OBFUSCATION IN COMPETITIVE MARKETS (FEHR AND WU, 2021)

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Motivation Hypothesis
Methods Results
Discussion

OUR ROADMAP

MANY PRODUCTS ARE COMPLEX AND HARD TO EVALUATE, LIKELY DELIBERATELY SO

- Complex products and price schedules are prevalent in modern economies
  - E.g. printers being sold in complex bundles with differently priced add-ons like ink cartridges
  - E.g. electronic products with cheap base products with limited capacities, but many possible upgrades on memory, warranty etc.
- Product and price complexity makes it difficult to evaluate individual products or compare them across different sellers
- Firms appear to deliberately obfuscate the true values and prices of their products, shrouding them in additional complexity

HOW DOES OBFUSCATION AFFECT COMPETITIVE MARKETS?

- Do sellers always use available obfuscation opportunities, and why?
- How does obfuscation affect market prices, seller profit, consumer welfare?
- Can obfuscation allow sellers to persistently post prices above marginal cost in what would otherwise be perfectly competitive markets?
- What mechanisms enable positive seller profit and reduced buyer welfare?

THE LITERATURE IS MIXED ON THE IMPACT OF OBFUSCATION

- Vast theoretical literature suggests obfuscation reduces competition and allows sellers to earn higher profits (e.g. Gabaix and Laibson 2006; Carlin 2009)

- Empirical literature is mixed
  - Complexity and shrouded add-ons allow higher prices and mark-ups (e.g. Celerier and Vallee 2017; Seim, Vitorino and Muir 2017)
  - Shrouding does not improve, or perhaps reduces, firm revenues (Hossain and Morgan 2010) or decreases the seller's reputation (Chiles 2017)

- Empirical studies are difficult due to a lack of data, thus they run an experiment

NO OBFUSCATION MARKET SHOULD BE PERFECTLY COMPETITIVE

- Setup: Bertrand competition with non-differentiable goods and sellers that can each supply the entire market
- Prediction: sellers price their products at marginal cost and make zero economic profit, consumers capture any and all available surplus, law of one price holds
- Logic: if a seller prices above marginal cost their competitors will undercut them and supply the entire market
- Literature suggests at least 4 sellers needed to ensure this outcome, they use 6

OBFUSCATION MARKETS SHOULD NOT BE PERFECTLY COMPETITIVE

- Firms price add-ons monopolistically when buyer search costs are high and homogenous (Diamond 1971, Ellison and Wolitzky 2012), when buyers are price insensitive (Ellison 2005), or when buyers are myopic (Gabaix and Laibson 2006)

- Law of one price may be violated when consumers have heterogeneous search costs, where some are willing to search and thus some sellers undercut competitors on add-on pricing (Carlin 2009; Ellison and Wolitzky 2012; Chioveanu and Zhou 2013)
  - Final surplus depends on paramterisation / extent of competitive pressure

- Base prices will likely be more competitive than add-on pricing (Choi, Dai and Kim 2017)

- Buyers may be complexity averse (Carlin 2009; Chioveanu and Zhou 2013)

BASICS: MARKET FOR PHONE WITH REPEATED TRADING ROUNDS

- Each market has 6 sellers and 10 buyers (randomly assigned, all anonymous to one another) who engage in repeated trading rounds (10-20 rounds)
- Each seller produces the same phone with the same marginal cost (5), but they can create up to 6 add-on features with additional price and value to buyers
- Buyers have a random base value for the phone (0, 5, 10, 15 or 20) in each period, with each of the five values randomly assigned to two buyers
- Buyers only care about total value and features are all-or-nothing

BASICS: EACH TRADING ROUND HAS A SELLER, BUYER, FEEDBACK STAGE

- **Seller stage:** sellers choose number of features, base price, total value and price for all features (subject to rules), and the order in which features are visible

- **Buyer stage**: buyers are informed of their base value, incur a cost of 0.1 per second until they buy a product, and choose which product they want to buy
  - Buyers can only see base prices simultaneously, for features they need to look at each product one at a time. They had access to pen and paper.

