Enforced compatibility and control of switching costs in markets with network externalities: an experiment

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Abstract:
We experimentally investigate two competition policy measures relevant for markets with network externalities: mandating technological compatibility and lowering the cost of switching between providers. We do so in a virtual market with the roles of both sellers and buyers being played by student subjects. We find only limited support for usefulness of the analyzed measures: our treatment manipulations have no effect on sellers' pricing strategies. They do, however, reduce individual lock-in, helping the buyers to obtain the currently cheaper variant and thus increase customers' welfare.

Keywords: network externalities, lock-in, technology standards.
JEL Code: L11, L14, L15.

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1. Introduction

Several industries of knowledge-based economy, notably software development and telecommunication, display substantial network externalities – the utility derived from their products depends on the number of users. To enable these benefits, it is often crucial to implement technological standards, ensuring compatibility of products coming from different providers (Braunstein and White, 1985). Indeed, the possibility to communicate and interact smoothly with other nodes determines how much each user will benefit from the size of the network. The risk of *re-monopolization* emerges in this respect—the situation in which the market leader effectively blocks competitors' access by closing the standard. This threat is particularly substantial when the cost of switching from one product platform (e.g. in telecoms or computers) to another is high (Farrell and Klemperer, 2007).

It seems thus that two policy tools are of crucial importance here: technological compatibility enforcement and the cap on switching costs (Economides and White, 1994).

Because such markets are, by their very nature, large and path-dependent, identifying effectiveness of such measures in the field may be troublesome. Nevertheless, to the best of our knowledge, *experimental* research on the impact of competition policy tools on pricing choices in markets with network externalities, has been very limited.

In this paper we are trying to analyze both dimensions: enforced compatibility of products provided by different firms and control of switching costs. Our goal is to establish how these policy measures affect prices, firms' profits, customers' coordination and welfare.

Our tentative conclusion is that the analyzed measures do not have a sizable impact on pricing decisions. However, the customers do benefit from lower switching costs, which facilitate the purchase of whichever product is cheaper at any point in time.

2. Related experimental literature

Our literature search brought but a few experimental studies focused on markets with network externalities. Most of them deal with consumer behavior only, taking the market offer (prices) as fixed.

Etziony and Weiss (2002) investigated consumers' propensity to purchase goods causing network externality (effectively resulting in a seven-person coordination game with two possible choices), depending on the distribution of preference within the population. They concluded that customer heterogeneity (thus a situation in which, for given market penetration, some individuals value the good higher than others) facilitates coordination on the Pareto-efficient equilibrium. This is so because everyone recognizes that consumers with high willingness to pay for the product will most likely purchase it anyway, which helps reaching the critical mass. The authors propose thus that firms can support consumer heterogeneity by subsidizing selected purchases.

In their web-based study Drehmann et al. (2007) consider a situation in which 20 players make sequential rather than simultaneous choices between A and B. To be precise, each of them observes a signal which with certain probability correctly indicates which option, A or B, appears more attractive per se. Further, decisions (but not signals) of previous players are known, creating an information cascade (Bikhchandani et al. 1992). The game involves positive network externalities: the players obtain an additional payment proportional to the number of people who chose the same option (network treatment) or to the number of people that *subsequently* chose the same option (follower treatment). The latter situation is e.g. a natural model for the case of a product with limited backwards compatibility. The authors compare these experimental conditions to those with negative network externalities and none at all. As is to be expected, positive effects facilitate coordination of customers and make it easier to predict which product will ultimately prevail based on early decisions. Interestingly, in the network treatment, the most commonly (6 out of 12 cases) observed equilibrium was of the "stubborn" type, in which each player chooses the option that was *a priori* more likely to be superior, ignoring both one's own signal and predecessors' choices. The study is notable due to the huge and atypical sample (consisting mostly of graduate students and faculty members) and still relatively high expected per capita earnings.

We are aware of just three experiments that explicitly model the behavior of both sides of the market. Chakravarty (2003, 2004) implements the classical two-stage model of Katz and Shapiro (1985, 1986) with linear network externality, generally confirming the prediction of strategic purchasing of the currently more expensive product in the first stage, if it can be rationally expected to be more popular in the second stage. Producers correctly respond by setting prices below costs in the first stage.

Perhaps the experiment that comes closest to ours was recently run by Dang and Ackerman (2009). In their setup, 20 rounds of pricing and consumption decisions are run in groups of three sellers and eight buyers each. Notably, buyers are heterogeneous in that they differ in terms of base values (to which linear network externalities are added) of the goods. Dang and Ackerman compare three treatments: one with automated buyers that optimally react to naïve expectations about others' behavior and two with human buyers. One of the human buyer treatmentsentail positive cost of changing the seller, while the other two conditions involve no switching costs. They find that previous round's market share affects consumers' choices under positive switching cost only ("lock-in") but average prices and thus sellers' profits did not depend on this cost. Somewhat controversial features of their study involve very strict time constraints, the fact that different treatments were run three years apart and used different software and that trial rounds were paid but only when earnings were positive.

