On the dynamics of mark-ups, results section

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Contents

To Do List

- ADD a first half second half indicator - done, see field `period_half`.
- Code that runs.
- Get github up and running

Data

The object `sessDat` has data from all 6 sessions.

- There are 120 subjects
- Each subject participated in 15 rounds.
- Each round had 20 subperiods. The data lists 22 subperiods.
- Subperiod `0` is the settings `player.loc` and `player.price` the subject was initialized at.
- Subperiod `21` is the `player.price` the subject would be at if the period continued.

Variables in `sessDat`

- `session.code`
- `participant.code` is a unique subject identifyer.
- `player.period_number`
- `player.subperiod_number`
- `period_half` either "First Half" or "Second Half". `NA` if period 0 or 21.

- `player.loc` location
- `player.price` price
- `player.boundary_lo` and `player.boundary_hi` are the high and low boundary for this player currently
- `group_size` number of players in the group
- `group_size_str` a string for the group size

- `player.transport_cost` shopping cost, `0.10, 0.25, 0.40, 0.60`
- `player.mc` mill cost, `0.05, 0.15, 0.25`
- `player.rp` reserve price, `0.8, 0.9, 1.0`
- `score_subperiod` this player's current score
- `score_total` currency period's total score for this player.

Summary Statistics

Summary of sessions and subjects.

Number of Players	Sessions	Subjects	Periods Per Session
Four Player	3	72	15
Two Player	3	48	15

Sessions were run at the New York University Abu Dhabi and the United Arab Emirates with undergraduate students between Oct 17 and Oct 19th, 2017.

Subjects earned on average $84.25 from the experiment. After a 30 AED show-up fee and rounding up to the 5 AED, subjects walked away on average with $114.25

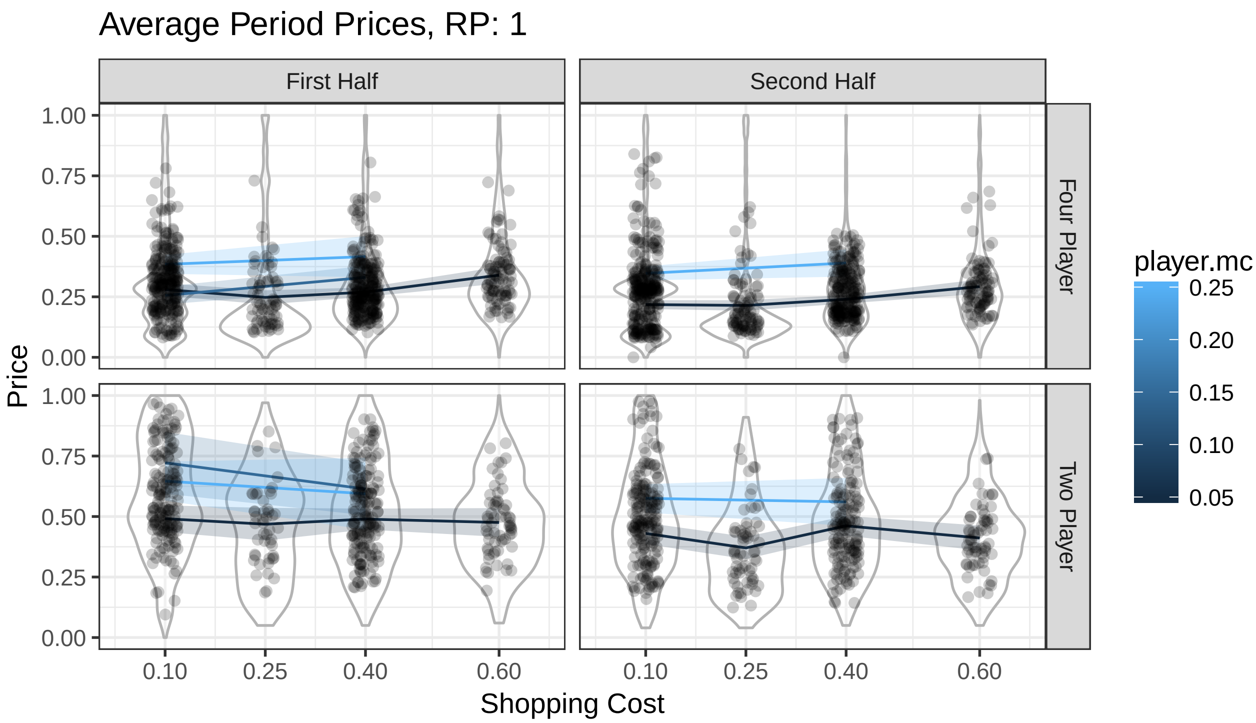
The experiment was conducted with oTree (*Citation: Chen, D.L., Schonger, M., Wickens, C., 2016. oTree - An open-source platform for laboratory, online and field experiments. Journal of Behavioral and Experimental Finance, vol 9: 88-97*) subjects were recruited with hroot (*Citation: Bock, Olaf, Ingmar Baetge & Andreas Nicklisch (2014). hroot – Hamburg registration and organization online tool. European Economic Review 71, 117-120*)

