An experimental study of competition in two-sided markets*

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Abstract

We conduct a two-sided market experiment with two platforms, in which subjects play the role of platform firms. First, we find a positive relationship between market prices and the transportation costs incurred by the consumers. Second, the price paid by consumers from one group is negatively affected by the level of positive externalities exerted on the other group. These results are consistent with the theory of platform competition (Armstrong, 2006).

JEL codes: C91, D03, D12, L13

Keywords: Two-sided Markets, Experiment, Duopoly, Network Effects, Platforms

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1 Introduction

Two-sided markets, where two distinct groups of economic agents interact with each other via one or more platforms, are growing in importance with rapid developments in information and communication technologies. Examples of two-sided platform markets include online trading platforms such as eBay and Amazon; app stores on mobile operating systems like iOS and Android; advertising supported media such as newspapers, Google search and Facebook; and peer-to-peer platforms such as Uber and Airbnb.

Existing literature provides a comprehensive theoretical analysis of two-sided markets, where two groups are connected through cross-group externalities so that interaction between the two parties is mutually beneficial (Rysman, 2009). Theoretical models examine issues such as platform's pricing structure (Rochet & Tirole, 2006), tipping into a single dominant platform (Rysman, 2009; Caillaud & Jullien, 2003), multi-homing and platform competition in differentiated platforms (Armstrong, 2006), and the use of exclusive contracts to restrict multi-homing (Rysman, 2009). There is however, a striking lack of empirical evidence to validate the theory.

Motivated by this, the present paper uses a laboratory experiment to test the comparative statics predictions of the seminal model of Armstrong (2006). In particular, we answer the following: How does the level of cross-group externalities (indirect network effects) and the degree of product differentiation between platform firms affect equilibrium prices? We employ a price setting duopoly experiment with a 2x2 factorial design where we vary the levels of transportation costs and network benefits. In the experiment, there are two horizontally differentiated platform firms offering goods to two groups of consumers who incur transportation costs when they make a purchase from one of these firms. One group (Group 2) is assumed to receive a network benefit which increases with the number of consumers from the other group (Group 1) buying from the same platform. Under this setting, by charging a relatively low price to Group 1, a firm gains dominant market share in Group 1, which subsequently contributes towards its bid for Group 2 market share.

The main results from the experiment are consistent with the theoretical predictions. Firstly, there is a positive relationship between the prices charged to agents from one group and the transportation costs incurred by these agents. Secondly, the prices paid by agents are negatively affected by how much the participation of these agents benefits the other group. In other words, the higher the positive externalities exerted from one group are, the lower are the prices charged to the agents in this group. However, the magnitudes of both relationships are lower than what is suggested by the theoretical model of Armstrong (2006).

The present experiment represents the first two-sided market laboratory study where human subjects are assigned the role of platform firms and select the prices charged to two groups of simulated consumers. This key feature separates the experiment in the present paper from previous experimental studies of such markets (Hossain & Morgan, 2009; Morgan *et al.* , 2011), which predominantly use human subjects as consumers and simulate the platform decisions. The experiment in the present paper is designed in this way because we focus specifically on the behaviour of platform firms and the role that their pricing strategies play in determining market outcomes.

This paper is related to experiments on Bertrand price competition with product differentiation (Orzen & Sefton, 2008; Huck *et al.* , 2000). Yet, in our experiment rather than dealing with one group of buyers, competing firms offer differentiated goods to two distinct consumer groups that are interrelated due to indirect network effects. As a result, on top of the two prices, consumer demand depends on the levels of transport costs and indirect network benefits in each of the two sides of the market. Additionally, a novelty of our experiment about the firms' decisions is that the firms have to choose two prices instead of one price, as is the case in most market experiments (see Cason & Davis (1995) for an exception). Having to choose two interdependent prices is not only a cognitively challenging task but it also allows for small errors in pricing by one of the sellers to possibly lead to large deviations in one or both prices. In this regard, our results show strong support for the theory despite the challenging pricing environment for the firms.

Our paper complements a growing empirical literature that use observational data from two-sided markets such as markets for yellow pages (Rysman, 2004), magazines (Kaiser & Wright, 2006), newspapers (Argentesi & Filistrucchi, 2007; Seamans & Zhu, 2013), video games (Clements & Ohashi, 2005; Lee, 2013), home VCRs (Park, 2004), payment cards (Rysman, 2007) and sportscard conventions (Jin & Rysman, 2015). While these studies contribute to our understanding of the properties of two-sided markets, observational studies have limitations (e.g. lack of variation and control on the level of network benefits) that we overcome using a controlled experiment.

2 The Theoretical Model

This section presents a two-sided market model that is used for the experimental analysis. This model is based on Armstrong (2006). In this model there are two groups of agents, group-1 and group-2, and there are two firms, firms A and B, which operate competing platforms that enable the two groups to interact. For simplicity, we assume that platform firms do not incur any cost in serving the two groups ($c_1 = c_2 = 0$). Each population is uniformly distributed on a line of unit length. Agents from groups 1 and 2 located at point x on the unit interval obtain the following utilities for joining the platform i:

$$u_1^i(x) = U_1^i(x) + \alpha_1 n_2^i - p_1^i; \quad u_2^i(x) = U_2^i(x) + \alpha_2 n_1^i - p_2^i, \quad i = A, B. \tag{1}$$

The utility functions indicate that by joining platform i, an agent from group-k receives a benefit of U_k^i, as well as an additional benefit $\alpha_k n_l^i$, $l, k = 1, 2$ ($l \neq k$) from interacting with agents from the other group who are also using the same platform, where α_l is the network benefit that agents from group l receive by using platform i, less the price p_i^k charged to each group-k by platform i.

It is assumed that the platforms are maximally differentiated so that platform A is located at 0 and platform B is located at 1. An agent from group-l located at $x \in [0, 1]$ incurs a transportation cost of $t_l x$ when she participates in platform A and $t_l(1 - x)$ when she subscribes to B. Hence the user benefit for an agent from group-k using platform i is given by

$$U_k^A(x) = \nu_k - t_k x; \quad U_k^B(x) = \nu_k - t_k(1 - x), \quad k = 1, 2, \tag{2}$$

where ν_k is the group benefit and constitutes the highest utility that agents from group-k receive from participating in this market. It is assumed that ν_k, $k = 1, 2$, is sufficiently high for both groups to warrant their participation. For simplicity, we assume that the cost of servicing an agent from each group is equal to zero. We will also assume that $t_k > \alpha_k$ for $k = 1, 2$. This assumption implies that multi-homing cost are high relative to network benefits and consumers will prefer to use a single platform (i.e., single home).

The profit function of platform i is

$$\pi^i = (p_1^i) n_1^i + (p_2^i) n_2^i, \quad i = A, B \tag{3}$$

Using the profit function (3) and the demand schedules generated from (1) and (2), the optimal pricing strategies of the two firms can be solved mathematically. The necessary and sufficient condition for a market-sharing equilibrium is

$$4 t_1 t_2 > (\alpha_1 + \alpha_2)^2. \tag{4}$$

With this assumption, the concavity of both platform firms' profit functions is guaranteed and there exists a unique consistent demand configuration for non-negative platform prices.[1]

Proposition 1 Where $t_l > \alpha_k$, for $k, l = 1, 2$ and $k \neq l$, the unique symmetric equilibrium prices in markets 1 and market 2 and are:

$$p_1 = t_1 - \alpha_2; \quad p_2 = t_2 - \alpha_1. \tag{5}$$

The profit and final demand equations for firm i can be expressed by

$$\pi^i = \frac{t_1 + t_2 - \alpha_1 - \alpha_2}{2}, \quad i = A, B. \tag{6}$$

and

$$n_1^i = \frac{1}{2} + \frac{\alpha_1(p_2^j - p_2^i) + t_2(p_1^j - p_1^i)}{2(t_1 t_2 - \alpha_1 \alpha_2)}; \quad n_2^i = \frac{1}{2} + \frac{\alpha_2(p_1^j - p_1^i) + t_1(p_2^j - p_2^i)}{2(t_1 t_2 - \alpha_1 \alpha_2)}, \tag{7}$$

for $i, j = A, B$ and $i \neq j$.