3. Design and procedures

We have modified the Dang and Ackerman's setup in a number of ways. The participants were divided into groups of nine. Two subjects in each group played the role of Sellers (S1, S2) and the others were Buyers (B1 to B7). The experiment spanned 20 rounds, preceded by three non-paid trial rounds. In each round each Seller offered their product to the Buyers. More precisely, each round proceeded as follows: first, product compatibility (which affected consumers' utility as explained below) was determined. In rounds with Voluntary Compatibility (*VC*), products were mutually compatible if and only if both producers wanted them to be compatible, whereas they were automatically compatible in the rounds with Enforced Compatibility (*EC*).

In the second stage, the Sellers had to choose their prices, p_1 and p_2 (non-negative real numbers). Finally, each Buyer could purchase at most one unit from S1, S2 or not purchase at all. All the decisions in any stage were made simultaneously and revealed to other group members at the beginning of the subsequent stage.

The Sellers' earnings in "Experimental Dollars" (*ED*) were equal to the product of the price and the number of their customers, $p_i q_i$, i=1,2. In other words, zero production costs and zero costs of implementing product (in)compatibility were assumed. The earnings for a Buyer who has purchased, from, say S1, were equal to:

$$v + e\,(q_1 + q_2) - p_1$$

if the products were compatible and

$$v + eq_1 - p_1$$

otherwise (and likewise if she[1] purchased from S2), whereby v = 5 was the basic consumption utility and e = 3 represented linear network externality. In the case of incompatible products the latter was limited to the customer base of the purchased product only.

Additionally, the Buyers had to bear the cost of switching c whenever they were purchasing from a Seller from whom they had not bought in the preceding round (thus also if they abstained in the previous round; switching costs also af-

[1] We will refer to any Buyer as "she" and any Seller as "he", obviously an arbitrary convention.

fected all those who decided to make a purchase in round 1). This cost was equal to zero in some rounds (C0 rounds) and five otherwise (C5 rounds). If a Buyer decided not to purchase at all, her earnings in this round were zero. Total earnings from all rounds were exchanged into Polish zloty at the end of the experiment at the rate of 10ED=1PLN.

As described above, four different types of rounds were played: VC/C0, VC/C5, EC/C0 and EC/C5. These conditions remained unchanged over five consecutive rounds and each group played four such five-round blocks, each corresponding to one the four treatments. Different orders of blocks were used in order to distinguish treatment effects from time effects. Because the regime change from VC to EC appeared more substantial than the change in switching costs, the former only took place once in each sessions, between rounds 10 and 11. The switching cost, on the other hand, would be changed between rounds five and six and then changed back between rounds 15 and 16.

Following these rules leaves four block orders possible:
EC/C0, EC/C5, VC/C5, VC/C0
EC/C5, EC/C0, VC/C0, VC/C5
VC/C0, VC/C5, EC/C5, EC/C0
VC/C5, VC/C0, EC/C0, EC/C5.

Each of these four orders was used in five nine-person groups. The subjects were told all the details of the design, except for the actual order of treatmentsin their groups (they were, however, duly informed about the current situation at the beginning of each round and they were told that the conditions could change every now and then). The buyers always knew the prices of the products and whether they were compatible or not before making their decisions.

As can be inferred from what was said above, a total of 180 subjects divided into 20 groups took part in the experiment. The experiment was computerized using LabSEE developed by Robert Borowski and was conducted at the University of Warsaw. The translation of the instructions used is provided in the Appendix. Thirty-seven percent of subjects were students of economics, 16% were lawyers, 14% studied journalism or political sciences. The age ranged between 18 and 29 with the average of 21 and nearly half the participants were female.

4. Predictions

To simplify our analysis, we focus on finding equilibria of the game played in a single round only. As mentioned before, subjects were told that the rules could change between rounds, they were thus likely to pay little attention to future rounds. Even if this was not the case, some backward induction arguments may justify our approach, at least in the case of zero switching costs, in which we have relatively strong predictions of zero prices. In the case of positive switching cost, where it pays to enter any round with a larger market share, we may generally expect that players try to establish a large customer base by charging a "dumping price in early rounds".

The case of zero switching costs

Assume that compatibility and prices have already been determined and, for the time being, that $p_1 \neq p_2$. Clearly, no matter whether products are compatible or not, all Buyers purchasing from the same, cheapest Seller (charging p_L, while the other charges p_H) is the equilibrium of this subgame which is preferred by all buyers, provided of course that $v + eq - p_L \geq 0$ ($q = 7$ being the total market size). However, in case of incompatible products, as long as $v + eq - p_H \geq v + e - p_L$ (so that $p_H \leq p_L + e\ (q - 1)$), all Buyers purchasing from the most expensive Seller is also an equilibrium. Further, if most of them were purchasing from him in the previous round and the price difference is low, it could well be the focal one.

In the special case of $p_1 = p_2 \leq v + eq$, any distribution of players between the two Sellers is an equilibrium if products are compatible while in the case of incompatible products the two (obviously payoff-equivalent) equilibria involve all Buyers purchasing from the same seller. Finally, if $v + q - p_L \leq 0$, all Buyers abstaining is also an equilibrium, no matter what p_H is.