- **Feedback stage**: sellers learn units sold, realised earnings, the other products offered in the market and summary statistics for the market. Buyers learn earnings and time cost

- No time limits

BASICS: 3X2 DESIGN WITH THREE ADD-ON COST TREATMENTS AND 2 MARKETS

Table 1: Treatments in the current experiment

	Market with obfuscation opportunities (OO market)	Market with no obfuscation (NO market)
Half Cost Treatment (HCT)	6 markets	6 markets
Convex Cost Treatment (CCT)	5 markets	5 markets
Surplus-Neutral Treatment (SNT)	6 markets	6 markets

OO MARKET: OBFUSCATION OPPORTUNITIES

- **Change in buyer stage:** when looking at add-on features buyers could only see one feature at a time
- They click on a product to see its first feature in isolation, click again for the second feature in isolation etc.
- Minimum of 2 seconds between clicks
- 20 trading rounds in total

Figure 1

Base Price:
20

Features:

Label	Value	Price
shipping:	7	4
display:	9	5
capacity:	3	6
camera:	3	3
warranty:	2	4

NO MARKET: NO OBFUSCATION OPPORTUNITIES

- **Change in buyer stage:** when looking at add-on features buyers were told the total value and total price of all features immediately
- Thus, only one click needed per product to understand its full value
- 10 trading rounds in total
- The same participants would participate in the OO and NO markets

Figure 1

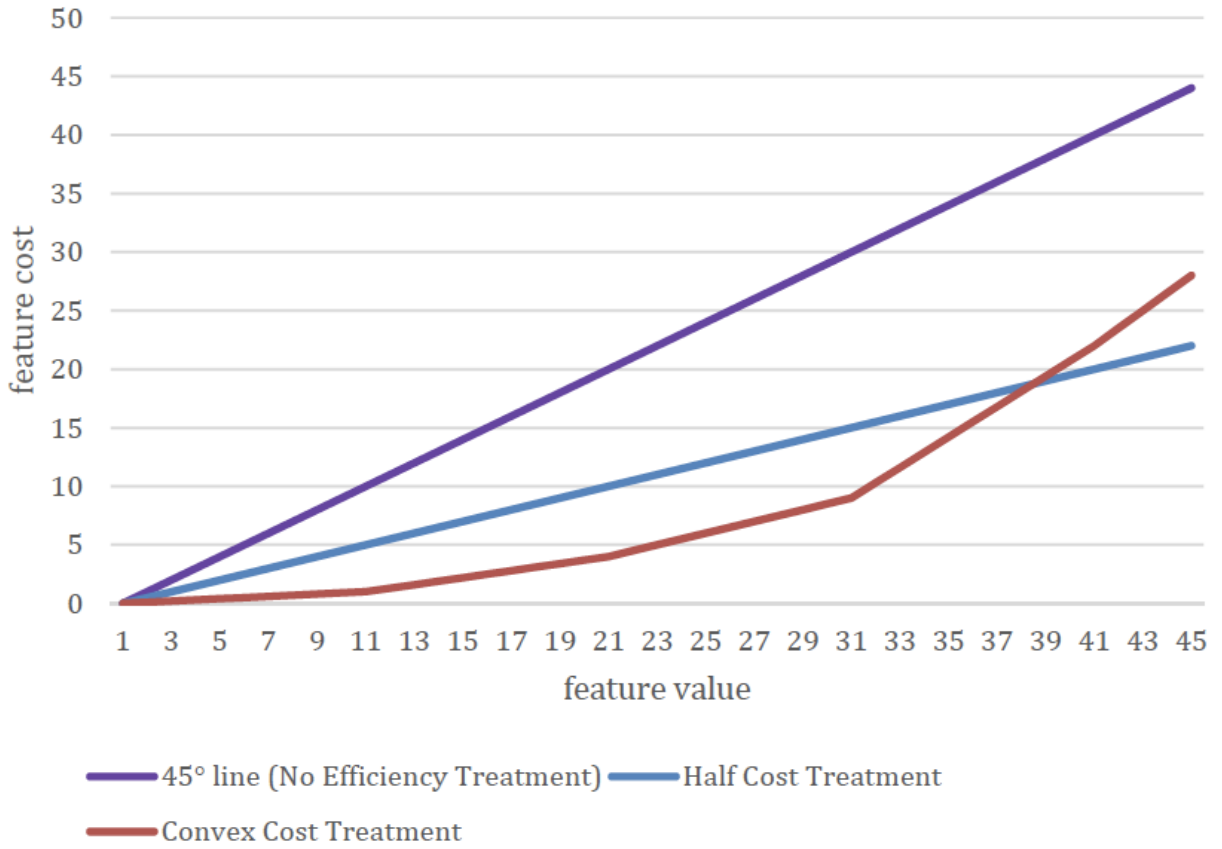
Base Price:
20

Features:

Label	Value	Price
shipping:	7	4
display:	9	5
capacity:	3	6
camera:	3	3
warranty:	2	4

THREE TREATMENTS: FEATURES ARE FULL COST, HALF COST, CONVEX COST

Figure 2: Feature cost as functions of feature value in the 3 between-subject treatments

