24 units of the good, each unit has the same production cost which is the same for all the sellers.
- Each of the 24 buyers can buy at maximum one unit of the good, the buyers can have different values of the good.

The unit production cost does not change across periods but the buyerâs valuation of the good will change from one period to another.

Session 2 (*Perfect Competition with quotas*)

This session is the same as Session 1. The only difference is that, in each trading period:

- Each of the 4 sellers can sell at maximum 6 units of the good (each one having the same unitary production cost, which is the same for all sellers, similarly to Session 1)

Session 3 (*Illegal Cartel*)

This session is the same as Session 1 (each of the 4 sellers can sell 24 units of the good), with the only difference that, before the start of the session, the 4 sellers can agree upon the price to apply to all the units to sell in the subsequent trading periods of this session.

The agreement is implemented through the following rules (keeping anonymity among sellers):

- Each seller writes down on a paper the price that he/she would like to apply to all the units in the following three trading periods of this session.
- The experimenter collects each price proposal from each seller.
- The experimenter computes the average of the prices that the four sellers have indicated: such average price is the only one that the four sellers should offer in each trading period during this session.

The experimenter shows to each seller the price proposed by the other three sellers and the average price they should propose.

If they want, sellers can make offers that deviate from such average price. They are not obliged to respect the agreement.

Session 4 (*Illegal Cartel with quotas*)

This session is the same as Session 3. The only difference that, in each trading period:

- Each of the four sellers can sell at maximum 6 units of the good (each unit having the same unitary production cost, which is the same for all sellers, as in Session 1).

Session 5 (*Monopoly*)

In each of the three trading periods of this session, there are 4 similar markets, with only one seller and six buyers. The four markets are similar in the sense that, in each of them:

- The seller can sell six units of the good, each one having the same unitary cost of production, which is the same for all sellers.
- Each of the six buyers can buy at maximum one unit of the good. The buyerâs valuation of the good is different from that of the other buyers.
- The distribution of the valuations of the six buyers is the same among markets.