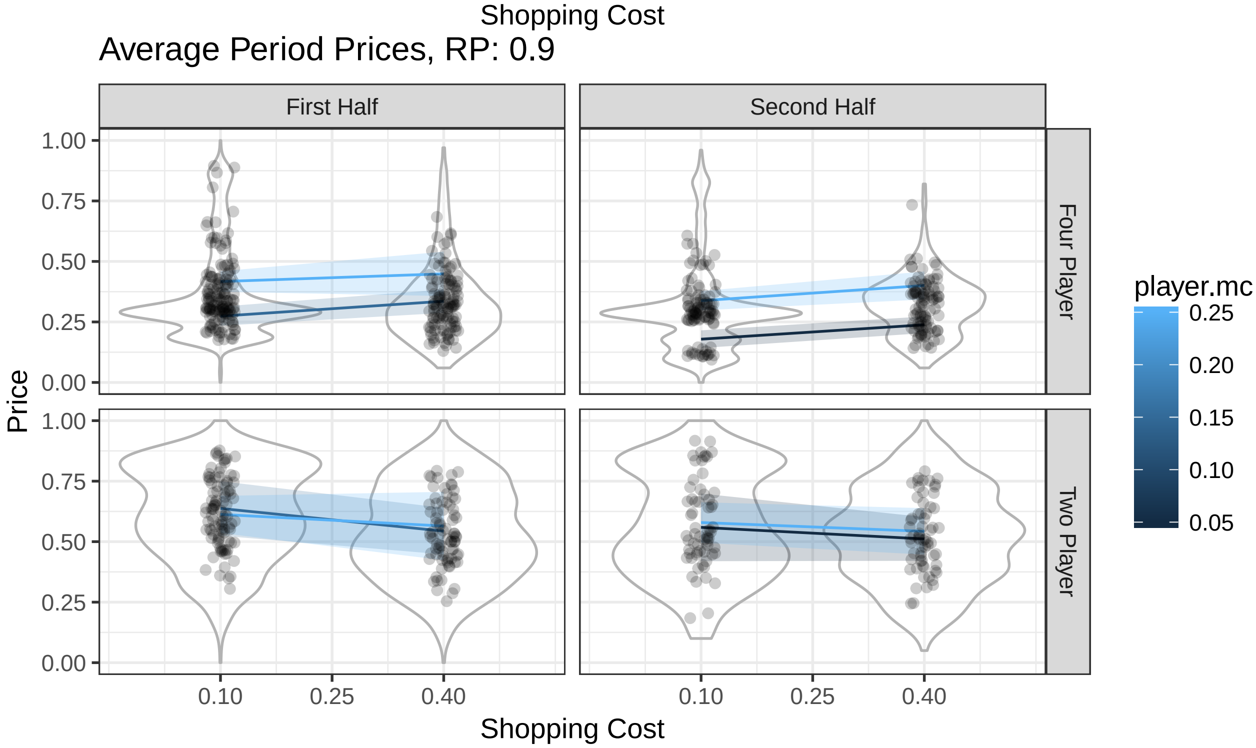
Hypothesis 1 - competitiveness and mark-ups

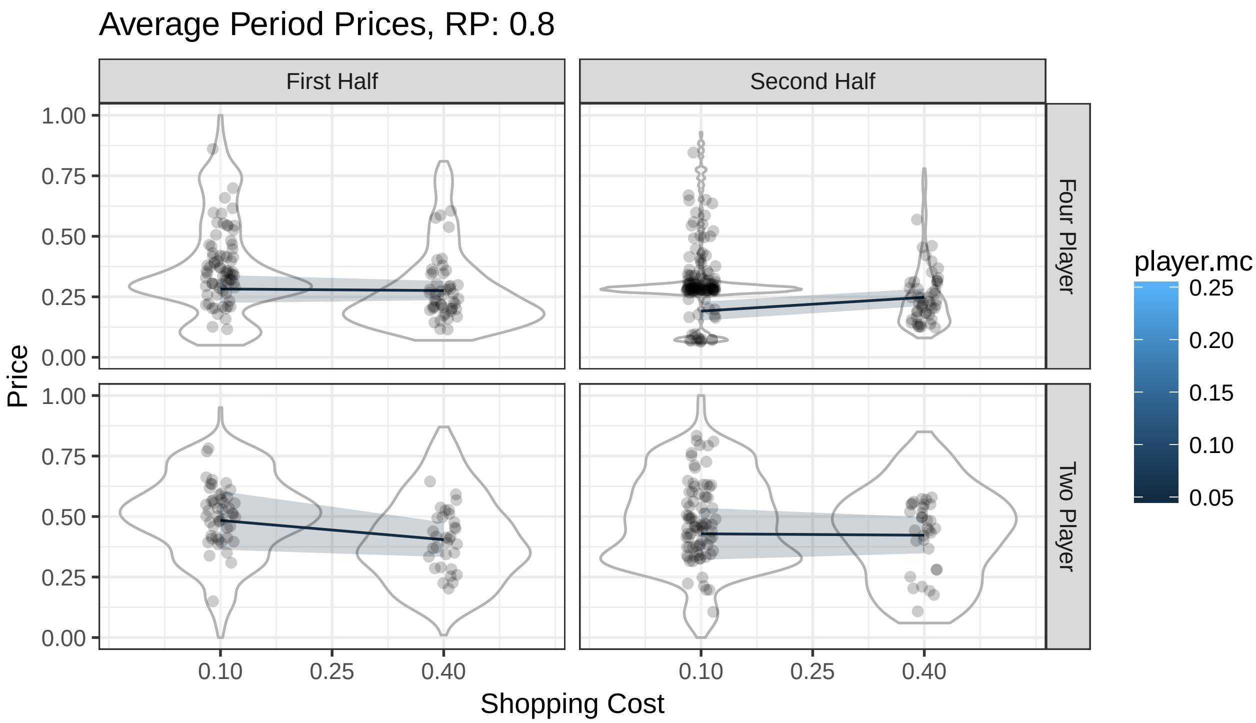
Hypothesis 1. *Static mark-ups will be lower in more competitive (higher N) markets.*