Such a multiplicity of (subgame) equilibria is a trademark of models with network externalities, making it difficult to predict the Buyers' and, especially, Sellers' choices. We can assume that the Sellers expect the payoff-dominant equilibrium to emerge in the subgame with $p_1 \neq p_2$ and the equilibrium which involves the smallest possible number of switches in the case of $p_1 = p_2$. What are then the optimal pricing decisions? Any Seller who does not capture the entire market benefits from undercutting the opponent, choose the price at the lowest possible level, which tends to 0 (prices were non-negative real numbers). That is why in the first round of experiment, the only possible equilibrium price choices are (0, 0), essentially the Bertrand competition case. Because it does not depend on product compatibility, we have no specific predictions as to this choice of the sellers, as explained in more detail below.

The case of positive switching costs

In the case of product compatibility, the Buyers simply want to make their purchase possibly cheap, meaning that they are expected to switch if and only if the other product is cheaper and the difference exceeds c (of course they can also switch in the case of exact indifference).

Multiplicity of equilibria in Buyers' subgame and discontinuity of demand functions render the notion of Nash Equilibrium not very helpful in predicting sellers' behavior – models such as this tend to have no equilibria (D'Aspremont, Gabszewicz, Thisse, 1979; Economides, 1986; Shy, 1996). That is because, unlike in the standard Bertrand game, it only pays to undercut when prices are relatively high. Consider for example the case of compatible products with $p_1 = 4$ and no complete market polarization. Seller 2 cannot effectively undercut (because the cost of switching is $c = 5$), so his optimal response will be to choose a price that merely prevents his own customers' from switching, i.e. $p_2 = p_1 + c = 9$. Yet in such case Seller 1 will either want to undercut (say, choosing, 3.9) or raise his price further, depending on the initial distribution of customers etc. It is easy to show that no equilibrium emerges. Morgan and Shy (2000) have thus proposed an alternative notion of undercut-proof equilibrium (UPE).[2] While in the standard NE other player's choices are expected to stay constant, Morgan and Shy allow for the possibility that each seller expects the other to undercut if it is profitable. Seller 1 therefore sets the price such that Seller 2 is indifferent between undercutting, i.e. charging $p_1 - c$ (and capturing the entire market) and sticking to his current strategy. This yields $p_2 q_2 = (p_1 - c)q$. Similarly, $p_1 q_1 = (p_2 - c)q$.[3] It is easy to find (Morgan and Shy 2000, p. 7) that, given market shares (inherited from the previous round), the equilibrium prices are:

$$\begin{cases} p_1 = \dfrac{cq\,(2q - q_1)}{q^2 - qq_1 + q_1^2};\ \pi_1 = p_1 q_1 \\[2ex] p_2 = \dfrac{cq\,(2q - q_2)}{q^2 - qq_2 + q_2^2};\ \pi_2 = p_2 q_2 \end{cases}$$

[2] Contrary to what the name could suggest, a UPE is not necessarily a NE, i.e. it is a weaker concept.

[3] Clearly, as a result no buyer switches, so that market shares remain whatever they happened to be in the previous round. In this sense the solution is strongly path dependent and it hardly yields any prediction as to market shares. As mentioned earlier, we may expect the sellers to charge minimal price in round 1 to capture as much market as possible early on.

Not surprisingly, in the special case of no switching costs ($c = 0$), we are back in the Bertrand case of null prices (and profits), no matter how many clients each seller had to start with. Otherwise, the firm with a larger number of customers will have a lower price (perhaps a counter-intuitive result), because it is more tempting to undercut it but overall the impact of market share on price is weak, see Figures 1-2.

Figure 1. Prices under UPE, the case of compatible products ($q = 7$, $c = 5$)