Equation (6) shows that equilibrium profit has a negative relationship with the network benefit parameters $\{\alpha_1, \alpha_2\}$ and a positive relationship with transportation costs parameters $\{t_1, t_2\}$. As mentioned above, the cross-group externalities increase the level of competition in a two-sided market. As shown in the demand functions (7), losing market share on one side will cause a market share loss on the other side. In this sense, a platform needs to perform well on both sides of the market. Such a setting effectively intensifies competition, which leads to a fall in platform price and profit. Conversely, with product differentiation, platforms can behave like local monopolies and charge prices higher than marginal costs, hence this explains the positive relationship between transportation costs and profits. This is consistent with the argument made regarding the relationship between prices and transportation costs, which says that platforms can charge prices above marginal costs when there is product differentiation.

2.1 Hypotheses

The purpose of the paper is to validate the theoretical predictions of Armstrong (2006). For this we vary the level of cross-market externalities and product differentiation and examine the comparative statics.

[1] See Armstrong (2006) for the proof.

To simplify the experiment, we impose asymmetry in cross-group externality effects, such that only Group 2 cares about the participation of Group 1, but not the other way around ($\alpha_1 = 0$ and $\alpha_2 > 0$). As a direct consequence, a firm's market share in Group 1 depends only on prices of both firms while Group 2 market share is endogenous to that particular firm's Group 1 market share. We vary α_2 across treatments to examine the effect of network benefits on prices. Besides that, as this paper is interested in the effects of product differentiation on prices, the transportation costs incurred by Group 1 (t_1) agents is varied across treatments. The direct implication of positive transportation costs is that the firms cannot capture the whole market with marginal undercutting.

The main hypotheses to be tested follows the pricing equation (5) and can be outlined below:

Hypothesis 1: The prices charged to the agents from Group 1 decrease with the level of network benefits to Group 2.

Hypothesis 2: As the transportation costs incurred by agents from Group 1 increases, so do the prices charged to these agents for platform access.

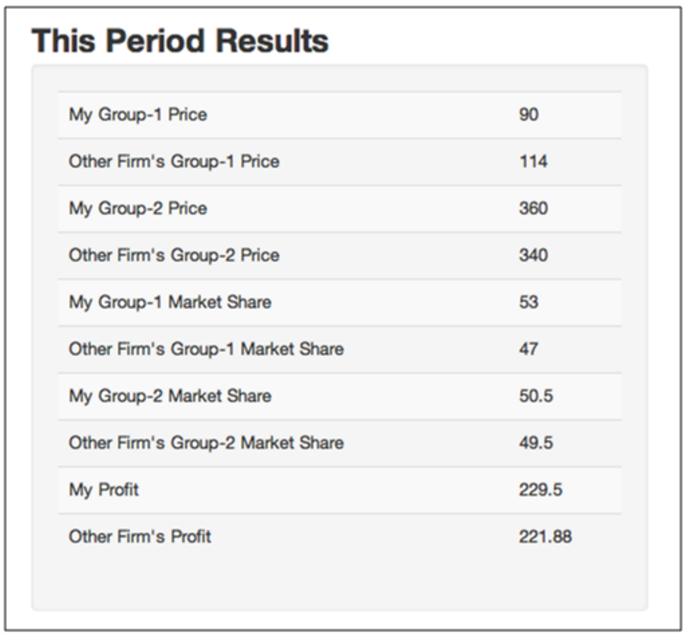
3 Experimental Design

The experimental market environment consists of two platforms and two groups of consumers (Group 1 and Group 2). In line with the price-taking assumption, each group consumers of platform services are uniformly distributed along the line of unit length, with platform firms located at opposite ends of the lines. Subjects take the role of competing platform firms, simultaneously selecting prices charged to the two consumer groups. Once prices are decided (four prices in each market), market shares of each firm in both groups are calculated using demand equation (7). The prices, profits and market shares for each platform are derived using formulae in equations (5) - (6). The parameters used in each treatments and the resulting equilibrium prices and profits are summarised in Table 1.

Treatment	No. of Subjects	Independent markets	Parameter Values				Predictions		
			t_1	t_2	α_1	a_2	p_1	p_2	π
T600E400	20	5	600	600	0	400	200	600	400
T600E200	20	5	600	600	0	200	400	600	500
T400E400	20	5	400	600	0	400	0	600	300
T400E200	20	5	400	600	0	200	200	600	400

Table 1: Experimental design parameters and predicted prices and profits

The experimental sessions were run in the Experimental Economics Laboratory at the University of Queensland using an experimental interface programmed using the Java programming language. The interface was accessed by subjects online with a compatible internet browser such as Google Chrome or Safari. Programming the experiment in Java has provided a high level of flexibility in developing the experimental software, particularly in the graphical user interface design.[2] A total of eighty individuals, mainly undergraduate students from varied educational backgrounds, participated in the experiment. Each treatment was conducted in two separate sessions with either two or three independent matching groups, adding up to a total of five for every treatment. Each session lasted approximately 1.5 hours, with an average monetary payoff of $23 AUD.


This Period Results

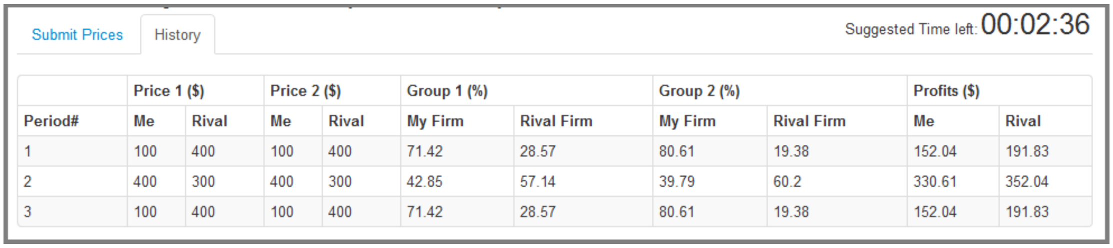
My Group-1 Price	90
Other Firm's Group-1 Price	114
My Group-2 Price	360
Other Firm's Group-2 Price	340
My Group-1 Market Share	53
Other Firm's Group-1 Market Share	47
My Group-2 Market Share	50.5
Other Firm's Group-2 Market Share	49.5
My Profit	229.5
Other Firm's Profit	221.88

Figure 1: Feedback screen

In each matching group, there were 4 participants and they were randomly paired to form two markets. The random pairing process within each matching group was repeated in every period. This procedure was implemented to avoid collusion, which would obfuscate the effect of cross-market externalities and consumer preferences on the pricing decisions of subjects. Subjects are allowed to set a price for each group in the interval [0,1000]. After submitting their prices, subjects are shown a feedback screen (see Figure 1) that exhibits final prices of both firms and the resulting market shares and profits. In addition, by clicking on "History" on the experimental interface

[2]For instance, the profit calculator introduced in the present experiment would not be possible were the experiment programmed in z-Tree (Fischbacher (2007)).

screen, subjects are able to access similar information and review the results from previous periods, presented in a table form (see Figure 2).



Submit Prices | History — Suggested Time left: 00:02:36

	Price 1 ($)		Price 2 ($)		Group 1 (%)		Group 2 (%)		Profits ($)	
Period#	Me	Rival	Me	Rival	My Firm	Rival Firm	My Firm	Rival Firm	Me	Rival
1	100	400	100	400	71.42	28.57	80.61	19.38	152.04	191.83
2	400	300	400	300	42.85	57.14	39.79	60.2	330.61	352.04
3	100	400	100	400	71.42	28.57	80.61	19.38	152.04	191.83

Figure 2: History table

During each period, subjects were provided with a profit calculator (see Figure 9), which they could access on their terminal. The profit calculator was embedded with the demand and profit equations, together with treatment-specific parameter values. The calculator was developed to assist subjects in making informed pricing decisions. By typing in fictitious prices from the two firms, subjects could simulate different combinations of prices and explore the consequences before deciding what prices they want to submit. Subjects could also adjust the prices by using the horizontal bars on the top left corner and observe in real time how the change in prices affects both firms' market shares and profits. There was no time restriction in each period, in the sense that subjects could take as much time as they wish in making their pricing decisions. However, there was a non-binding countdown timer on the screen that provided subjects with an indication of the amount of time they should be taking to submit their prices. The non-binding time limit was varied across periods, starting from 5 minutes in the first two periods, 3 minutes in period 3 to 10, and 2 minutes in period 11 to 30. Subjects had to wait for all other subjects in their session to make their decisions before moving to the next period.