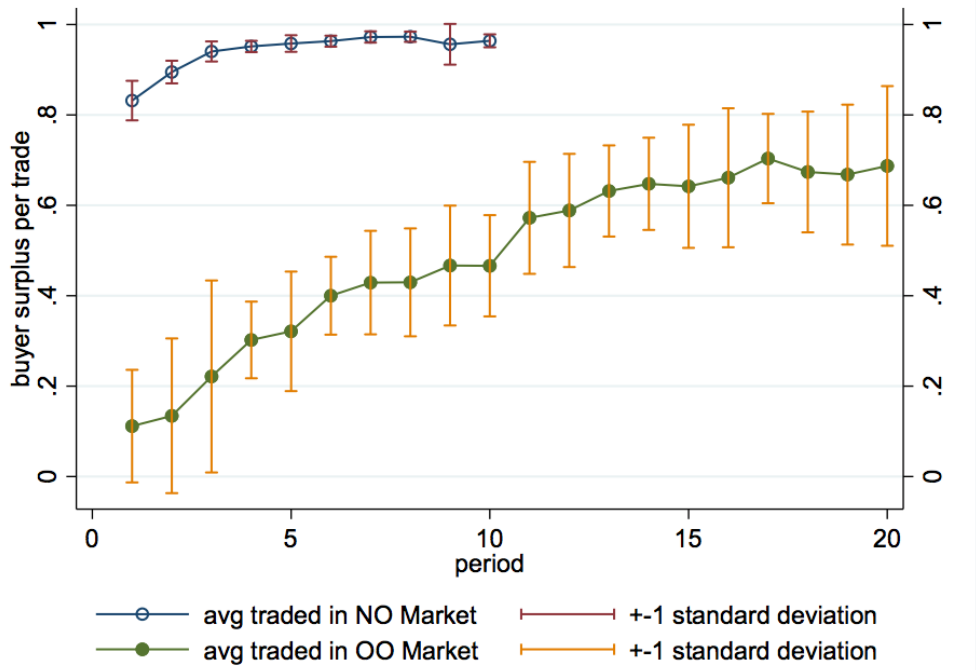


INCENTIVES AND PARTICIPANT DETAILS

- After 20 rounds of OO market buyers were asked for their belief on the average net feature value of products in the market
- Participants were rewarded for 10 random trading periods in the OO market, 5 random trading periods in the NO market, and (for buyers) if their belief was within 2 of the true net feature value
- 272 participants in total (mostly students), each session lasted ~2.5 hours, participants earned an average of 65 swiss francs

OBFUSCATION REDUCED LONG-RUN BUYER SURPLUS BY 1/3

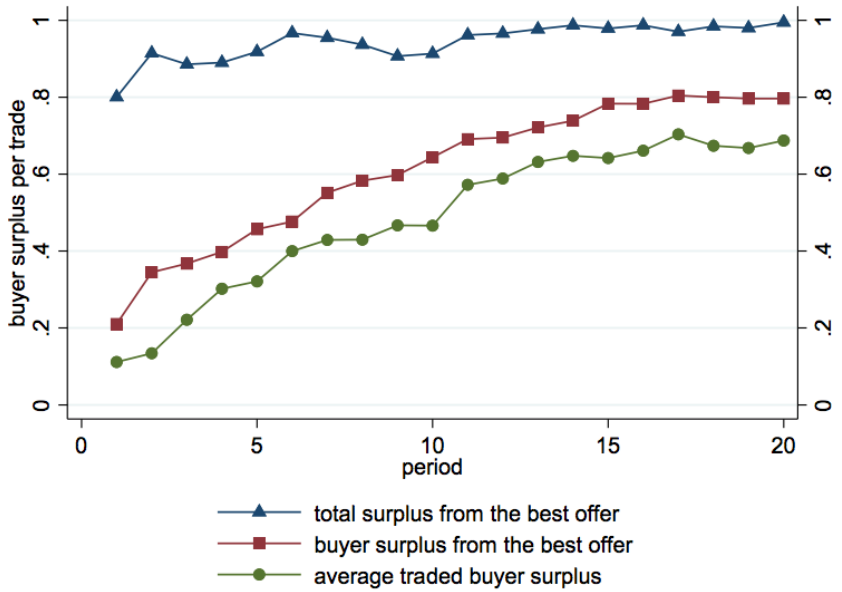
Figure 3: Average buyer surplus per trade as a share of the maximally possible surplus in NO Market and OO Market



Notes: The figure shows the average buyer surplus per trade (plus/minus one standard deviation) as a percentage of the maximum possible total surplus across the 20 periods in the market without obfuscation (NO Market) and the market with obfuscation (OO Market). The figure is based on the pooled data from the Half-Cost Treatment and the Convex Cost Treatment. The traded buyer surplus in the OO market is significantly lower than the buyer surplus in the NO market ($p = 0.000$, t test).