In the plot below,

- Each dot is the average price per subject in one period-half (20 subperiods, two halfs) with fixed shopping costs and player count.
- Violins are similarly based on average player-period prices.
- The line is the average price for that player-number period-half combination,
- Ribben is the confidence interval, one se plus or minus.


Average Period Prices, RP: 1
First Half
Second Half
Four Player
Two Player
Price
Shopping Cost
0.10
0.25
0.40
0.60
1.00
0.75
0.50
0.25
0.00
player.mc
0.25
0.20
0.15
0.10
0.05


Average Period Prices, RP: 0.9
First Half
Second Half
Four Player
Two Player
Price
Shopping Cost
0.10
0.25
0.40
1.00
0.75
0.50
0.25
0.00
player.mc
0.25
0.20
0.15
0.10
0.05

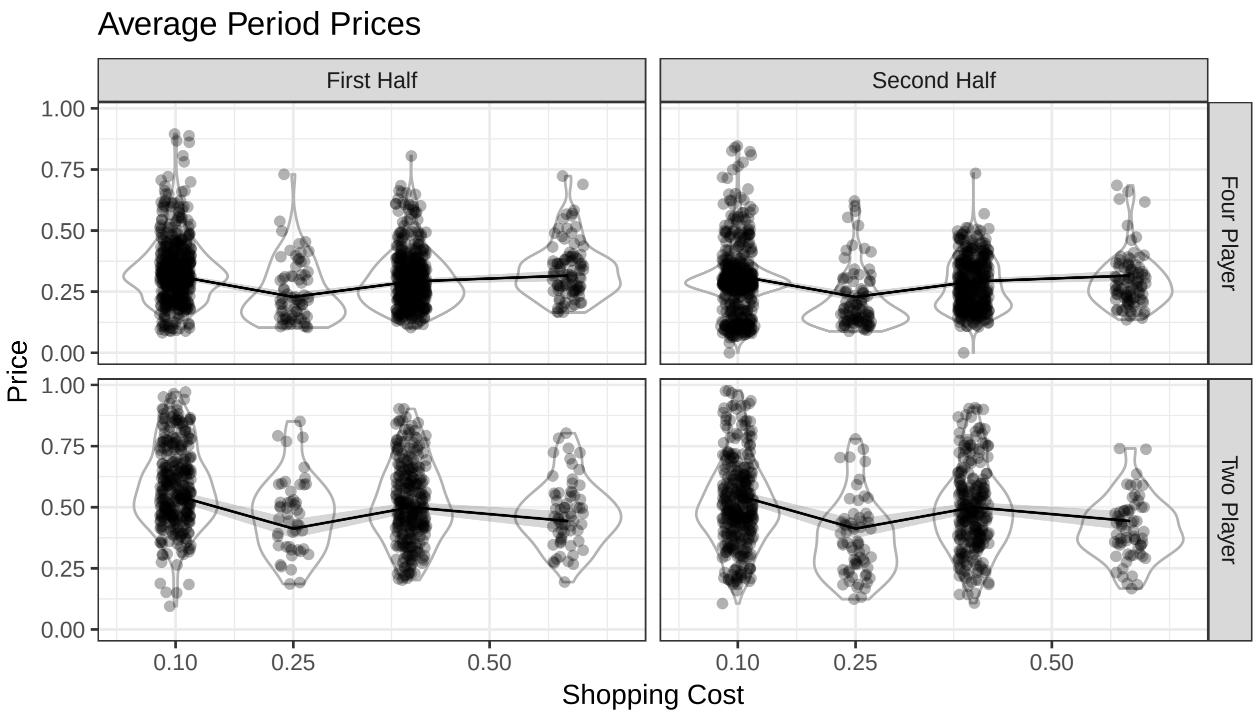


In the pilot we had a spread of transport costs from 0.1 to 1.0. Between 0.1 and 0.5 there wasn't a huge difference in price, only at 0.75 and 1.0 did we see a substantial increase in markups. In this design we only had a spread of transport costs between 0.1 and 0.6, and we don't see a consistent increase in price as transport costs increase.