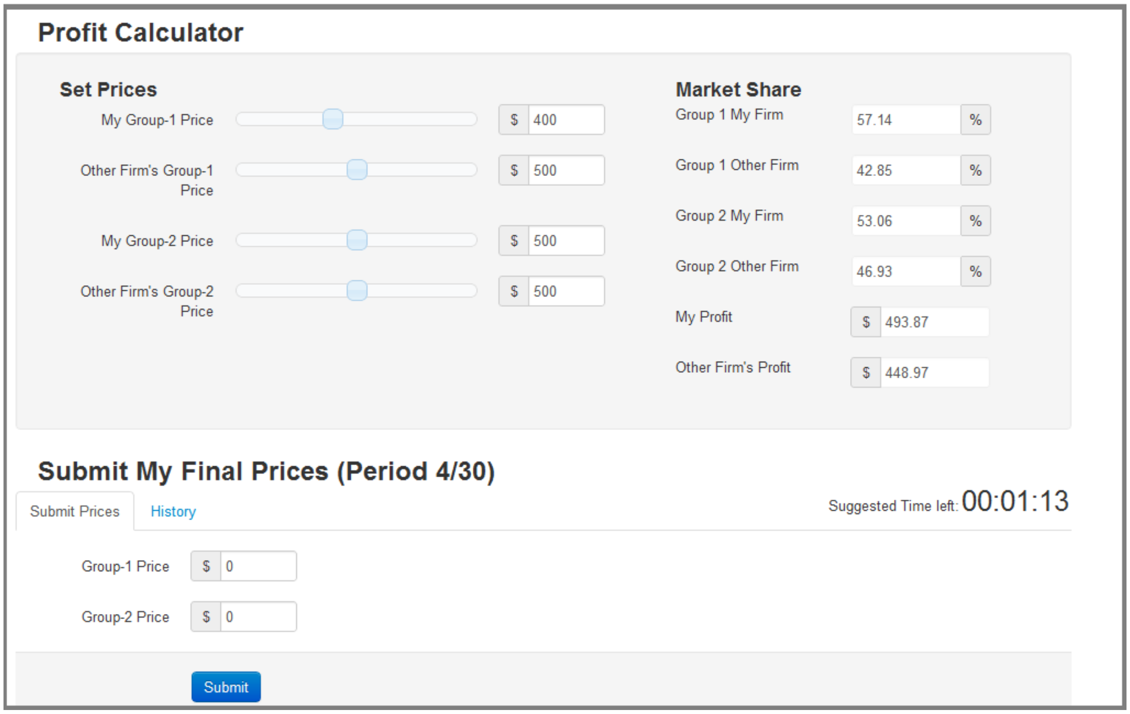


Figure 3: Profit calculator and submit prices screen

At the start of each session, participants were randomly allocated to a computer and were asked to sign a consent form. They were also randomly assigned into a matching group, made up of three other participants. While subjects were not informed about the identity of other group members, they were told that they would remain in the same group throughout the experiment. Subjects were provided with the instructions (See Appendix A) in printed form and on the terminal screen. The experimenter also read the instructions to the subjects prior to the start of the experiment. Participants were then given time to reread the instructions and resolve any inquiry privately with the experimenter. Subjects were then given a short quiz to ensure that every subject understood the instructions before the experiment commenced.

The experiment ran for 30 identical periods, where in each period the subjects would play the game with a participant randomly chosen from their respective matching group. The exchange rate between *Denar* (the experimental currency) and Australian dollar, was 15 *Denar* = 1 AUD. One of the 30 periods were selected at the end of the experiment and subjects were reimbursed privately based on their profits earned in this particular period. Subjects were told that the time limit was not binding, but were advised to abide to the suggested time. At the end of the session an informational questionnaire was conducted (See Appendix B).

The experimental setting was explained to subjects using neutral terms such as “Group 1” and

"Group 2", complemented by a market example of two local newspaper publishers dealing with advertisers and newspaper readers. To explain the Hotelling specification, subjects were told that each member from the two groups has their own preferences, hence even in the case where a firm offers a relatively low price for one of the groups, there might be some members who still prefer to purchase from the other firm with the higher price depending on the actual price difference. In the instructions, details of the parameter values were presented in the form of comparative statics. During the experiment subjects were not explicitly informed about these formulas; however they were provided with the profit calculator to calculate market shares and profits, that performs those tasks.

4 Results

This section focuses on the development of Group 1 and Group 2 prices in the experiment. Treatment effects are examined with a Wilcoxon-Mann-Whitney test using the averages of an independent matching group as the unit of observation and data from Periods 6-30. The reported p-values are one-sided, unless otherwise noted.

Recall that based on the theoretical predictions (see Table 1), the prices charged to Group 2, p_2, should not differ between treatments. This is because changes in the transportation cost t_1 and the cross-market externality α_2 are expected to impact only p_1. Figure 4 plots the median of Group 1 prices over the 30 periods for each treatment[3].

The average prices in all treatments experience an initial decline, then gradually settle on a steady state. The initial price adjustment (Periods 1-6) can be interpreted as subjects learning and familiarising themselves with the experiment. As the prices for Group 1 become increasingly stable, the price dispersion across treatments becomes more visible. This is evidenced by the average Group 1 prices across all treatments, which ranged between [29,370] *Denar* in periods 6 to 30. According to the theory, the equilibrium Group 1 price is 400 *Denar* for T600E200, 200 *Denar* for T600E400 and T400E200, and 0 *Denar* for T400E400. While, the ordinal ranking of each treatment's Group 1 price is found to be consistent with the theoretical model, the actual values are not.

[3]While we use the median price in the following analysis the results do not change qualitatively if we instead use the mean. Generally, mean prices are higher than the median prices as some subjects did attempt to collude. Recall that subjects set prices between [0,1000] *Denar* and there exists a straightforward cooperative outcome which involves both firms charging *the maximum price* to the two groups of agents.

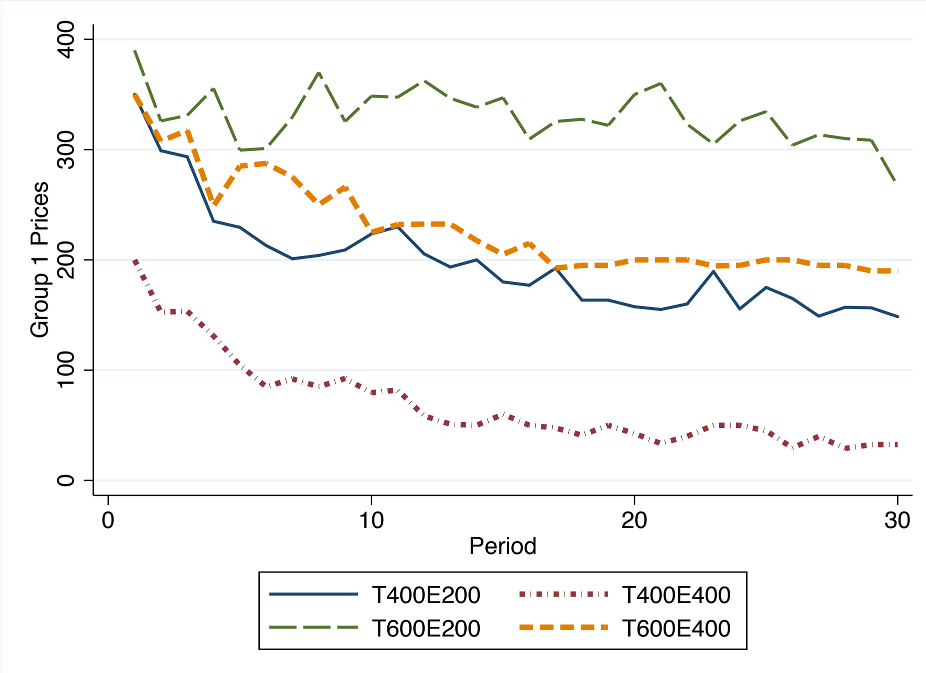


Figure 4: Group 1 prices over time

Result 1 *As the transportation costs incurred by agents from Group 1 increases, so do the prices charged to these agents for platform access.*

Average Group 1 prices in T600E200 (328.3 Denars) are significantly higher than in T400E200 (191.2 Denars; p-value =0.076). Similarly, average Group 1 prices in T600E400 (194.9 Denars) are higher than in T400E400 (69.5 Denars; p-value =0.028). Overall, these statistical results are in line with the comparative statics predictions of Armstrong (2006), that higher transportation costs lead to higher prices.