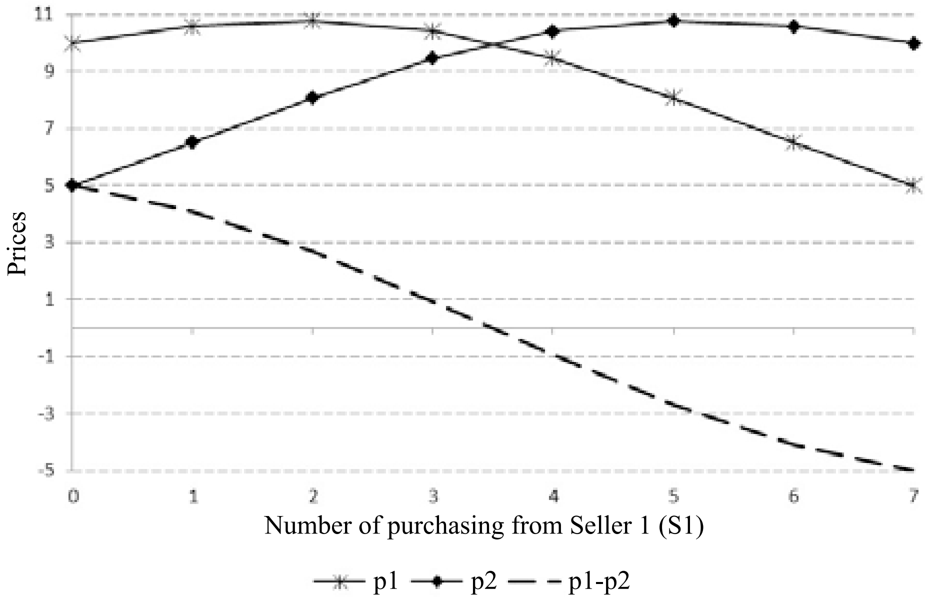
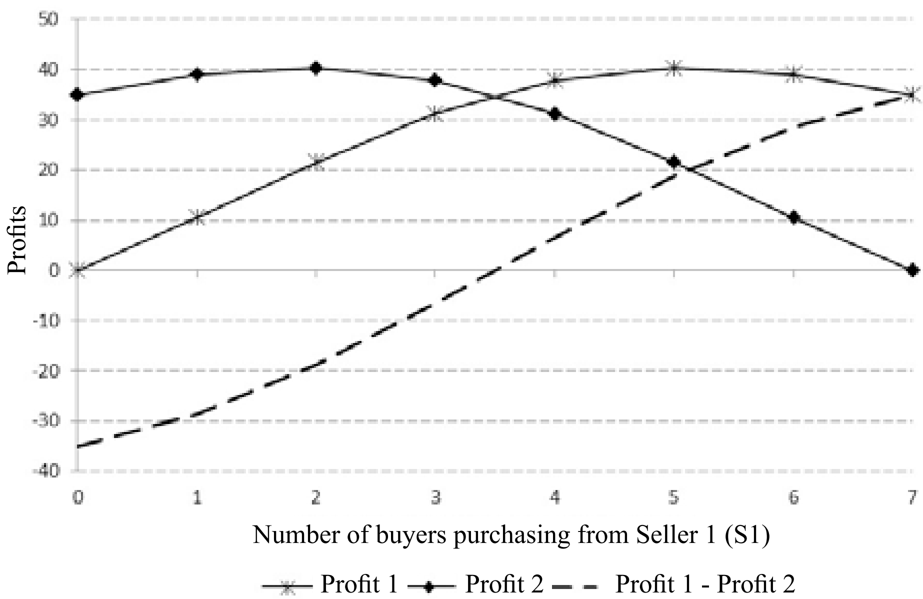


Figure 2. Profits under UPE, the case of compatible products B ($q = 7$, $c = 5$)



In the case of incompatible products, a consumer previously buying from Seller 2 finds it profitable to switch to S1 if $U_2(1) > U_2(2) \Leftrightarrow v + e(q_1 + 1) - p_1 - c > v + eq_2 - p_2 \Leftrightarrow p_1 < p_2 - c + e(q_1 - q_2 + 1)$ and similarly for those previously buying from S1: $U_1(2) > U_1(1) \Leftrightarrow v + e(q_2 + 1) - p_2 - c > v + eq_1 - p_1 \Leftrightarrow p_1 > p_2 + c - e(q_2 - q_1 + 1)$. Subtracting the RHSs of the restrictions on p_1 that assure no switching, we get 2e-2c, which means that two cases must be considered: $c < e$ and $c \geq e$. In the former case, all consumers will purchase the good from the same seller, no matter what they did in the previous round. In the case of c=0 the only possible equilibrium price choices are (0, 0), essentially the Bertrand competition case.

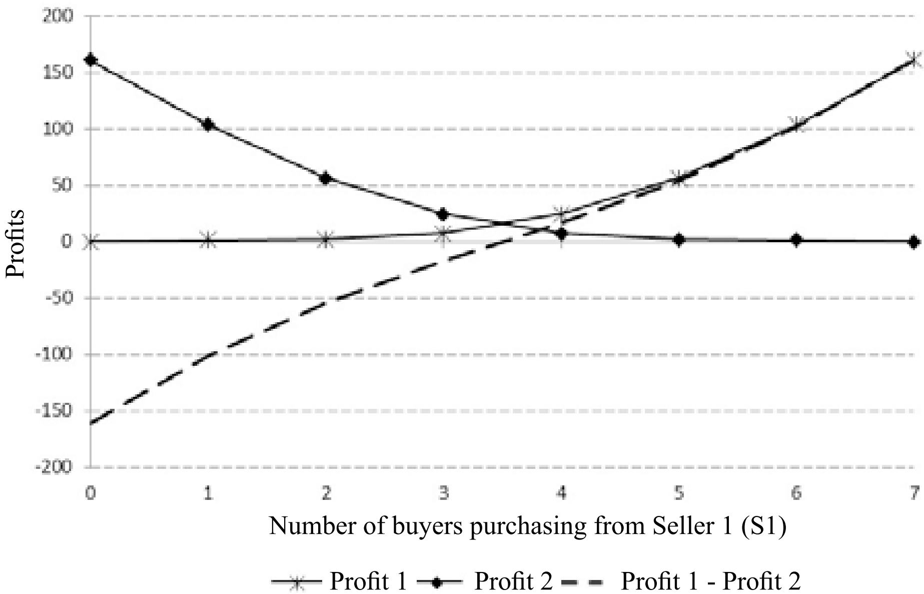
When $c \geq e$ (as it in the case in rounds with switching cost of 5) a price range exists in which no consumer will want to switch assuming others stay with their current providers. In our case this will require that the difference between utilities of consumers buying from different sellers does not exceed 2 (=c-e=5-3). UPE may be easily found to yield:

$$\begin{cases} p_1 = \dfrac{cq\,(2q - q_1) + eq(2q_1^2 - (q-1)q_1 - 2q)}{q^2 - qq_1 + q_1^2)}; \pi_1 = p_1 q_1 \\[2ex] p_2 = \dfrac{cq\,(2q - q_2) + eq(2q_2^2 - (q-1)q_2 - 2q)}{q^2 - qq_2 + q_2^2)}; \pi_2 = p_2 q_2 \end{cases}$$

Again with $q = q_1 + q_2 = 7$=7. Resulting prices and profits are depicted in Figures 3-4.

Figure 3. Prices under UPE, the case of incompatible products (*q* = 7, *c* = 5)

Figure 4. Profits under UPE, the case of incompatible products (*q* = 7, *c* = 5)



Comparing the expected profits depending on market share, we find that **incompatibility of products becomes profitable (in fact very profitable) when the seller has five or more customers**.

Hypotheses

Basing on the game-theoretic analysis sketched above we can formulate the following general hypotheses, separately for the behavior of sellers and buyers.

HS1: Sellers will tend to opt for incompatibility when they have had many (five or more) customers in the previous round and switching costs are high.

HS2: Automatic compatibility and (especially) low switching costs will lead to lower prices.

HS3: Price level will only depend on previous round's market size in the case of incompatible products and high switching costs – this impact will be positive.

HS4: Price level will tend to increase over time under voluntary compatibility (compared to the enforced compatibility treatment) and high switching cots (compared to the zero switching cots treatment) – penetration pricing.

HS5: Other seller's price will have a positive impact on own price, especially under low switching costs and automated compatibility.

HB1: Buyers will tend to purchase from the cheaper seller.

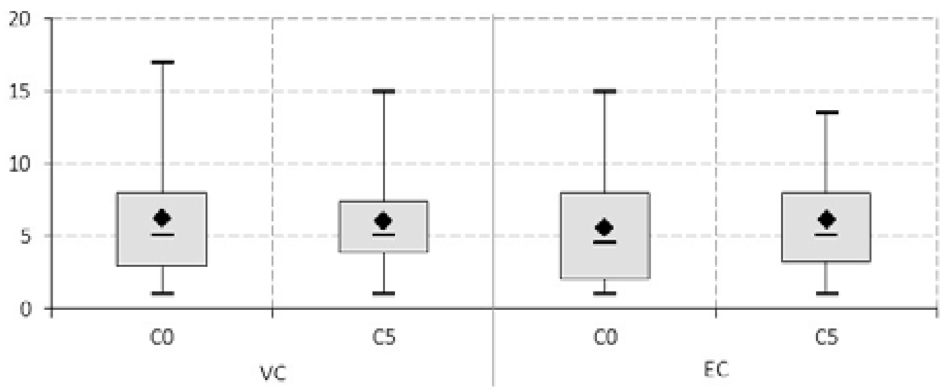
HB2: This tendency will be weakened by inertia (individual lock-in), especially with high switching costs.
HB3: Buyers will tend to choose the seller that was dominant in previous round, especially under voluntary compatibility.
HB4: Higher welfare will obtain under low switching costs and automated compatibility.

5. Results

Descriptive statistics

A preliminary illustration of the data is given in Figures 5-7. Figure 5 contains market prices. Mean price picked by sellers was 6.073. The sellers aimed at the Bertrand equilibrium strategy of $p = 0$ in just 0.25% of cases (in 3% of cases the price was less than 1). Prices were comparable across treatments.

Figure 5. Market prices by treatment (EC/C0, EC/C5, VC/C5, VC/C0)



comparable across treatments.

Figure 6 shows sellers' profits. While overall mean was 18.28, sellers made a bit more under high cost of switching.

As for buyers, profits were, as expected, highest in the case of enforced compatibility and zero switching cost and lowest in the opposite case, see Figure 7.