- RP 0.9 is interesting.

In the plot below,

- each dot is the average price per subject in one period (20 subperiods) with fixed shopping costs and player count.
- violins are based on average player-period prices.
- the line is the average price for that player-number, shopping cost comvination,
- ribben is the confidence interval, one se plus or minus.
- A very similar plot appears when looking at all prices over all subperiods.



Comparing prices in both treatments. - We see with greater competition there are lower prices accross all shopping costs.

playerNum	0.1	0.25	0.4	0.6
Four Player	0.31 (±0.0123)	0.23 (±0.0176)	0.28 (±0.0117)	0.31 (±0.024)
Two Player	0.55 (±0.0263)	0.41 (±0.039)	0.5 (±0.0255)	0.44 (±0.0419)

Now, looking just at the later half of each period, subperiods 11 to 20, (remove from final)

playerNum	0.1	0.25	0.4	0.6
Four Player	0.31 (±0.0123)	0.23 (±0.0176)	0.28 (±0.0117)	0.31 (±0.024)
Two Player	0.55 (±0.0263)	0.41 (±0.039)	0.5 (±0.0255)	0.44 (±0.0419)

Strong evidence for Hypothesis 1.

- Looking at the average prices within a period (all 20 subperiods) with the same player number and transport cost, there is a statistically significant difference between prices at each transport level between player number treatments.
- Even comparing `t = 6.0` in the four player game – the transport cost in which the four-player game with highest prices – to `t = 0.25` in the two player game – in which prices were the lowest in the two-player game – the two player game has statistically significantly higher prices (p-value < 0.001).

```
##
##  Welch Two Sample t-test
##
## data:  player.price[(playerNum == "Two Player" & player.transport_cost ==  and player.price[(playerNu
## t = 5.5709, df = 176.38, p-value = 9.331e-08
```

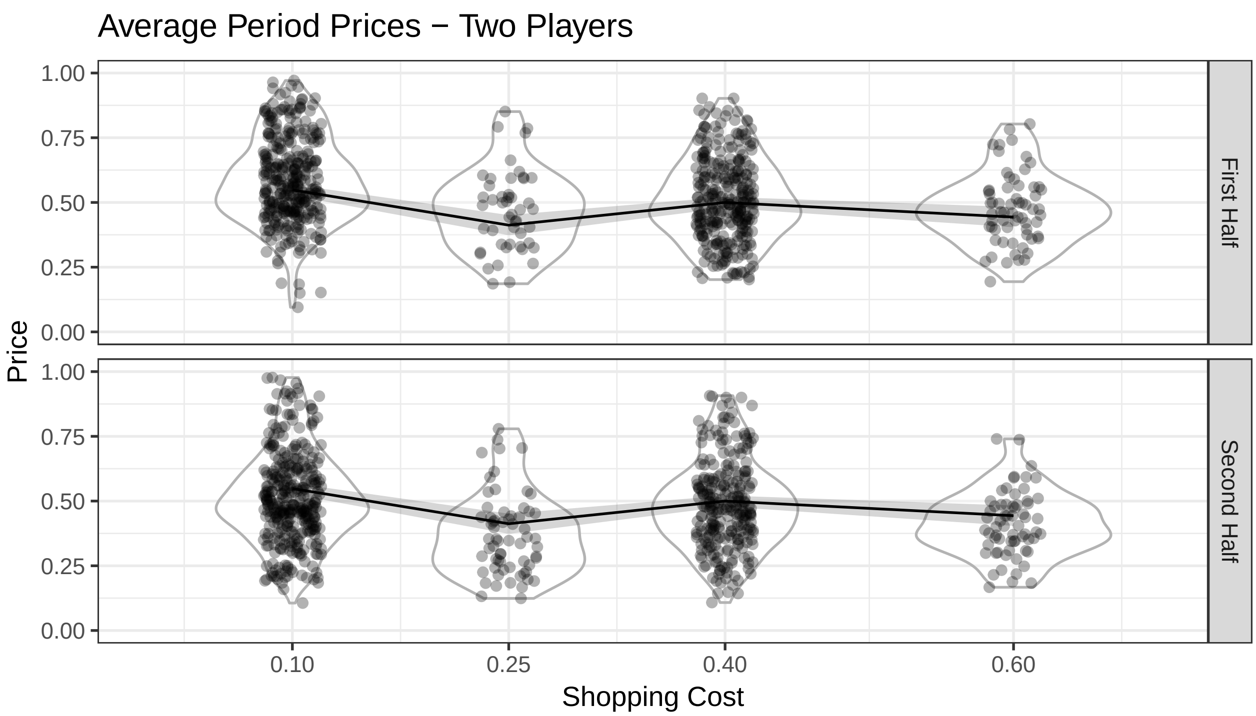
```
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.06173099 0.12946116
## sample estimates:
## mean of x mean of y
## 0.4129291 0.3173331
```