Result 2 *The prices charged to the agents from Group 1 decrease with the level of network benefits to Group 2, in which the benefits are generated from the participation of Group 1 agents.*

Average Group 1 prices in T600E200 (328.3 Denars) are significantly higher than in T600E400 (194.9 Denars; p-value =0.047). Similarly, average Group 1 prices in T400E200 (191.2 Denars) are significantly higher than in T400E400 (69.5 Denars; p-value =0.036). Again, these results are in line with the comparative statics predictions of Armstrong (2006), that higher network benefits provided by a group lead to lower prices for that group.

Figure 5 displays the average prices for Group 2 across all treatments for each time period of the experiment. Firstly, when comparing Group 1 and Group 2 prices it can be seen that the subjects are charging relatively higher prices to Group 2 consumers, on average. This is in line with the theory, which predicts higher prices charged to Group 2 consumers. The graphs also indicate that the price difference between treatments is smaller in Group 2 relative to the first consumer group. In this context, the prices are found to be closer to each other in absolute terms over the 30 periods.

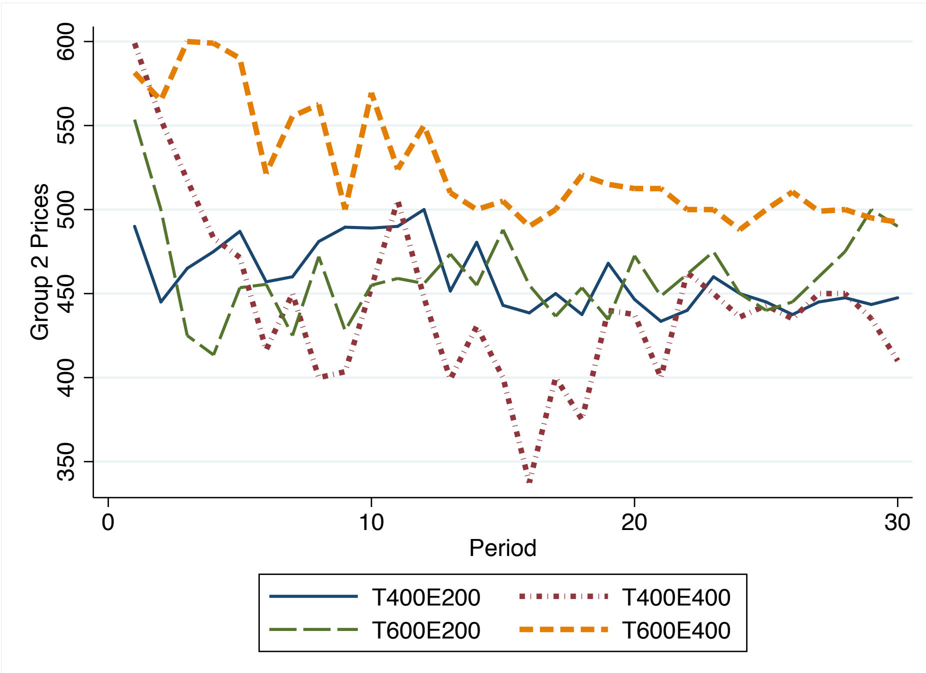
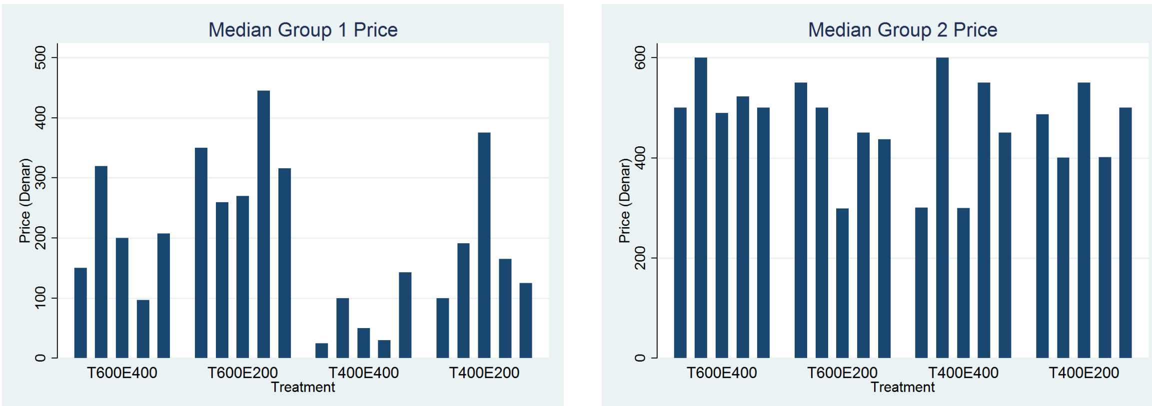


Figure 5: Median Group 2 prices over time

The average Group 2 price is 522.6 Denars in T600E400, 447.3 Denars in T600E200, 440.2 Denars in T400E400, and 467.7 Denars in T400E200. The average Group 2 prices in all treatments do not significantly differ from each other (for all treatment comparisons p-values > 0.15, two-sided). The statistical results indicate that the pricing behaviour of firms is consistent with the comparative statics predictions of the underlying theoretical model. Note that the theory predicts a uniform equilibrium price of 600 *Denar* for Group 2 across all treatments. As shown in Figure 5, each treatment's average Group 2 price is significantly below this expectation (p-values < 0.05, two-sided), exhibiting no signs of convergence to the predicted price. Furthermore, it seems that T600E400's average Group 2 price is consistently above its counterpart in other treatments, while the remaining treatments are overlapping with each other for the most part of the experiment. These observations therefore depart from the predicted prices for Group 2 reported in Table 1.

To illustrate the heterogeneity in pricing within treatments, Figure 6 displays the average posted prices for Group 1 and Group 2 at the individual matching group level. The prices exhibit behaviour that is substantially different from each other even within the same treatment.



(a) Group 1 Prices (b) Group 2 Prices

Notes: Based on the observations from period 6 to 30.

Figure 6: Median posted Group 1 and Group 2 prices (matching group level)

Up to this point, the model in Section 2 has not been formally assessed for its performance in predicting the equilibrium prices and the magnitude of treatment effects on the prices. In fact, while the prices behave in accordance with the theory, in terms of whether they rise or fall in response to varying treatments, Fig. 4 and 5 indicate that the average prices in treatments do not necessarily converge to their predicted values. For instance, the average Group 1 price in T600E200 is found to deviate from its predicted price of 400 *Denar*. Likewise, the results from other treatments also display a similar pattern. This observation is expressed in the following result:

Result 3 *The effects of both transportation costs and network benefits on market prices were consistent with the relationships suggested in Armstrong (2006). However, the magnitude of both relationships was less than the unit (one to one) relationship implied by the theory.*

To have a deeper understanding of why this happens, a random effects regression with Group 1 price as the dependent variable is conducted (see Table 2). The random effects model is chosen as it allows for identification of explanatory variables which do not vary over each period, as opposed to the fixed effects model which eliminates such factors. Also, four variants of the random effects model are estimated. The first column results are derived from the general model which includes all possible explanatory variables. In Column 2, the variables found insignificant in the first attempt are eliminated unless the theory suggests otherwise. Column 3 adopts robust standard errors clustered at independent group level since observations are likely to correlate within matching groups. The last column is identical to Column 3 other than it is based on the observations from period 26 to 30. The results from Columns 3 and 4 are taken as the most accurate estimates for the analysis purposes. This approach will be applied throughout this section.