Figure 6. The sellers' profits by treatment (EC/C0, EC/C5, VC/C5, VC/C0)

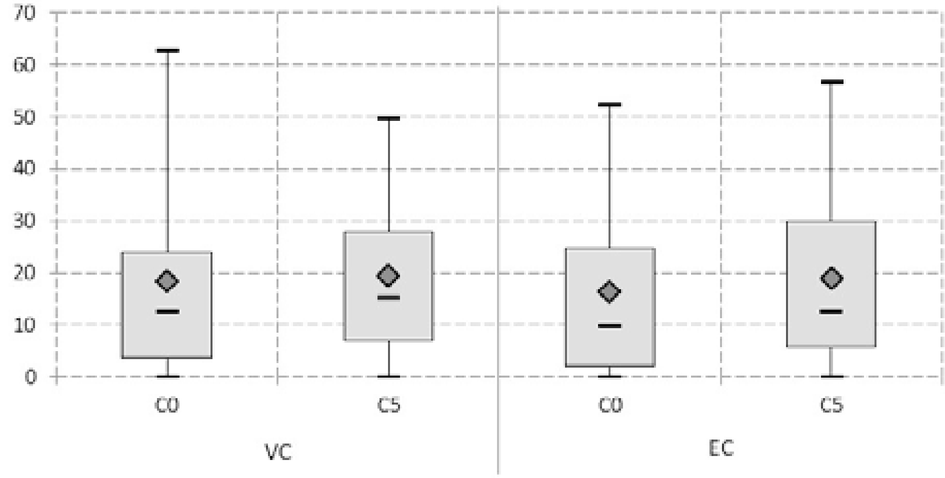
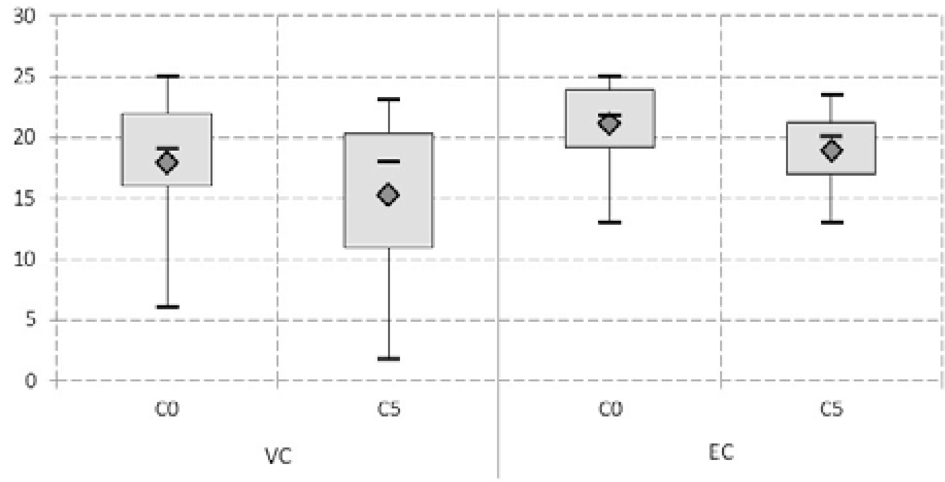


Figure 7. The buyers' profits by treatment (EC/C0, EC/C5, VC/C5, VC/C0)



The choice of compatibility

Overall, in the rounds in which they had the opportunity to do so, the Sellers would opt for compatibility of the products 65% of the time. As a result, the products were actually mutually compatible in 43% of the rounds in which this was not guaranteed by the rules of the game. Table 1 contains the results of a fixed-effect[4] logistic regression seeking to explain the choice of compatibility. Because HS1 stipulates that market share affect compatibility choice under high switching cost

[4] The Hausman test was used to choose between fixed and random effects in all the reported regressions.

only, it was conducted separately for the two switching cost conditions. It turns out that indeed our main variable of interest – own clients in *t*-1 – had a large negative impact under high switching cost only: sellers with a large customers base were inclined to close standards when they knew switching to the competitor would be costly. In the zero switching cost condition the coefficient is nowhere close to significance, we observe though that opponents previous round compatibility choice plays some role, there is also a moderate time effect.

Table 1. The choice of compatibility

Zero switching cost rounds (C0):

Compatibility	Coef.	Std. Err.	Z	P>|z|	[95% Conf. Interval]	
Own comp. t-1	-.600	.450	-1.33	0.183	-.483	.288
Other's comp. t-1	1.164	.519	2.24	0.025	.147	2.181
Own price t-1	.042	.120	.35	0.728	-.193	.276
Other's price t-1	-.004	.132	-.03	0.975	-.262	.254
Own clients t-1	-.046	.093	-.50	0.617	-.228	.135
Round number	-.946	.427	-2.22	0.027	-1.783	-.109

High switching cost rounds (C5):

Compatibility	Coef.	Std. Err.	Z	P>|z|	[95% Conf. Interval]	
Own comp. *t*-1	.363	.437	.83	0.406	-.494	1.221
Other comp. *t*-1	-.444	.428	-1.04	0.300	-1.283	.396
Own price *t*-1	-0.30	.088	-0.34	0.732	-.203	.143
Other's price *t*-1	.027	.094	0.29	0.774	-.157	.211
Own clients t-1	-.352	.131	-2.70	0.007	-.608	-.096
Round number	.109	.314	0.35	0.730	-.507	.724

Note: Own (Other's) comp. *t*-1 represents own (other's) choice of compatibility product in previous round;
Own (Other's) price *t*-1 represents own (other's) price choice in previous round;
Own clients t-1 is the number of own clients in previous round.

The choice of prices

Table 2 shows mean posted price by treatment.