MUCH OF THE REDUCED BUYER SURPLUS WENT TO THE SELLER

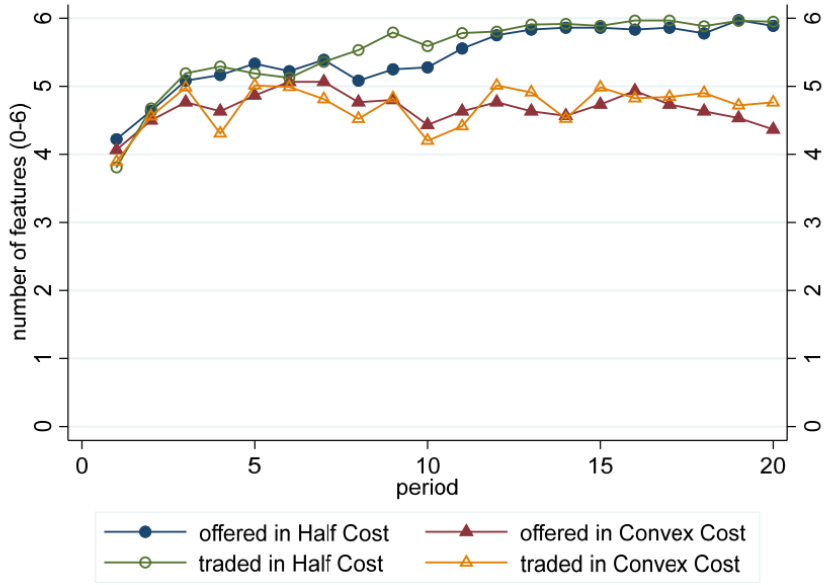
Figure 4: Decomposition of buyer surplus loss in markets with obfuscation opportunities (OO Markets)



Notes: The figure shows the average buyer surplus in traded products, the buyer surplus buyers could earn if they identify and buy the best offer in the market, and the total surplus generated by the best offer (product) in the OO market. The figure is based on the pooled data from the Half-Cost Treatment and the Convex Cost Treatment, and all graphs are displayed as a percentage of the maximum possible total surplus. The buyer surplus from the best offer is significantly lower than its total surplus ($p = 0.000$), and the average traded buyer surplus is also significantly lower than the buyer surplus from the best offer ($p = 0.000$).

OBFUSCATION IS CONSISTENTLY HIGH, ESP. WHEN FEATURES ARE VALUABLE

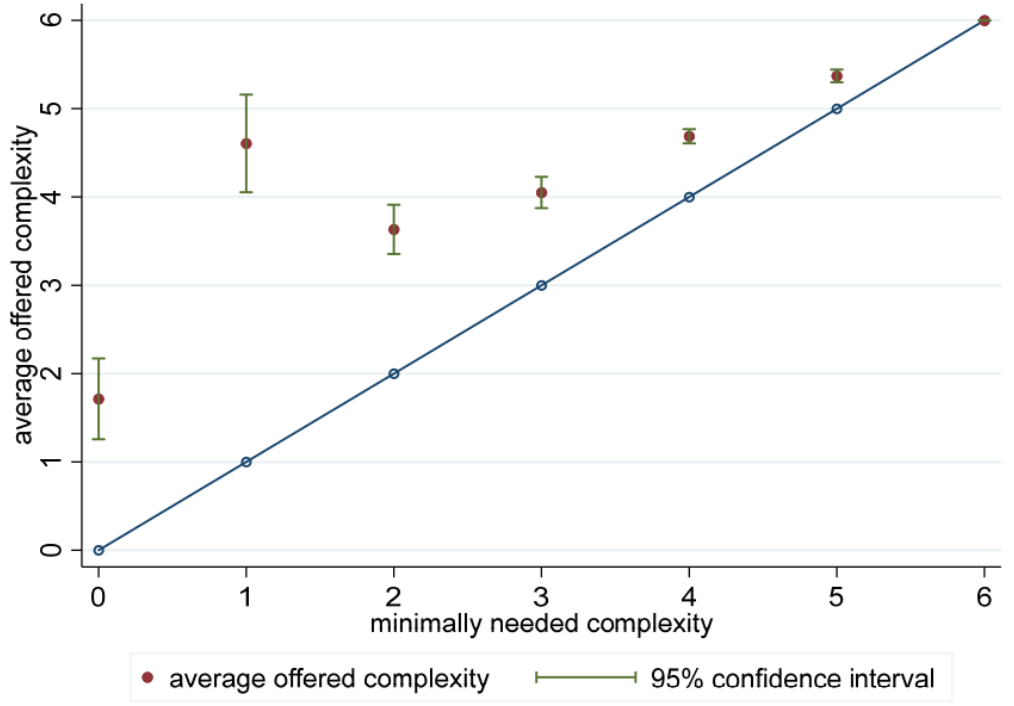
Figure 5: Product complexity in the Half Cost Treatment (HCT) and the Convex Cost Treatment (CCT) of markets with obfuscation opportunities (OO Markets)



Notes: The figure shows the average number of features in both the offered and traded products in the OO market. The figure presents data from the Half-Cost Treatment and the Convex Cost Treatment separately. The average offered product complexity in CCT is at a stable level significantly above 4 ($p = 0.009$), but is significantly below the average offered product complexity in HCT ($p = 0.006$).

OBFUSCATION EXCEEDED THAT REQUIRED TO ACHIEVE CERTAIN FEATURE VALUES

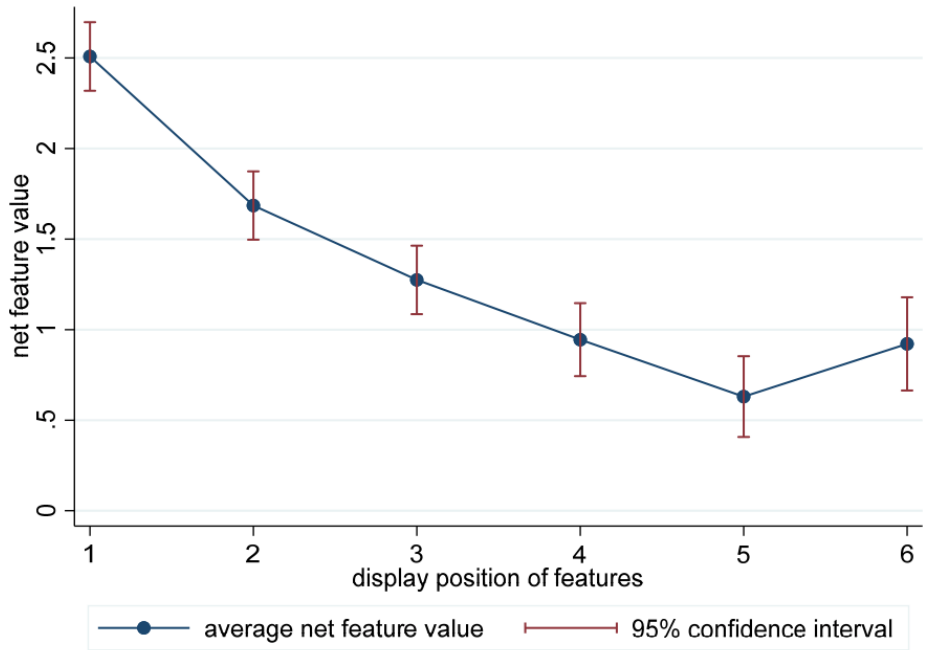
Figure 6: Over-obfuscation in markets with obfuscation opportunities (OO Markets)



Notes: The figure shows the average complexity of offered products (together with the associated 95% confidence interval) compared to the minimal complexity needed to generate the offers' intended feature values. The figure is based on the pooled data from the Half-Cost Treatment and the Convex Cost Treatment.

SELLERS STRATEGICALLY ORDERED FEATURES IN DESCENDING NET VALUE

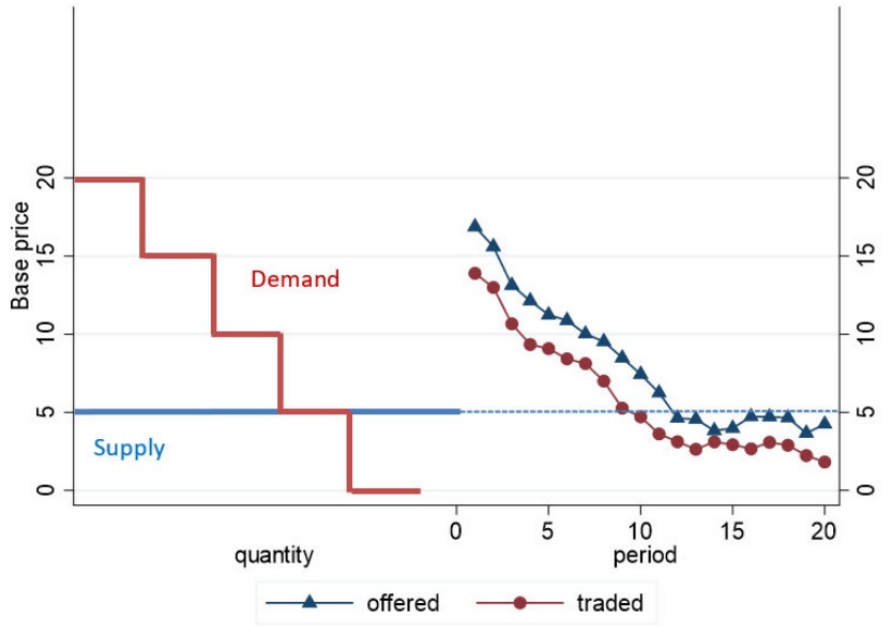
Figure 7: Net feature values across display positions of add-on features