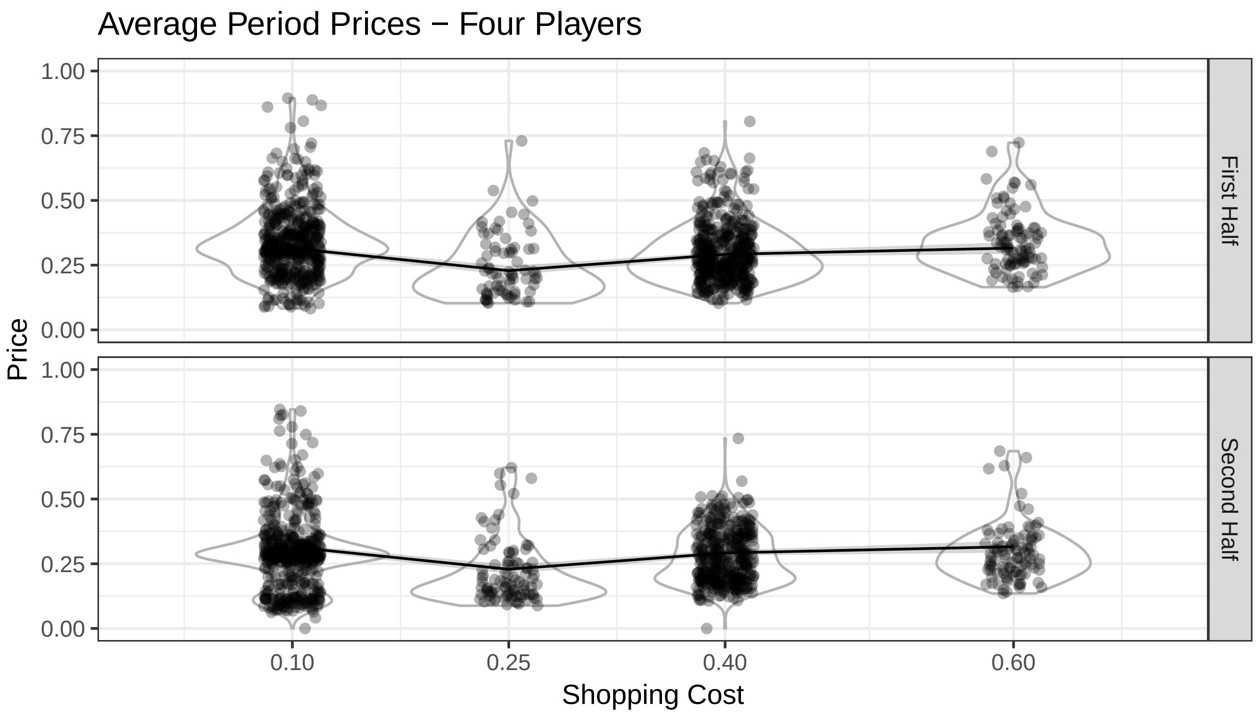
```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  player.price[(playerNum == "Two Player" & player.transport_cost ==  and player.price[(playerNu
## W = 12880, p-value = 1.696e-07
## alternative hypothesis: true location shift is not equal to 0
```

Hypothesis 2 - shipping costs and mark-ups

Hypothesis 2 - *There is a positive relationship between shopping costs and mark-ups.*

Looking at the two-player game





	Shopping Cost	N	Mean Price	Median Price	Standard Error
Four Player	0.10	648	0.312	0.303	0.005
Four Player	0.25	168	0.229	0.195	0.009
Four Player	0.40	576	0.280	0.260	0.004
Four Player	0.60	168	0.311	0.299	0.008
Two Player	0.10	432	0.547	0.523	0.008
Two Player	0.25	112	0.412	0.404	0.015
Two Player	0.40	384	0.500	0.482	0.008
Two Player	0.60	112	0.443	0.436	0.012

Recall there were 72 subjects in the four-player treatment and 48 subjects in the two-player treatment.

Initial Look at Two-Player Game

First, within the two player game, comparing prices in `t = 0.1` and `t = 0.6` (see below), there is to be a statistically significant difference.

There is a relationship between prices and shopping cost treatments. In higher shopping cost settings subjects tended to have higher prices.

- Unit of observation is an individual's average price within a period, at a set shopping cost level.
- A t test comparing prices between min and max shopping costs. Prices are average price at the session, participant, and period level. P-value 2.867e-11
- A MW rank sum test comparing prices between min and max shopping costs. Prices are average price at the session, participant, and period level. P-value 1.12e-09

```
##
##  Welch Two Sample t-test
##
## data:  mean_price[player.transport_cost == 0.1] and mean_price[player.transport_cost == 0.6]
```

```
## t = 7.0137, df = 218.42, p-value = 2.867e-11
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.0748557 0.1333672
## sample estimates:
## mean of x mean of y
## 0.5472454 0.4431339
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  mean_price[player.transport_cost == 0.1] and mean_price[player.transport_cost == 0.6]
## W = 33222, p-value = 1.12e-09
## alternative hypothesis: true location shift is not equal to 0
```

Initial Look at Four-Player Game

In the four-player game the relationship, at least between the lowest and highest shopping cost, does not appear stronger.