Table 2. Mean prices picked by sellers

Compatibility	Switching cost	
	Zero (C0)	High (C5)
Voluntary (VC)	6.323	6.119
Enforced (EC)	5.672	6.178
Incompatible	6.339	6.302
Compatible	5.865	6.086

It turns out there is no treatment effect here. It is in particular remarkable how far the prices are from the equilibrium in the case of zero switching cost.

To investigate dynamics of prices we have run regressions on previous round's own market share, own price, opponent's price and round number, for each of the four treatments separately. The results (available upon request) indicate that own market share has a positive large effect undervoluntary compatibility and high switching costs – sellers used their dominant market position to raise their prices, on average by 0.36 ED per previous round's customer ($p < 0.001$). The effect was smaller under VC and zero switching cost (0.23, $p = 0.008$) and altogether absent under automated compatibility. Hypothesis HS3 is thus largely confirmed.

To verify the penetration pricing hypothesis (HS4) we have computed the difference of the average price within group between the last and the first round of each block. We have then applied the Mann-Whitney test to find out whether such differences are affected by treatments. In line with the predatory pricing hypothesis, it was found that higher switching cost contributes to the growth of prices ($p = 0.0096$) – the prices are relatively low at the beginning of the block and then go up. No effect of automated product compatibility was found ($p = 0.397$).

The buyers' choices

Panel logistic regression shown in Table 3 seeks to verify the lock-in effects. The dependent variable is the choice of Seller (1 or 2), thus positive coefficients are interpreted as factors increasing the likelihood of Seller 2 being chosen rather than Seller 1.[5] We find strong support for HB1 – the binary variable indicating that Seller 2 is cheaper as well as his price advantage over Seller 1 have strong impact on choices. HB2 is also confirmed in that buyers tend to stay with the old seller, especially when the cost of switching is high (individual lock-in effect). Unexpectedly, automatic compatibility does not moderate individual lock-in (not even in interaction with switching costs).

The systemic lock of HB3 is not confirmed in the EC/C0 treatment – the number of consumers in t-1 is irrelevant per se. However, it is important in other treatments, namely under higher costs of switching and (as expected) undervoluntary contribution.

[5] About 1% of observations in which the Buyer decided not to buy at all are ignored. Further, because we want to investigate the impact of the previous round, we ignore observations from Round 1.

Table 3. Determinants of buyers' choices – a logit regression

Choice (of S2 rather than S1)	Coef.	Std. Err.	Z	P>|z|	[95% Conf. Interval]	
Choice in t-1	1.506	.372	4.05	0.000	.777	2.234
Choice in t-1*C5	3.417	.516	6.63	0.000	2.406	4.428
Choice in t-1*VC	-.576	.482	-1.19	0.232	-1.520	.367
Choice in t-1*VC*C5	.397	.690	0.57	0.565	-.956	1.75
S2 customers in t-1	.029	.063	0.47	0.640	-.094	.153
S2 customers in t-1*C5	-.267	.082	-3.26	0.001	-.428	-.107
S2 customers in t-1*VC	.176	.078	2.27	0.023	.024	.328
S2 customers in t-1*VC *C5	-.047	.111	-0.42	0.673	-.264	.170
p1-p2	.175	.026	6.68	0.000	.124	.226
p1-p2 in t-1	.008	.017	0.47	0.640	-.026	0419
Seller 2 cheaper	2.452	.188	13.02	0.000	2.083	2.822

Note: Choice in *t*-1 denotes own choice of product in previous round;
Choice in *t*-1*VC*C5- own choice of product in previous round with treatment VC/C5. Etc.

Another way to analyze treatment effects on buyers' behavior is to look at probability of switching between sellers. As shown in Table 4, number of switches is (not surprisingly) strongly affected by its cost, but not by the fact whether compatibility is enforced, chosen or absent. As a result, zero cost of switching greatly increases the fraction of buyers that end up purchasing the currently cheaper product, but compatibility has no effect. Consequently, markets tend to be more polarized under zero switching costs (the mean absolute difference in the number of customers is higher). This variable is, predictably, also affected by compatibility – the possibility to lock the standards facilitates emergence of a larger network (all the differences described above are significant at $p = 0.0291$ or less in a group-level Mann-Whitney-Wilcoxon test, except for the impact of compatibility products (Yes/No) on the absolute difference in the number of their customers when switching costs is low, where $p = 0.850$).

Table 4. Switching, efficiency and market polarization by treatment

Compatibility	Switching cost	
	Zero (C0)	High (C5)
Voluntary (VC)	45.3% 86.0% 4.820	24.7% 60.3% 3.620
Enforced (EC)	41.4% 87.3% 5.200	17.2% 62.0% 4.410
Incompatible	44.9% 86.7% 5.000	26.6% 65.3% 3.707
Compatible	42.8% 86.6% 5.014	22.1% 59.5% 4.141

Note: Entries for each treatment are, respectively, the fraction of switchers, the fraction of customers purchasing the cheaper product (or any product when prices are equal), absolute value of the difference in number of customers.