Table 2: Group 1 price regression estimates

	(1)	(2)	$(3)^{+}$	$(4)^{+\#}$
Constant	126.080	67.587	67.587	35.700
	(117.626)	(77.239)	(116.670)	(100.174)
Group 1 transport costs (t_1)	0.757^{***}	0.765^{***}	0.765^{***}	0.682^{***}
	(0.135)	(0.129)	(0.169)	(0.148)
Group 2 network benefits (α_2)	-0.478^{***}	-0.504^{***}	-0.504^{***}	-0.599^{***}
	(0.132)	(0.129)	(0.169)	(0.148)
Period	-4.534^{***}	-4.542^{***}	-4.542^{***}	−3.746
	(0.345)	(0.344)	(1.535)	(2.241)
Time	-0.266^{***}	-0.269^{***}	−0.269	
	(0.067)	(0.067)	(0.180)	
Gender	−16.554			
	(26.827)			
Age	−1.912			
	(3.484)			
Max market share	−64.653			
	(44.162)			
Higher profit	−26.116			
	(30.672)			
Others	42.474			
	(61.488)			
# of observations	2000	2000	2000	400

Notes: Linear regression with subject random effects;
$^{+}$ indicates standard errors clustered at independent group level.
* indicates statistical significance at 10%; ** at 5%; *** at 1%.
Time refers to the amount of time taken (in seconds) for the subject to submit prices
Max profit (base case), *Max market share*, *Higher profit* and *Others* are strategy dummy variables chosen by the subject.
$^{\#}$ *Period*>25

In the post-experiment questionnaire, subjects are asked to describe their strategies by choosing one of the followings: maximise profit; maximise market shares; earn a higher profit than opponent; or others. As illustrated in Column 1, with "maximise profit" strategy being the base case, the coefficient estimate of other strategy dummies are statistically insignificant, meaning that these strategies do not significantly affect how subjects select their prices for Group 1. Similarly, the constant term, *Age* and *Gender* variables are also not significant. Column 1 indicates that the Group 1 prices are significantly affected by variables *Group 1 transport costs, Group 2 network benefits*, *Period* and *Time*. Nevertheless, the use of robust standard errors means that the *Time* variable becomes insignificant (p-val=0.135) as shown in Column 3. Likewise, in the model based on the observations from period 26 to 30, the *Period* variable is considered insignificant at 10% level of significance (p-val=0.095). This coincides with Fig.4 which suggests that the average Group 1 prices become increasingly stable towards the end of the experiment.

Columns 3 and 4 indicate that Group 1 prices are positively affected by *Group 1 transport costs* variable while negatively affected by *Group 2 network benefits.* In absolute terms, the point estimate for t_1 is greater than the α_2 parameter, although they are not statistically different (p-val=0.892 based on Column 3). Recall that in Section 3, the equilibrium prices reveal that the *Group 1 transport costs* and *Group 2 network benefits* variables have a respective theoretical marginal effect on the Group 1 price of "1" and "-1". Clearly, this is not the case exhibited by the point estimates in the last two columns. Moreover, using Column 4 results, it is found that the 95% confidence intervals for both variables do not include their respective theoretical marginal effects, implying that these parameter values significantly differ from the theoretical benchmark.

Table 3: Group 2 price regression estimates

	(1)	(2)	$(3)^{+}$	$(4)^{+\#}$
Constant	271.230^{**}	373.965^{***}	373.965^{***}	387.306^{***}
	(107.372)	(73.023)	(73.058)	(88.818)
Group 1 transport costs (t_1)	0.217	0.192	0.192	0.098
	(0.123)	(0.121)	(0.173)	(0.195)
Group 2 network benefits (α_2)	0.202	0.218	0.218	0.209
	(0.121)	(0.120)	(0.182)	(0.196)
Period	-1.714^{***}	-1.580^{***}	-1.580	-1.116
	(0.359)	(0.324)	(1.189)	(2.292)
Time	-0.061			
	(0.070)			
Gender	-9.060			
	(24.467)			
Age	4.712			
	(3.177)			
Max market share	-102.189^{**}	-111.740^{**}	-111.740^{*}	-91.309^{*}
	(40.275)	(39.550)	(51.832)	(45.488)
Higher profit	-81.490^{***}	-92.262^{***}	-92.262^{***}	-79.429^{***}
	(27.973)	(26.765)	(22.518)	(27.508)
Others	-33.563	-26.014	-26.014	-23.052
	(56.080)	(55.534)	(76.045)	(76.742)
# of observations	2000	2000	2000	400

Notes: Linear regression with subject random effects;
$^{+}$ indicates standard errors clustered at independent group level.
* indicates statistical significance at 10%; ** indicates statistical significance at 5%;
*** indicates statistical significance at 1%.
Time refers to the amount of time taken (in seconds) for the subject to submit prices
Max profit (base case), *Max market share*, *Higher profit* and *Others* are strategy dummy variables chosen by the subject.
$^{\#}$ *Period*>25

Table 3 reports random effects regression results regarding Group 2 prices. The variables *Group 1 transport costs* and *Group 2 network benefits* do not have a significant impact on Group 2 prices, and this is in line with the theory. Furthermore, in Table 3 the dummy variables *Max market share* and *Higher profit* remain significant even when robust standard errors are used. This suggest that subjects choosing one of these strategies will post Group 2 prices that are significantly lower than subjects who described themselves as profit maximisers. This implies that subjects' strategies do affect their behaviour during the experiment, potentially causing the results to deviate from the equilibrium outcome. This leads to the following result

Result 4 *Subjects that did not describe themselves as profit maximisers in the experiment set Group 2 prices significantly lower than those who did.*

4.1 Profits

According to the theory, the equilibrium profit is 500 *Denar* for T600E200, 400 *Denar* for T600E400 and T400E200, and 300 *Denar* for T400E400. Fig. 7 illustrates the development of average firms' profits across periods. First, it is no surprise that the average profits have not converged to their equilibrium predictions given the preceding discussion regarding the observed prices. Firms in T600E200 earn the highest profits on average, followed by T600E400, T400E200 and T400E400.

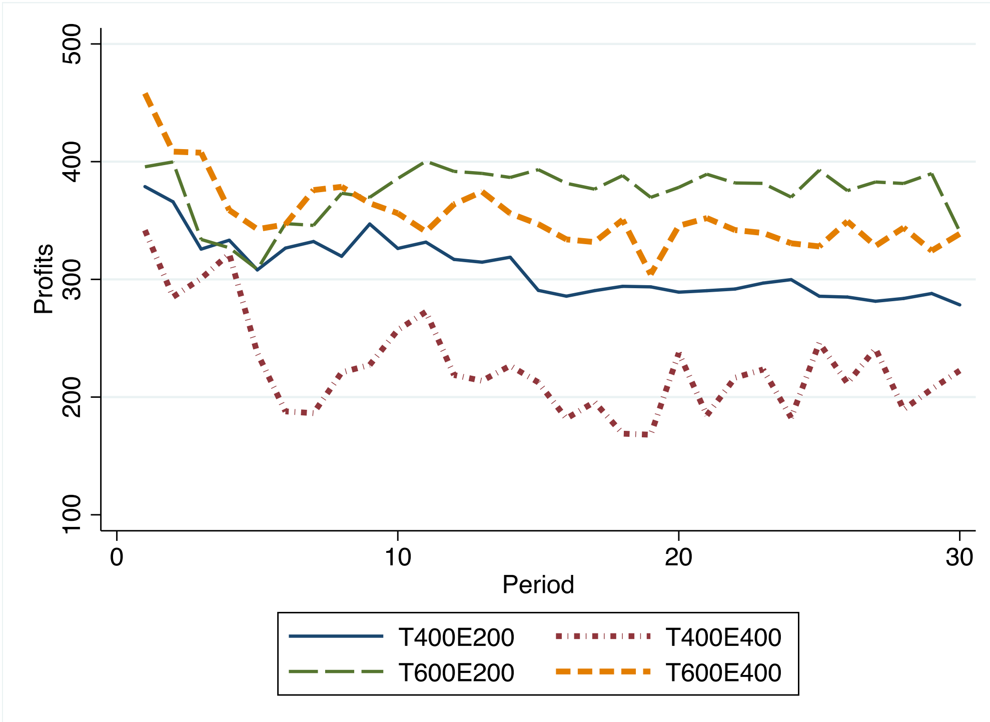


Figure 7: Average Profit (median)

Theoretically, the equilibrium profit is negatively affected by the network benefits parameters and positively affected by the transportation costs parameters. Recall that the difference between T600E400 and T600E200 falls on their respective α_2 parameter values. Similarly, this applies to the treatment pair T400E400 and T400E200. Nevertheless, the average profits in T600E400 and T600E200 are not significantly different. Conversely, firms in T400E200 are found to earn a higher profit than those in T400E400 (p-val=0.076).

Likewise, treatments T600E400 and T400E400 differ in their parameter value of t_1, with the former having a larger Group 1 transportation cost parameter. T600E200 and T400E200 can be separated by the same aspect. As indicated by the results, there is no significant difference in firms' profits between T600E200 and T400E200 (p-val=0.347) while median profit in T600E400 are significantly larger than T400E400 (p-val=0.047). Therefore, it cannot be concluded that the relationships specified by the theory are observed in the experiment.