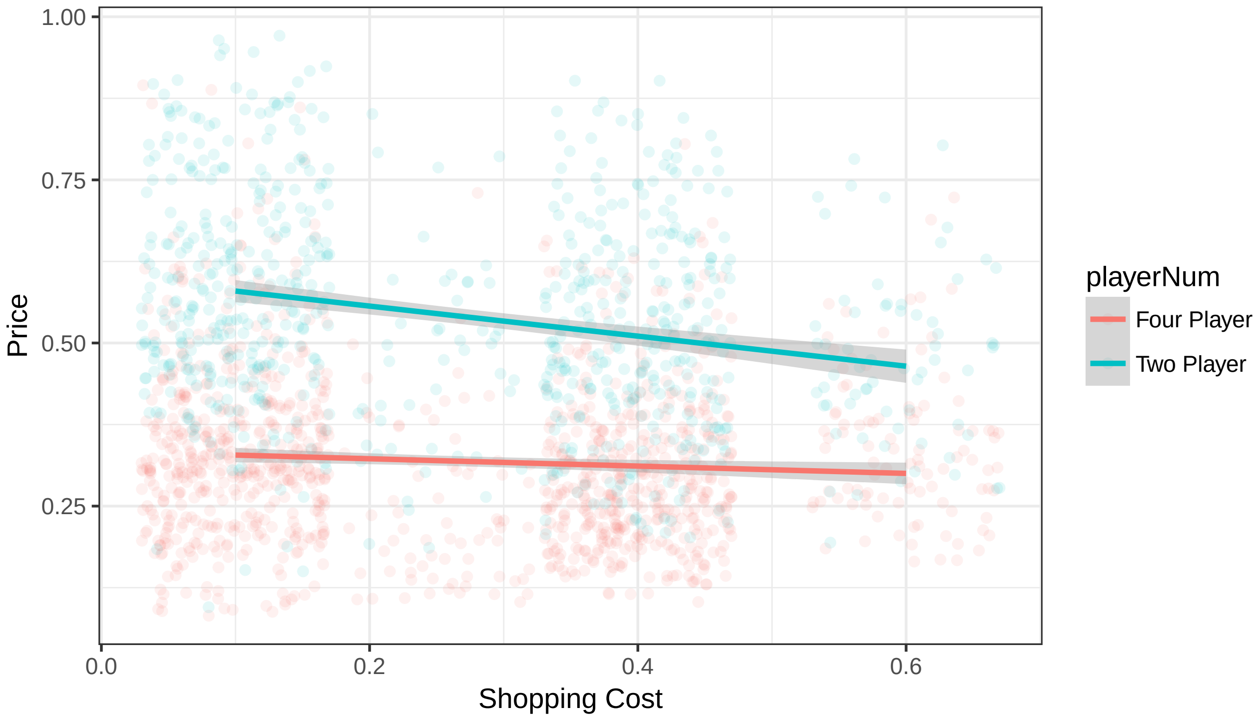
- A t test comparing prices between min and max shopping costs. Prices are average price at the session, participant, and period level. P-value 0.9459.
- A MW rank sum test comparing prices between min and max shopping costs. Prices are average price at the session, participant, and period level. P-value = 0.8919

```
##
##  Welch Two Sample t-test
##
## data:  mean_price[player.transport_cost == 0.1] and mean_price[player.transport_cost == 0.6]
## t = 0.06797, df = 310.47, p-value = 0.9459
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.01850285  0.01982693
## sample estimates:
## mean of x mean of y
## 0.3118495 0.3111875
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  mean_price[player.transport_cost == 0.1] and mean_price[player.transport_cost == 0.6]
## W = 54802, p-value = 0.8919
## alternative hypothesis: true location shift is not equal to 0
```

Model

Only looking at the first half of periods



Here we have a log-log model regressing prices on shopping costs, with player-number fixed effects.

$ln(P_{ip}) = \beta_0 + \beta_1\delta_i + \beta_2 ln(S_{ip}) + \beta_3 Period_p + \epsilon_{(ip)}$

```
##
## Call:
## lm(formula = log(price) ~ playerNum + log(player.transport_cost) +
##     player.period_number, data = df %>% mutate(price = price +
##     0.01))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.66267 -0.22208  0.01354  0.24857  1.05850
##
## Coefficients:
##                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)                -1.272706   0.025519 -49.873  < 2e-16 ***
## playerNumTwo Player         0.540056   0.017600  30.685  < 2e-16 ***
## log(player.transport_cost) -0.074936   0.012182  -6.151 9.45e-10 ***
## player.period_number       -0.003878   0.002013  -1.926   0.0542 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3658 on 1796 degrees of freedom
## Multiple R-squared:  0.3532, Adjusted R-squared:  0.3521
## F-statistic: 326.9 on 3 and 1796 DF,  p-value: < 2.2e-16
```

- Where P_{ip} is the average price for for this participant in this period, the average of 20 sub-periods.
- δ_i is an indicator equal to 1 if individual i participated in the two-player treatment.
- S_ip is the shopping cost this individual faced in this period.
- where $Period_p$ is the period number. Period fixed effects.