These effects have a clear bearing on welfare measures. Buyers' profits are systematically affected by treatment: they are higher under automated compatibility and no switching costs (all differences significant at p=.02 or less in a group-level Mann-Whitney-Wilcoxon test). The same relationships exist between compatible and incompatible goods. These differences remain significant at 5% if we consider profits net of switching costs. By contrast, Sellers' profits were not significantly affected by treatment (except that p=.019 for the impact of switching costs under compatible goods and that p=.028 for the impact of switching costs under enforced compatible), as Figure 2 suggested.

Table 5. Buyers' mean profits

Compatibility	Switching cost	
	Zero (C0)	High (C5)
Voluntary (VC)	17.986	15.279
Enforced (EC)	21.189	18.971
Incompatible	16.117	12.444
Compatible	20.937	19.037

Summary

Our results provide only limited support for the policies under consideration. Lowering switching costs and mandating compatibility of products was found not to affect sellers' pricing policies – prices picked diverged strongly from the theoretical predictions, particularly in the case of zero switching cost. Only the conjecture that larger market share will trigger higher prices under high switching cost and voluntary product compatibility was confirmed.

However, low switching costs and enforced compatibility did reduce the lock-in effect, allowing the consumers to obtain the cheaper variant more often, which resulted in consumer utility gains. To the extent that in practical field applications such policy measures do not come for free as they did in our stylized environment, such anticipated benefits must be carefully weighed in each specific case, for they may be insufficient to make bearing the costs of regime change worthwhile.

As a referee noted, the structure of the experiment, particularly due to the relatively low number of rounds in each treatment gave limited room for the process of reaching the equilibrium. It cannot be excluded that participants'decisions would converge to the theoretical prediction if they had more time to learn the market.

Future experimental research should address robustness of findings of our exploratory study, allowing for such modifications as even higher switching costs, more opportunity for learning and other market structures. We believe nevertheless that our basic design of repeated two-sided market with immediate feedback will continue to prove to be a viable laboratory research vehicle to address the effects of competition policies on prices and welfare in industries displaying network effects.

Appendix: Instructions (translated from Polish)

[… welcome, house rules etc…]
During the experiment you will earn Experimental Dollars (ED). How much of these you get will depend on your decisions, as well as on decisions of the other eight participants in your group. At the end of the experiment you will receive an amount in Polish Zloty calculated as follows:

10 ED = 1 Zloty

The experiment is anonymous: neither the experimenter nor remaining participants will be able to tell the name of anyone who has made any specific decision or earned given amount of money.

Two participants in your group will play the role of Sellers (we call them S1 and S2). Each Seller will offer their product (Product 1 and Product 2 resp.) to the remaining seven participants – **Buyers (B1 to B7). This role assignment will be done once**, for the entire experiment.

The experiment will consist of 20 rounds. Each round will proceed as follows:

1. Products 1 and 2 will be announced mutually compatible or not. In some rounds this compatibility will be introduced automatically, in other rounds the products will only be compatible if both Sellers sowish (and Sellers' decisions on compatibility will be announced to all participants of the group). Compatibility of products is important for the Buyers, as explained below.
2. The Sellers will simultaneously set the price (0-25 ED) of their respective product. These will be revealed to all participants.
3. Each Buyer will choose between three options – buy one unit of product from S1, buy one unit of product from S2 or not buy at all.

The Seller's *i* (*i*=1,2) earnings in any round will be equal to the **price of the product he has selected, p_i, and the number q_i of Buyers actually purchasing it** (thus production costs are assumed to be zero):

$\Pi_{Si} = p_i q_i$

The Buyers' earnings are calculated as follows. If she has not bought anything in this round, her earnings are zero. If she has, her earnings are equal to:

a) A fixed amount of 5ED…

b) … less cost of switching *c*, if she is purchasing from a Seller she had not purchased from in the previous round. The costs of "switching" is also incurred in Round 1. The level of *c* may change between rounds.

Having, for example, chosen to purchase from S1, the buyer will make:

$\Pi_K(S1) = 5 + 3(q_1 + q_2) - p_1$ *if products are compatible*

$\Pi_K(S2) = 5 + 3(q_1) - p_1$ *otherwise,*

possibly reduced by c, if she has not purchased from S1 in the previous round. Note that the resulting number can be positive or negative. You will be able to browse the history of your decisions

Three trial rounds will take place before the actual experiment. Their only purpose is that participants get familiar with the rules of the game – they have no-impact on the earnings. They thus provide ample opportunity to "experiment" with different strategies. **Please note**: this also means that other participants' choices may be very different when you move on to paid rounds.

Your earnings in ED will be equal to the sum of earnings in all the rounds. It will be translated into Polish Zloty and paid in cash immediately after the experiment.

Summary

In each round the products will either be automatically made compatible or the Sellers will make their choices (and the product will be compatible if they choose for that). Next, the Sellers will simultaneously set their prices. Each Buyer will decide whether to buy from S1, S2 or not buy at all. The Sellers' earnings will be equal to the products of price and number of clients. Each Buyer's earnings will depend on the total number of Buyers purchasing any product (or the same product only in case of incompatible products), on the price they pay and whether they changed their seller wrt. to the previous round.

Please raise your hand if you have any questions or press the button to continue.

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