Table 4: Firm's profit regression estimates

	(1)	(2)	(3)$^{+}$	(4)$^{+\#}$
Constant	115.841	177.083***	177.083**	187.390**
	(70.134)	(47.732)	(39.462)	(83.232)
Group 1 transport costs (t_1)	0.433***	0.421***	0.421***	0.385**
	(0.080)	(0.079)	(0.148)	(0.155)
Group 2 network benefits (α_2)	−0.203**	−0.215**	−0.215	−0.234
	(0.078)	(0.079)	(0.145)	(0.159)
Period	−1.064***	−1.079***	−1.079	−1.880
	(0.350)	(0.349)	(1.043)	(2.127)
Time	0.208***	0.201***	0.201**	0.111
	(0.068)	(0.068)	(0.07)	(0.131)
Gender	2.547			
	(2.065)			
Age	2.547			
	(2.065)			
Max market share	−30.195			
	(26.179)			
Higher profit	−10.327			
	(36.464)			
Others	53.625			
	(36.464)			
# of observations	2000	2000	2000	400

Notes: Linear regression with subject random effects;
$^{+}$ indicates standard errors clustered at independent group level.
* indicates statistical significance at 10%; ** at 5%; *** at 1%.
Time refers to the amount of time taken (in seconds) for the subject to submit prices
Max profit (base case), *Max market share*, *Higher profit* and *Others* are strategy dummy variables chosen by the subject.
$^{\#}$*Period*>25

To further the investigation on this matter, a regression analysis on firm's profit is conducted (see Table 4). As noted previously, the variables t_2 and α_1 cannot be included into the model as explanatory variables as they are fixed across treatments throughout the experiment. Hence, the effects of these variables are expected to fall into the constant term. In Column 1, while the strategy dummy variables are considered insignificant, the coefficient estimate of *Max market share* and *Higher profit* suggest that subjects adopting such strategies earn a lower profit as compared to profit maximising subjects. Besides that, the constant term is significant in Columns 3 and 4, which is in line with expectation. Interestingly, Column 3 illustrates that the *Time* variable has significant explanatory power (p-value=0.004), implying that subjects who took a longer time in making their pricing decisions subsequently earned a higher profit.

According to the comparative statics, the respective theoretical marginal effects of *Group 1 transportation costs* and *Group 2 network benefits* on a firm's profit are "0.5" and "-0.5". Nevertheless, as Columns 3 and 4 reveal, while *Group 1 transportation costs* remains significant under robust standard errors, the variable *Group 2 network benefits* is considered insignificant in both models, including the regression that is based observations beyond period 25. The insignificance of *Group 2 network benefits* in explaining firm's profit comes as a surprise since it was previously shown that this variable significantly affects Group 1 prices (see Table 2). The statistical results are summarised as follows.

Result 5 *Profit earned by platform firms is positively affected by the transportation costs incurred by agents. Conversely, externality has no robust impact on a firm's profit.*

Amongst all possible explanations, Result 4 is most likely to be caused by noise aggregation. Since profit is derived from the observed prices for Group 1 and Group 2, it is highly plausible that the noise originated from two distinct sources is sufficient to significantly alter the relationship between firm's profit and network benefits specified by Armstrong (2006). For instance, Result 4 illustrates that not every subject is a profit maximiser and they adopted different strategies when setting Group 2 prices. Such variation in the pricing behaviour is likely to have contributed to the insignificance of *Group 2 network benefits.* Furthermore, note that there are only 5 independent matching groups for each treatment. The limited number of independent observations could play a role in explaining Result 4.

4.2 Strategic behaviour

Result 3 indicates a divergence between the results reported in this experiment and the predictions implied by the underlying theoretical model. This sections discusses three possible explanations, based on behavioural considerations. First, in deriving the Nash equilibrium, it is assumed that firms are profit-maximising entities and choose a pair of prices that is the best response to the expected opponent's prices (Peeters & Strobel, 2005). However, this may not be the case for every subject who participated in this experiment. In our post experiment survey, only 39 out of a possible 80 participants declared that they were trying to maximise profits in the experiment, while 35% of the participants chose "earn a higher profit than opponent" as their strategy. As reported in Result 4, the participants who did not describe themselves as profit maximisers in the experiment set Group 2 prices lower than those who did.

However, one can also see the robustness of the relationships between transportation costs, network benefits and market prices proposed by Armstrong (2006). This is even in the case where not all firms are maximising their profits, the observed effects of product differentiation and network benefits on Group 1 prices remain to be consistent with the theory. It is noteworthy to mention that while subjects' responses in the questionnaire might not necessarily reflect their actual behaviour during the experiment, this result shows that the assumption that firms set prices to maximise profits may not necessarily be the case. For a significant proportion of subjects maximising market share is a criteria used for pricing and would present one argument for the divergence between experimental and predicted equilibrium prices. This observation may inform further research in the area of platform competition.

The previous point relates to the relationship between bounded rationality and strategic environment raised in Fehr & Tyran (2008). Fehr & Tyran (2008) report that the aggregate outcome and the speed of convergence towards equilibrium are affected by the strategic environment of the market when boundedly rational agents are present. They found evidence of market converging at a much faster rate when it is characterised by strategic substitutability as opposed to complementarity. This is because the economic costs attached to making non-optimal decisions are much bigger under substitutability, meaning that there is a relatively higher incentive for subjects to play rationally. Since the present experiment is characterised by strategic complementarity, it is thus more likely to deviate from the equilibrium predictions in the presence of boundedly rational subjects. The lack of strong incentives for subjects to choose optimal prices can potentially explain Result 3.

Other than the preceding reasons, deviations from the equilibrium predictions can be explained by the complexity of the experiment. As noted in the preceding section, because there exist two consumer groups in the market, a firm's best response to a given pair of opponent's prices is not as straightforward as opposed to the one-sided case. Even though in the experiment subjects are provided with a profit calculator to assist them in computing their best response, this remains to be relatively complicated task. For instance, using the profit calculator, one can vary her Group 2 price and observes how the change in the price for such group affects her profit. In doing so, first she has to fix the opponent's prices as well as her own Group 1 price in the calculator. Clearly, while she can input the opponent's prices by referring to the history, if her own Group 1 price is not set at its optimal level given the opponent's prices, the Group 2 price that maximises her profit computed from the profit calculator would naturally not be the best response as well. Nevertheless, this does not necessarily imply that this bias would have a lasting impact on the prices. In fact, we would expect that with more periods the bias would eventually wear out. While 30 periods might not be sufficient for such learning to occur we do not observe a trend towards equilibrium prices.

5 Conclusion

The main objective of this paper is to contribute towards the empirical literature on two-sided markets. In pursuit of this aim, a price setting duopoly experiment is developed. This experiment is based on a model of two-sided single-homing market first proposed by Armstrong (2006), in which agents are only allowed to purchase from one of the two platform firms for exogenous reasons. Unlike other experimental studies of two-sided markets, human subjects played the role of platform firms while the demand from both sides of the market was computerised in the present experiment. Such a setup allows the experiment to capture the role of strategic interaction between firms and how it interplays with the firms' responses to changes in level of transportation costs and network benefits. This is in contrast to the previous experimental studies which predominantly focus on the role of consumers in determining the economic outcome of such markets.

Overall, the results from the experiment are largely in line with theoretical predictions. First, we find that there is a positive relationship between market prices and the transportation costs incurred by agents. Second, the prices paid by agents from one group are negatively affected by how the participation of this group benefits the agents from the other group. In other words, the higher the positive externalities exerted from one group, the lower the prices charged to agents in this group. However, while the effects of both transportation costs and network benefits on market prices were consistent with the relationships suggested in Armstrong (2006), empirically, the magnitude of both aforementioned relationships was less than the unit (one to one) relationship implied by the theory. In the experiment prices do not necessarily converge to the predicted equilibrium prices. Similarly, the regression results indicate that the respective marginal effects of transportation costs and network benefits on market prices are less than the theoretical benchmark. In explaining the deviations from equilibrium predictions, one of the possible reasons is that some subjects are not profit maximisers as assumed by the theoretical model. Less than 50% of the participants declared that they adopted the profit maximising strategy in the post-experiment survey. We find that subjects who are non profit maximisers exhibited behaviour that are significantly different when setting their prices as opposed to profit maximising individuals. Having said that, this has not caused a change in the relationships between transportation costs, network benefits and market prices as specified by the model, but merely the magnitude of effects caused by a change in these variables on market prices.