In this specification, the coefficient β_2 measures the average effect of being assigned to the less competitive two-player treatment group. With $\beta_2 = -0.056040$, a 1% increase in shopping costs leads to a -5.6% decrease in prices. This is significant.

Hypothesis 3 - mark-up responsiveness to competition

Hypothesis 3. *Mark-ups will be less responsive to changes in shopping costs in less competitive (lower N) markets.*

$ln(Price_{(i,p)}) = \beta_0 + \beta_1 \delta_{2p} + \beta_2 ln(ShoppingCost) + \beta_3 \delta_i ln(ShoppingCost) + \epsilon_{(i,p)}$

```
##
## Call:
## lm(formula = log(price) ~ playerNum + log(player.transport_cost) +
##     playerNum:log(player.transport_cost), data = df %>% mutate(price = price +
##     0.01))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.68752 -0.22339  0.01848  0.25154  1.05189
##
## Coefficients:
##                                                Estimate Std. Error t value
## (Intercept)                                    -1.26325    0.02628 -48.071
## playerNumTwo Player                             0.45058    0.04155  10.844
## log(player.transport_cost)                     -0.04844    0.01558  -3.108
## playerNumTwo Player:log(player.transport_cost) -0.05857    0.02464  -2.377
##                                                Pr(>|t|)
## (Intercept)                                     < 2e-16 ***
## playerNumTwo Player                             < 2e-16 ***
## log(player.transport_cost)                      0.00191 **
## playerNumTwo Player:log(player.transport_cost)  0.01756 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3656 on 1796 degrees of freedom
## Multiple R-squared:  0.3539, Adjusted R-squared:  0.3528
## F-statistic: 327.9 on 3 and 1796 DF,  p-value: < 2.2e-16
```

The coefficient β_2 estimates that a 1% increase in shopping costs will leave to a 3.4% decrease in prices in the four-player game. The β_3 coefficient indicates *a one unit increase in shopping cost leads to a 5.9% decrease in prices in the two-player game relative to the 4-player game*".

Dependent Var: $ln(P_{ip})$	Model 1		Model 2	
δ_i (two-player)	0.559101	***	0.45058	***
	(0.015870)		(0.04155)	
$ln(ShoppingCost)$	-0.056040	***	-0.04844	***
	(0.011023)		(0.01558)	
$\delta_i \cdot ln(ShoppingCost)$			-0.05857	*
			(0.02464)	
N	552		552	

Hypothesis 4 - Collusion and Shopping Costs

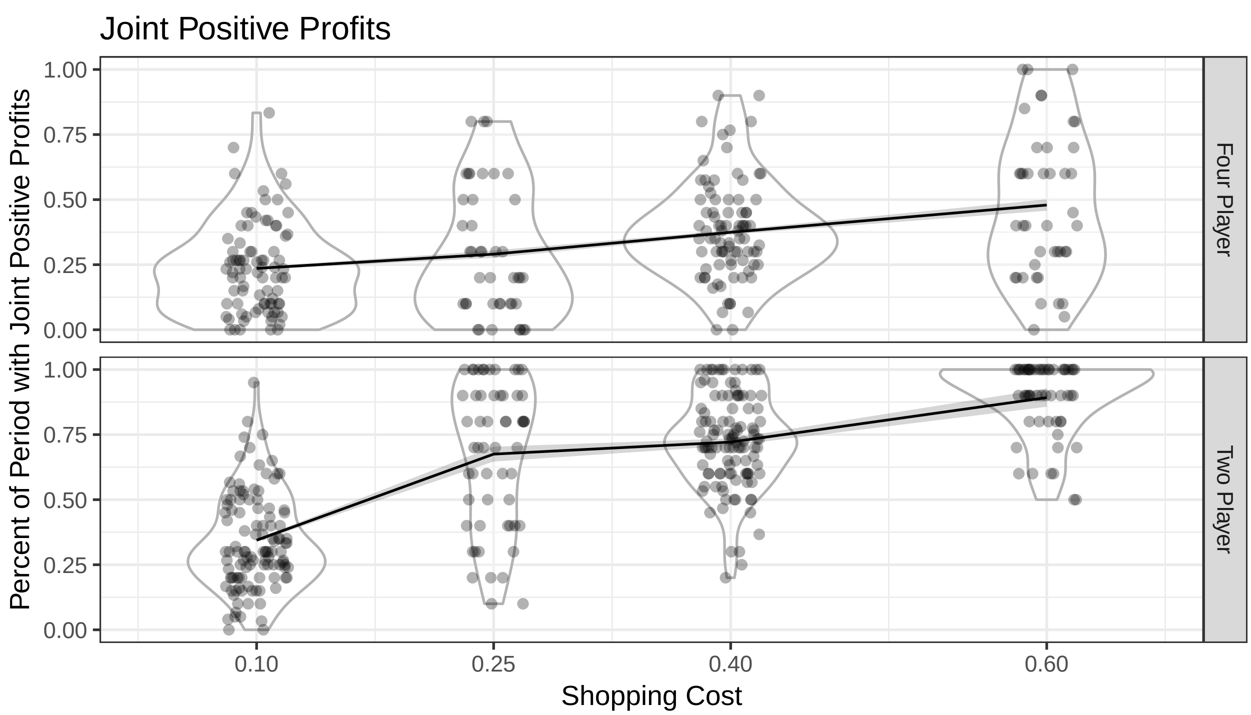
Hypothesis 4. *Collusion will be easier to form in low shopping cost environments*