Notes: The figure shows the average net feature value (i.e., feature value – feature price) of individual add-ons in offered products across display positions of individual features within a product. The associated 95% confidence intervals are also presented. The figure is based on the pooled data from the Half-Cost Treatment and the Convex Cost Treatment. A joint t-test for whether the net feature value of each feature is higher than its next feature yields a p-value of 0.001. The first 4 features are also individually significantly (at least at a 10% level) different from each other ($p = 0.001$ between the first and the second feature, $p = 0.072$ between the second and the third feature, and $p = 0.016$ between the third and the fourth feature).

HEADLINE PRICES WERE VERY COMPETITIVE, FALLING BELOW MARGINAL COST

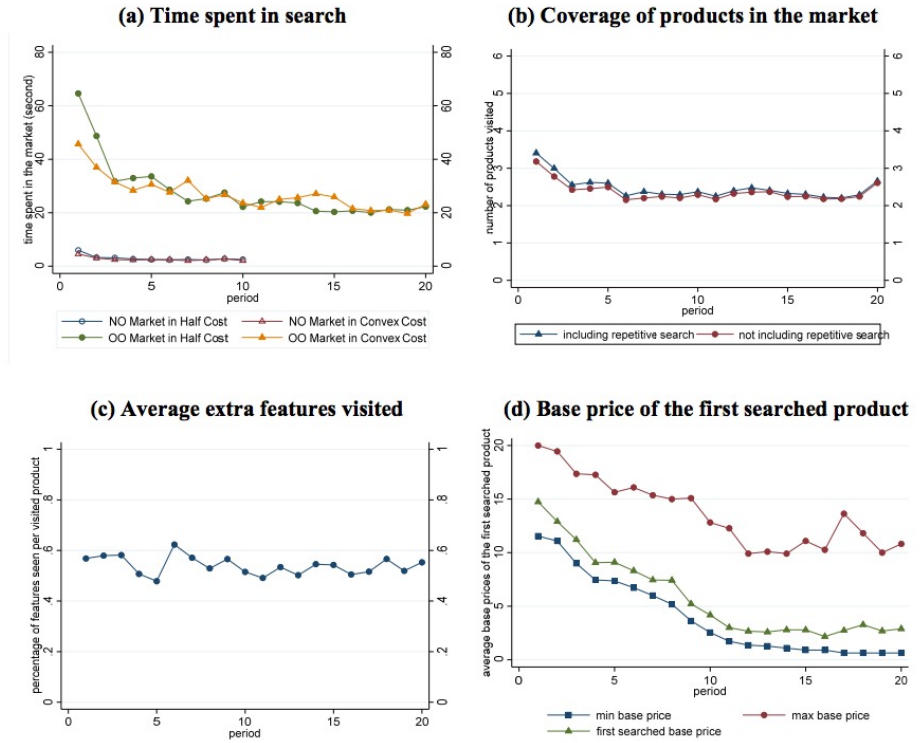
Figure 8: The development of headline prices over time



Notes: The figure shows the constant marginal cost of the basic product (blue thick line in the left part of the figure), the buyers' valuations of the basic product (red thick line in the left part), and how the prices of the offered and traded basic products evolve over time (in the right part of the figure). The figure is based on the pooled data from the Half-Cost Treatment and the Convex Cost Treatment. From Period 11 onwards, the average traded base prices are significantly lower than the marginal cost ($p = 0.020$).

BUYERS ONLY EXPLORED HALF THE MARKETPLACE

Figure 11: Buyers' search behavior

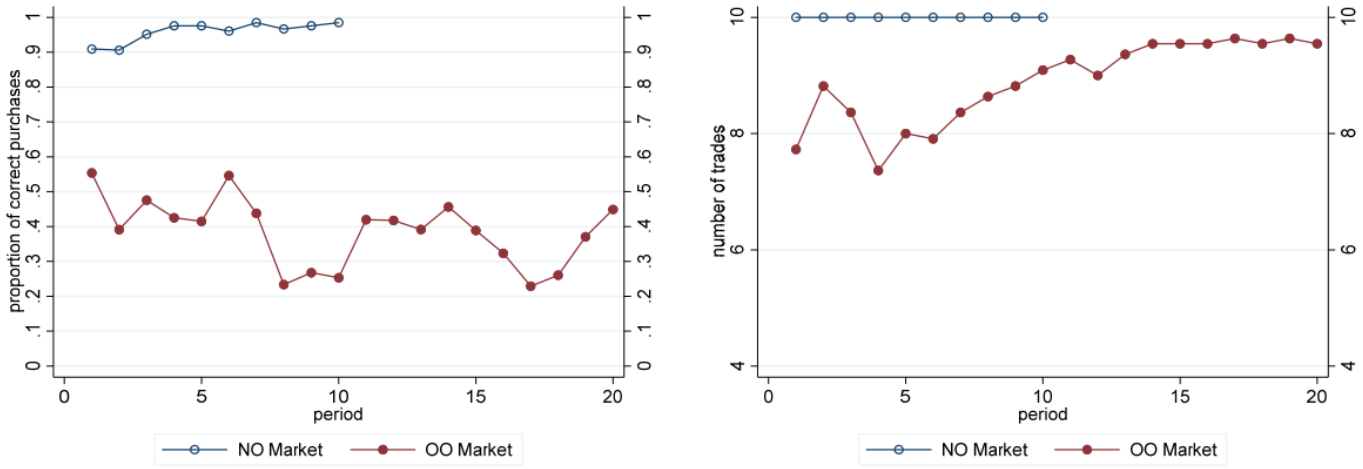


Notes. Figure (a) shows the average time buyers spend in searching the OO market and the NO market for the Half-Cost Treatment and the Convex Cost Treatment separately. Figure (b) illustrates the average number of products that buyers visit in the OO market; we show the case where buyers repeatedly visited the same product separately. Figure (c) shows the percentage of add-ons the buyers collected information about when they visited a product. Figure (d) shows the average base price of buyers' first visited products together with the range of base prices across different periods. Figures (b), (c). and (d) are based on the pooled data from the Half-Cost Treatment and the Convex Cost Treatment. In Figure (d), the average base price of the first searched products is higher than the lowest base prices in the market with $p = 0.000$.

ALL BUYERS FOUND THE BEST PRODUCT IN NO MARKETS, ONLY HALF IN OO MARKETS

Figure 12: Buyers' trading mistakes and failures to trade

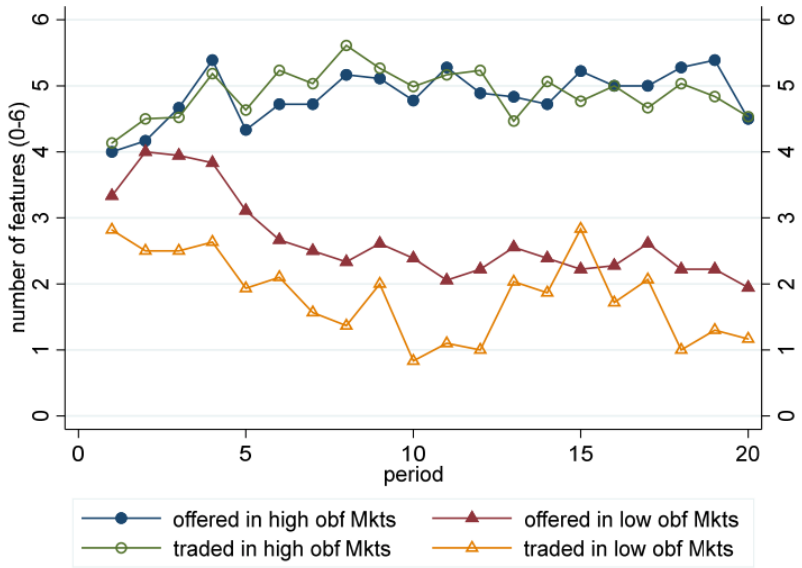
(a) Proportion of correct purchases **(b) Number of trades**



Notes: Figure (a) shows the proportion of buyers who managed to buy the best available product in the market. Figure (b) shows the number of buyers who traded among the 10 buyers in the market. Both Figures (a) and (b) are based on the pooled data from the Half-Cost Treatment and the Convex Cost Treatment. The proportion of buyers who are able to buy the best product in the NO Market is lower than in the OO Market with $p = 0.000$. The number of trades that occur in the NO Market is also lower than in the OO market with $p = 0.000$.

PURELY EXPLOITATIVE OBFUSCATION LED TO FRAGMENTED MARKETS

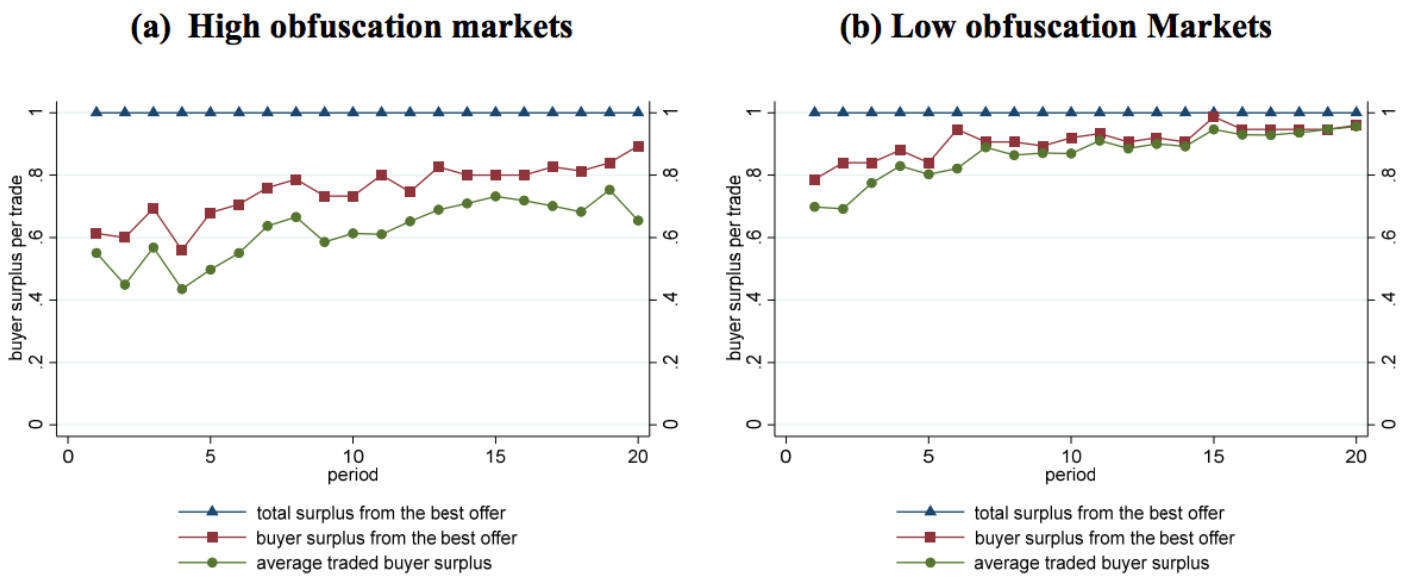
Figure 13: Obfuscation levels in the market with obfuscation opportunities (OO Markets) in Surplus-Neutral Treatment (SNT)



Notes: The figure shows the average number of features in both the offered and traded products in the OO markets of the Surplus-Neutral Treatment. The average number of extra features in offered and traded products is higher in the high obfuscation compared to the low obfuscation markets ($p = 0.001$ for offered products, $p = 0.000$ for traded products).

IN HALF THE MARKETS BUYERS FIGURED OUT FEATURES WERE WORTHLESS

Figure 14: Buyer surplus in markets with obfuscation opportunities (OO Markets) in the Surplus-Neutral Treatment



Notes: These figures shows the buyer surplus in traded products, the buyer surplus associated with the best available offer in the market, and the total surplus associated with the best offer in the OO market. The figures are based on the data from the Surplus-Neutral Treatment. In this treatment, the total surplus from any (i.e., also the best) offer in the market is always 100% by construction because the number of chosen extra features has no surplus consequences.

LIMITATIONS / FUTURE TWEAKS

- How robust are and/or sensitive are these results to:
  - Different parameterisation of, for example, search costs?
    - E.g. buyers have 100 seconds to choose before (on average) their endowed valuation is completely eroded. It takes a minimum of 72 seconds to get all information
  - Sequential viewing of obfuscated features? In many cases all features can be viewed simultaneously
  - Anonymity – what if sellers had reputations to uphold?
  - Less predictable and rules-based add-on pricing

IMPLICATIONS: STRATEGIC OBFUSCATION MITIGATES MARKET COMPETITION

- Causal evidence that strategic obfuscation can give firms' market power in what would, without obfuscation, be perfectly competitive markets
- Even in small markets consumers do not search the whole market
- Purely exploitative obfuscation appears less stable than surplus-enhancing add-on features
- Potential regulation: products can only be sold for a single price and with all add-ons included
  - Theoretical work suggests this benefits both consumers that would *and* wouldn't have purchased the add-ons if they were optional (Ellison 2005)

FURTHER RESEARCH QUESTIONS

- Why did buyers become complexity averse in only half of the purely exploitative obfuscation markets?
- How can the computational complexity of these markets be characterised?
- How can the experimental markets be extended to better reflect real decisions?

ANY QUESTIONS?