Finally, there are two important implications from this experiment. Firstly, the experimental results show that externality effects do matter to platform firms, in the sense that it is economically beneficial for firms to take account of these network effects when deciding their prices. Under the setting where signals are clear, there is no reason that firms will ignore how the demand from each side of the market is interconnected. In examining the market power of a firm in the two-sided context, this experiment implies that regulators should not judge the competitiveness of a market purely based on the prices paid by consumers in that market. Rather, because markets are interconnected, regulators need to take account of how the platform firm is taking advantage of its dominant position in one market (even in the case where it is charging low prices) to earn a monopoly profit in another related market.

Secondly, from a behavioral perspective, this paper provides evidence of agents reporting to use heuristics when making decisions in a market setting. Our results suggest that the use of heuristics, such as maximizing market share by managers and firm owners, can lead to outcomes that differ from theoretical benchmarks. Given that the use of heuristics, particularly in management science, has a long history due to its advantages of computational simplicity and flexibility (see (Simon, 1957) for an early discussion in the context of bounded rationality and Hilary & Hsu (2011), Hirshleifer *et al.* (2006), Malmendier & Tate (2008), Menkhoff *et al.* (2006) for applications in finance), there is a need to understand the implications for managers and firm owners in applying heuristics when making strategic decisions and how to align incentives with heuristic decision making behavior. We think that this is an important area for future research, particularly in studying platform markets with strong network effects (see Armstrong & Huck (2010) for an earlier overview of a similar argument).

References

Argentesi, Elena, & Filistrucchi, Lapo. 2007. Estimating market power in a two-sided market: The case of newspapers. *Journal of Applied Econometrics*, **22**(7), 1247–1266.

Armstrong, Mark. 2006. Competition in two-sided markets. *The RAND Journal of Economics*, **37**(3), 668–691.

Armstrong, Mark, & Huck, Steffen. 2010. Behavioral economics as applied to firms: a primer. *Competition Policy International Journal*, **6**(1), 3–45.

Caillaud, Bernard, & Jullien, Bruno. 2003. Chicken and Egg: Competition among Intermediation Service Providers. *RAND Journal of Economics*, **34**(2), 309–28.

Cason, Timothy N, & Davis, Douglas D. 1995. Price communications in a multimarket context: An experimental investigation. *Review of Industrial Organization*, **10**(6), 769–787.

Clements, Matthew T, & Ohashi, Hiroshi. 2005. Indirect network effects and the product cycle: Video games in the us, 1994–2002*. *The Journal of Industrial Economics*, **53**(4), 515–542.

Fehr, Ernst, & Tyran, Jean-Robert. 2008. Limited Rationality and Strategic Interaction: The Impact of the Strategic Environment on Nominal Inertia. *Econometrica*, **76**(2), 353–394.

Fischbacher, Urs. 2007. z-Tree: Zurich toolbox for ready-made economic experiments. *Experimental economics*, **10**(2), 171–178.

Hilary, Gilles, & Hsu, Charles. 2011. Endogenous overconfidence in managerial forecasts. *Journal of Accounting and Economics*, **51**(3), 300–313.

Hirshleifer, David, Subrahmanyam, Avanidhar, & Titman, Sheridan. 2006. Feedback and the success of irrational investors. *Journal of Financial Economics*, **81**(2), 311–338.

Hossain, Tanjim, & Morgan, John. 2009. The Quest for QWERTY. *American Economic Review*, **99**(2), 435–40.

Huck, Steffen, Normann, Hans-Theo, & Oechssler, Jörg. 2000. Does information about competitorsÕ actions increase or decrease competition in experimental oligopoly markets? *International Journal of Industrial Organization*, **18**(1), 39–57.

Jin, Ginger Zhe, & Rysman, Marc. 2015. Platform pricing at sports card conventions. *The Journal of Industrial Economics*, **63**(4), 704–735.

Kaiser, Ulrich, & Wright, Julian. 2006. Price Structure in Two-sided Markets: Evidence from the Magazine Industry. *International Journal of Industrial Organization*, **24**(1), 1–28.

Lee, Robin S. 2013. Vertical integration and exclusivity in platform and two-sided markets. *The American Economic Review*, **103**(7), 2960–3000.

Malmendier, Ulrike, & Tate, Geoffrey. 2008. Who makes acquisitions? CEO overconfidence and the market's reaction. *Journal of financial Economics*, **89**(1), 20–43.

Menkhoff, Lukas, Schmidt, Ulrich, & Brozynski, Torsten. 2006. The impact of experience on risk taking, overconfidence, and herding of fund managers: Complementary survey evidence. *European Economic Review*, **50**(7), 1753–1766.

Morgan, John, Hossain, Tanjim, & Minor, Dylan. 2011. Competing Matchmakers: An Experimental Analysis. *Management Science*, **57**(11), 1913–1925.

Orzen, Henrik, & Sefton, Martin. 2008. An Experiment on Spatial Price Competition. *International Journal of Industrial Organization*, **26**(3), 716–729.

Park, Sangin. 2004. Quantitative analysis of network externalities in competing technologies: The VCR case. *Review of Economics and Statistics*, **86**(4), 937–945.

Peeters, Ronald, & Strobel, Martin. 2005. *Differentiated Product Markets: An Experimental Test of Two Equilibrium Concepts.* Research Memoranda 020. Maastricht : METEOR, Maastricht Research School of Economics of Technology and Organization.

Rochet, Jean Charles, & Tirole, Jean. 2006. Two-sided Markets: A Progress Report. *RAND Journal of Economics*, **37**(3), 645–667.

Rysman, Marc. 2004. Competition between networks: A study of the market for yellow pages. *The Review of Economic Studies*, **71**(2), 483–512.

Rysman, Marc. 2007. An empirical analysis of payment card usage. *The Journal of Industrial Economics*, **55**(1), 1–36.

Rysman, Marc. 2009. The Economics of Two-Sided Markets. *Journal of Economic Perspectives*, **23**(3), 125–43.

Seamans, Robert, & Zhu, Feng. 2013. Responses to entry in multi-sided markets: The impact of Craigslist on local newspapers. *Management Science*, **60**(2), 476–493.

Simon, Herbert A. 1957. *Models of man; social and rational.* Wiley.

Appendix A: Instructions

Dear participant, thank you for taking part in this experiment today. Soon, you will be asked to make a series of economic decisions. You can earn yourself a monetary reward if you make good decisions. To ensure that the experiment takes place in an optimal setting, we would like you to abide to the following rules during the experiment:

- Please do not talk to other participants until the session is over.
- Please switch off your mobile phone!
- Read the instructions carefully. Should you have any questions now or during the experiment, please raise your hand and one of the experimenters will clarify your questions with you **privately**.
- You may take notes on this instruction sheet if you wish.
- After the experiment, please remain seated till your ID number is called.
- Please refrain from discussing the experiment with your fellow students as they might be participating in a similar experiment in the near future.

Your decisions are anonymous. Under no circumstances will we divulge your decisions to a third party.

You will be allocated into a group of 4 participants and shall remain in the same group throughout the experiment. The experiment lasts approximately 1.5 hours, broken down into 30 time periods. In each period, you play the game with another individual, randomly selected from your group (thus the individual may change across periods). You earn *Denar* (the experimental currency) based on the decisions made by you and other player. At the end of the experiment, 1 of the 30 periods will be randomly chosen and your earnings in that period are converted to cash using an exchange rate of 25 *Denar* = 1 AUD. Notice that the more *Denar* you earn in that period, the more cash you will receive at the end of the session.

Description

Assume a market consisting of two firms. Each firm offers goods to two groups of people, namely Group-1 and Group-2 (you can think of two newspaper publishers located in the same town, dealing with newspaper readers and advertisers). You control one firm while other player takes charge of the other firm. Responses made by members of the two groups are programmed.