Define collusion

Idea 1 - Joint positive profits.

A subject is said to be 'colluding' when they and their adjacent players have jointly positive profits. - In the save of the two-player game, both players' profits are positive. In the case of the four-player game, the profits of the two players to the left and right (circle marketplace) are positive. - This poses of problem in comparing "collusion" between two and four-player games. So we should not do that. - Look at violines for bit - bi-modal splits in distribution.

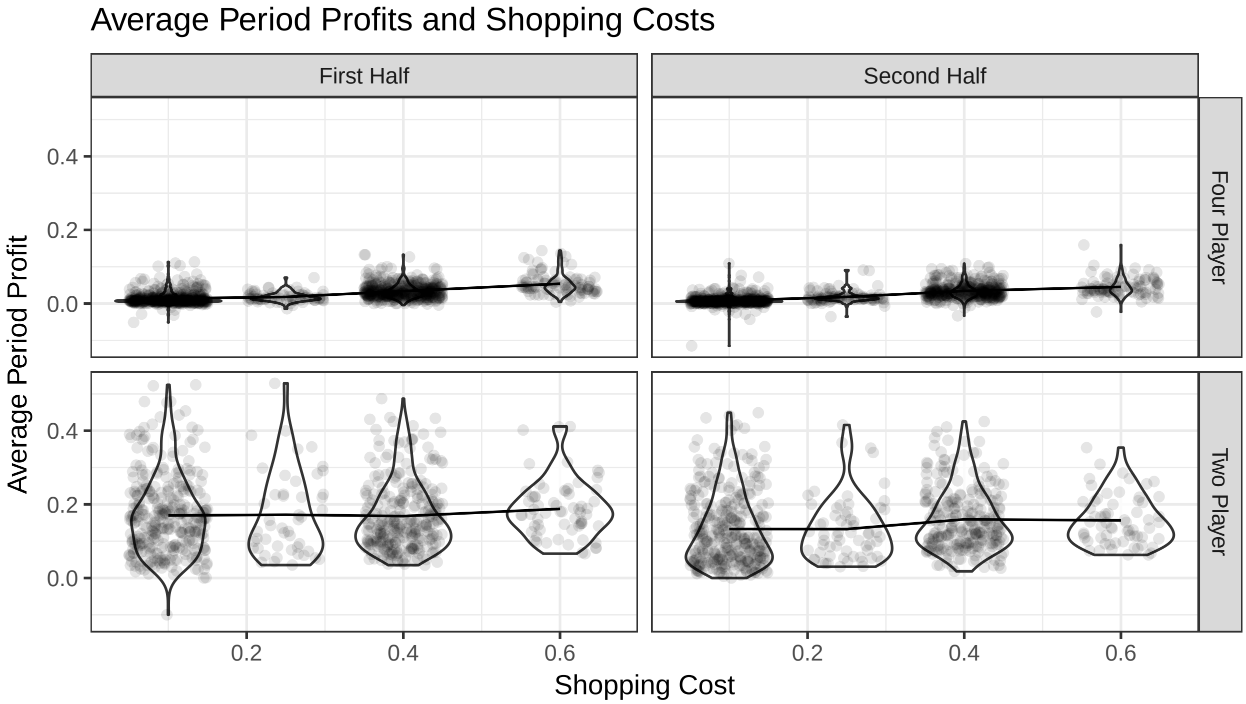
	Shopping Cost	Percent of Period Joint Positive Profits	Period Group Obvservation
Two Player	0.10	0.3442073	112
Two Player	0.25	0.6750000	56
Two Player	0.40	0.7213235	112
Two Player	0.60	0.8921875	56
Four Player	0.10	0.2357724	84
Four Player	0.25	0.2904762	42
Four Player	0.40	0.3745098	84
Four Player	0.60	0.4791667	42



There is visually suggestive evidence that with higher shopping costs, groups are better able to collude.

Idea 2 - Just look at profits.

Are profits higher? - Perhaps too linked to the discussion in Hypothesis 1-3.



to do for collusion

Tailing thing;

- get into more simple dynamics of collusion. . . .

Compiled by Curtis Kephart, curtis.kephart@nyu.edu, with R Markdown Notebook.

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