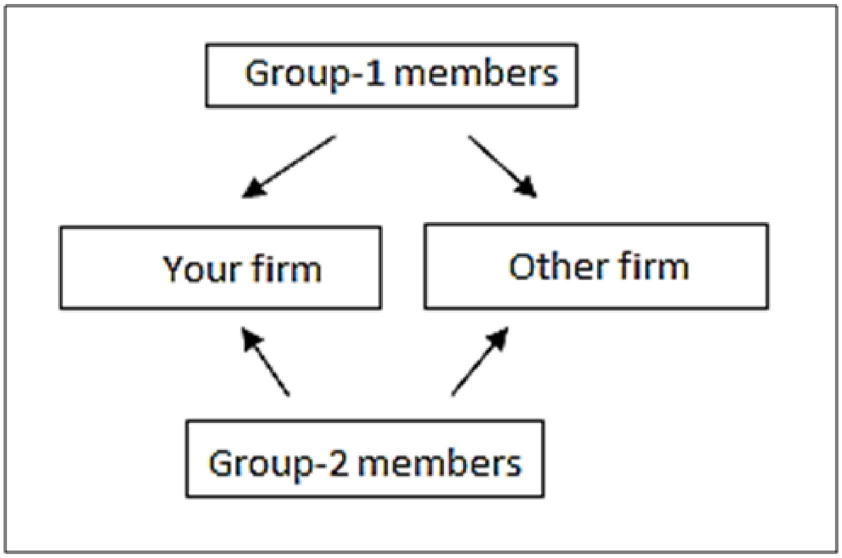


Figure 8: Stylized Market Schematic

At the beginning of every period, you and the other player each sets two prices, one for Group-1 and another for Group-2 (e.g newspaper price and advertising fee). Members of the two groups will respond to these prices. This process is repeated 30 times.

Suppose the population of the two groups is fixed and there are many Group-1 and Group-2 members. In every period, each member of the two groups must purchase **1** good. Every member will make a choice between buying from your firm or the other firm. In this experiment, a firm's "market share" in a group is defined as the percentage (%) of the group's population that buys 1 good from that firm. As every member can purchase at most 1 good in each period, if your market share in one of the groups is 40%, it must be the case where the other firm has a market share of 60% in that group. Your profit will be shown to depend only on market shares but not the actual number of goods sold.

While each member of the two groups prefers to pay a lower price, each of them also has their own preferences (for instance, newspaper readers have their "favourite" newspapers while advertisers are more inclined to publish their advertisement in a particular newspaper for demographic reasons). So, if your firm has a relatively high price for one of the groups, for example Group-1, it does not necessarily mean your firm will have 0% market share in Group-1, because depending on the actual price difference there might be Group 1 members who still prefer to purchase from your firm.

Also, suppose that **Group-2** members prefer to purchase from a firm with high market share in **Group-1** (think of advertisers wanting to advertise in a newspaper with high readership to maximise exposure), thus having more Group-1 members buying from your firm will generally increase your market share in Group-2.

More specifically:

- Your market share (%) in Group 1 depends *negatively* on your Group-1 price and *positively* on other firm's Group-1 price. Holding other prices constant, a 100 Denar decrease in your Group 1 price will raise your market share in Group 1 by 8.33 {12.5} percentage point.
- Your market share (%) in Group-2 depends *negatively* on your Group-2 price, *positively* on other firm's Group-2 price, *positively* on your market share in Group-1, and *negatively* on other firm's market share in Group-1. Holding other prices constant, a 100 Denar decrease in your Group-2 price will raise your market share in Group 2 by 8.33 percentage point. Furthermore, a 10 percentage point increase in your Group-1 market share will raise your Group-2 market share by 6.67 [3.33] percentage point.

You can set your prices to be between 0-1000 Denar (in whole numbers). The two firms do not incur any cost from selling goods to Group 1 and Group 2. Your firm's profit can be calculated based on the following formulae:

$$\begin{aligned}\text{Profit} &= \text{your Group-1 price} \times \text{your market share in Group-1(\%)} \\ &\quad + \text{your Group-2 price} \times \text{your market share in Group-2(\%)}\end{aligned}$$

During each period, you are provided with a profit calculator. At the end of each period after selecting your prices, the prices you and the other player have chosen are displayed on your terminal, along with the resulting market shares and profits.

Profit Calculator

The profit calculator computes the profits and market shares of the two firms in different scenarios. By typing in fictitious prices from you and other firm, you can test or simulate different combinations of prices and explore their consequences before submitting your prices in the "Submit Prices" section. Furthermore, you can change the prices by adjusting the bars on the left and observe how they affect the market shares and profits. For example, given the following prices:

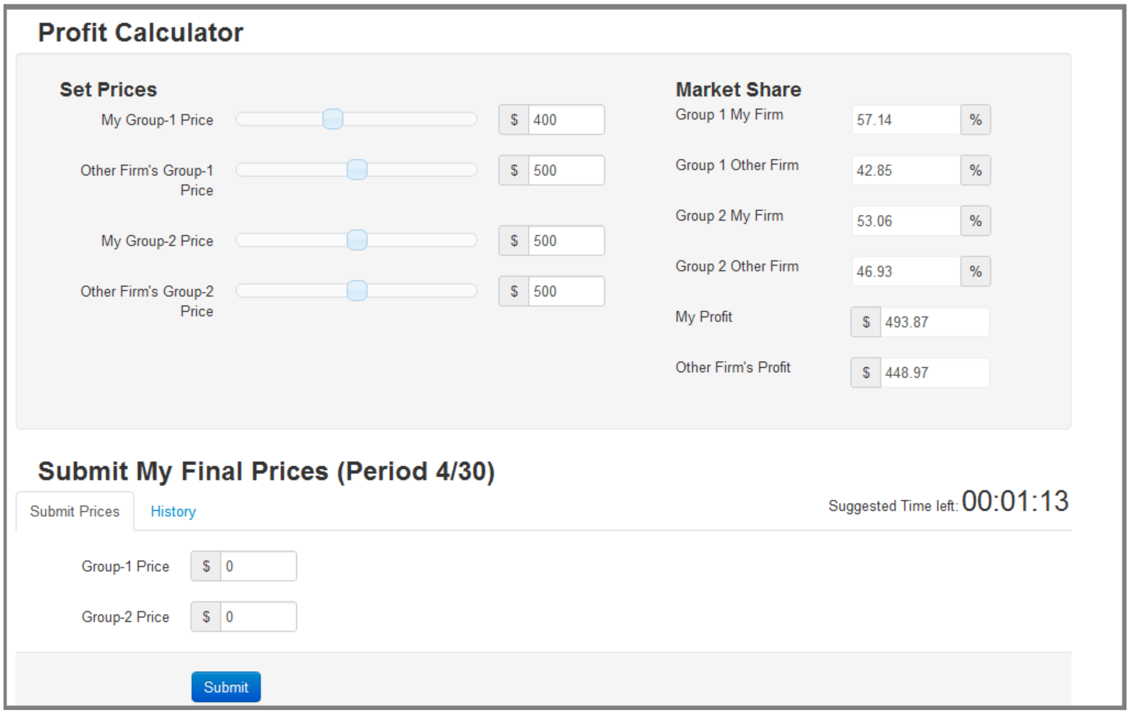


Figure 9: Profit calculator and submit prices screen

- Your Group-1 price: 500
- Your Group-2 price: 500
- Other firm's Group-1 price: 500
- Other firm's Group-2 price: 500

Each firm earns a profit of 500 Denar, with 50% market share in the two groups. Notice that your Group-1 market share increases by 8.33 percentage point when you reduce your Group-1 price by 100 Denar as mentioned in previous section.

When you begin your experiment, you will see the "**Submit Prices**" section underneath the Profit Calculator. This is where you can submit your prices. Besides that, this section shows which period you are currently in. Also, you can see the results from the previous periods by clicking on "History". The countdown timer is an indicator of the time you should be taking to make the decision. While nothing happens when the time runs out, please try to submit your prices within the suggested time frame.

Questionnaire

Please answer the following questions.

1. Does your market share in Group-1 affect your Group-2 market share? (Yes/No)

2. Does your market share in Group-2 affect your Group-1 market share? (Yes/No)

3. When your firm's market share in Group-2 is 30%, what is the other firm's market share in Group-2 (report your answer in whole numbers)?

4. What is your profit when given the following prices:

   - Your Group-1 price: 340
   - Your Group-2 price: 510
   - Other firm's Group-1 price: 202
   - Other firm's Group-2 price: 670

Appendix B: Post-Experiment Questionnaire

1. UserID:

2. Gender:

3. Age:

4. Program:

5. Where are you from: Asia / Australia / Europe / United States / Others

6. Which one best describes your strategy in the game: Maximise profit / Maximise market shares / Earn a higher profit than opponent / Others: ________

7. Other comments: