On the dynamics of mark-ups, results section

Curtis Kephart and David Munro

Contents

Summary Statistics

Summary of sessions and subjects.

Number of Players	Subjects	Periods
Four Players	24	15
Two Players	16	15

Sessions were run at the Unversity of California Santa Cruz' LEEPS Lab on February 8th and 9th 2017.

Subjects earned on average $7.2 from the experiment. After a $10 show-up fee and rounding up to the quarter subjects walked away on average with $17.32

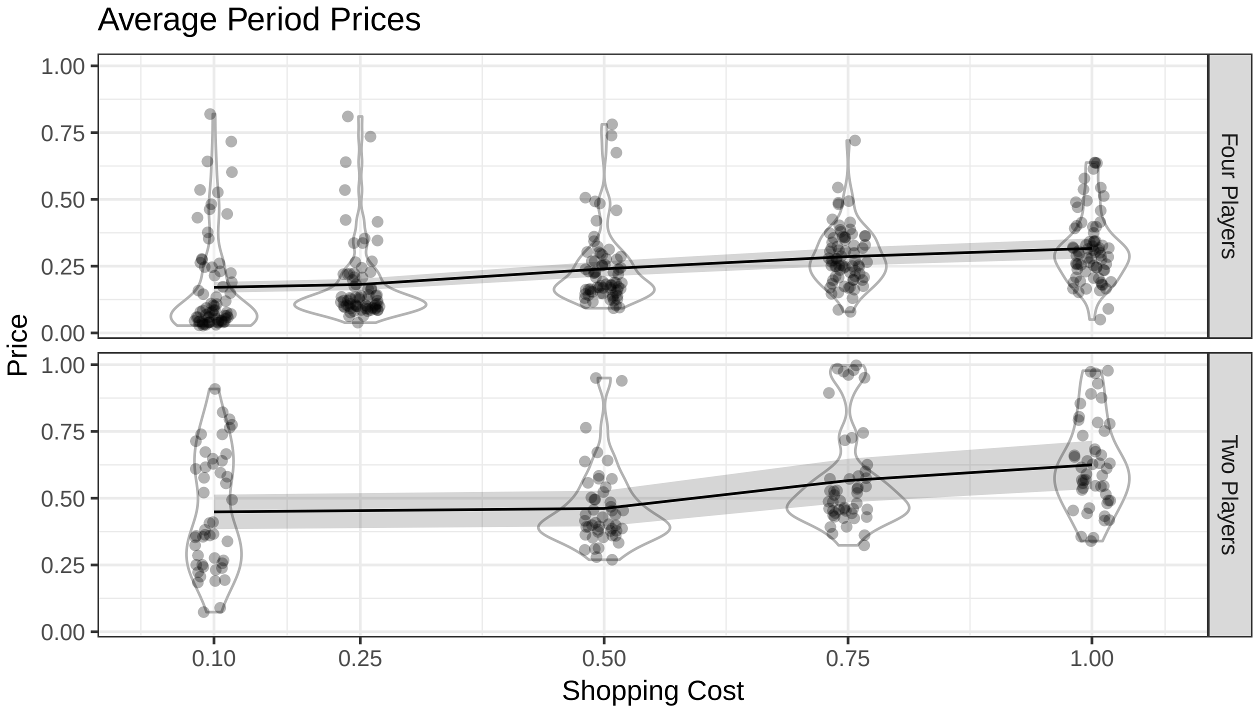
The experiment was conducted with oTree (*Citation: Chen, D.L., Schonger, M., Wickens, C., 2016. oTree - An open-source platform for laboratory, online and field experiments. Journal of Behavioral and Experimental Finance, vol 9: 88-97*) subjects were recruited with ORSEE (*Citation: Ben Greiner (2015), Subject Pool Recruitment Procedures: Organizing Experiments with ORSEE, Journal of the Economic Science Association 1 (1), 114-125. http://link.springer.com/article/10.1007/s40881-015-0004-4*)

No data for Two-Player 0.25 Shopping Cost Treatment

In pilots, due to data issues there is no data for the two-player shopping cost `t = 0.25` treatment. Subjects in this treatment were

Hypothesis 1 - competitiveness and mark-ups

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



In the plot above,

- each dot is the average price per subject in one period (20 subperiods) 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, shopping cost comvination,
- ribben is the confidence interval.
- A very similar plot appears when looking at all prices over all subperiods.

Comparing prices in both treatments.

	s = 0.1	s = 0.25	s = 0.5	s = 0.75	s = 1
Four Players	0.17 (±0.0201)	0.18 (±0.0214)	0.24 (±0.0283)	0.29 (±0.0337)	0.32 (±0.0373)
Two Players	0.45 (±0.0648)	NA	0.46 (±0.0666)	0.57 (±0.0817)	0.62 (±0.0902)

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

	t = 0.1	t = 0.25	t = 0.5	t = 0.75	t = 1
Four Players	0.15 (±0.0176)	0.14 (±0.0168)	0.2 (±0.0238)	0.25 (±0.0299)	0.29 (±0.0344)
Two Players	0.42 (±0.0605)	NA	0.46 (±0.0665)	0.56 (±0.0812)	0.63 (±0.0906)

Strong evidence for Hypothesis 1.

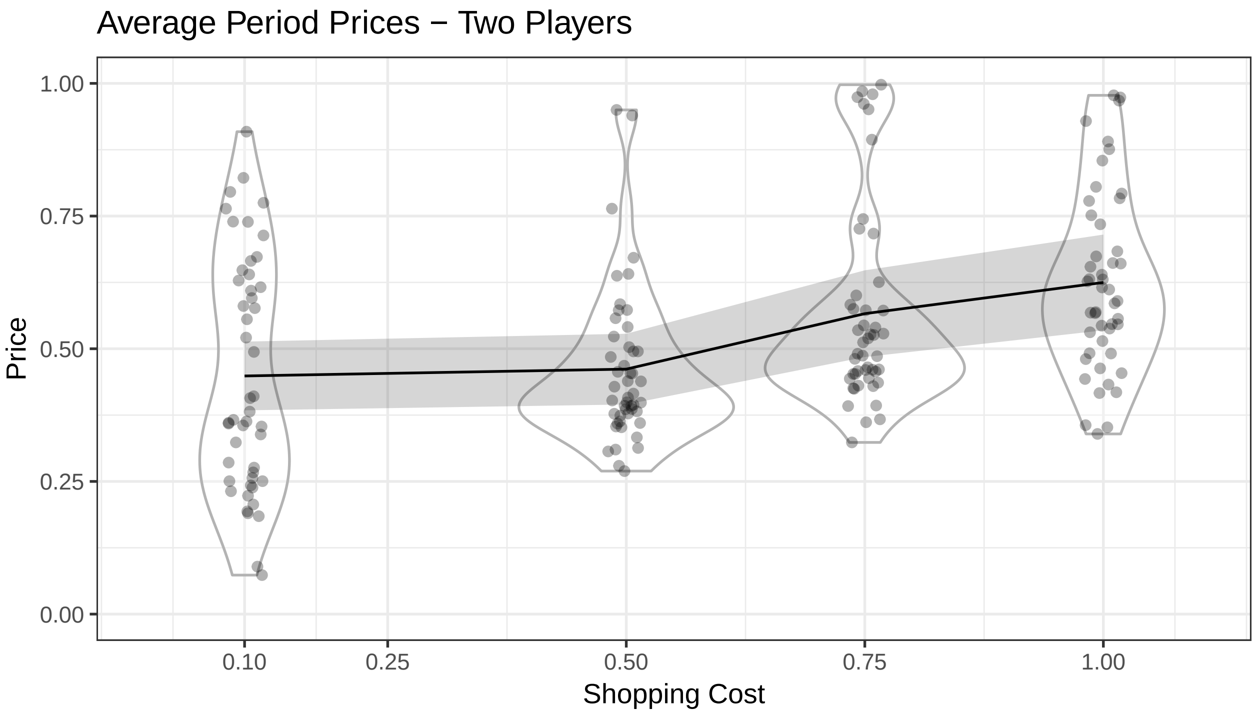
- Looking at the average prices within a period (all 20 subperiods) with the same player number and transport cost, there is a statistically significant difference between prices at each transport level between player number treatments.
- Even comparing `t = 1.0` in the four player game – the transport cost in which the four-player game had the highest prices – to `t = 0.1` 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).

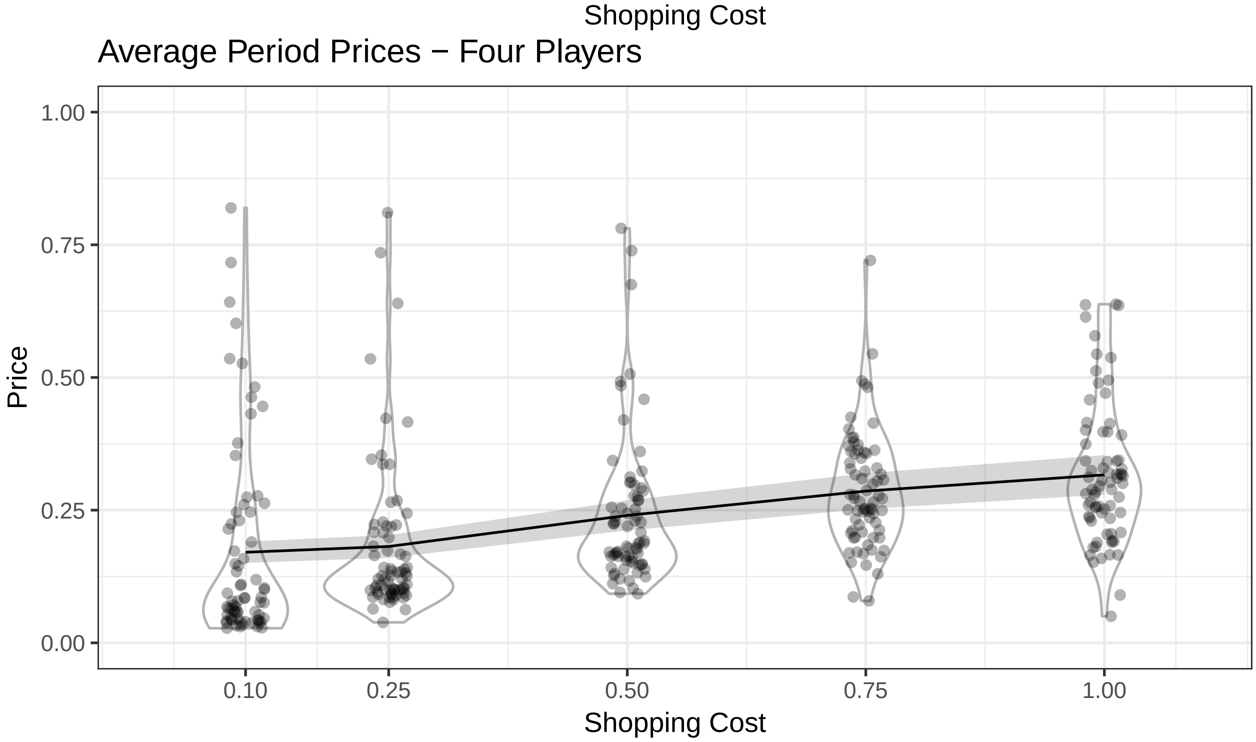
```
##
##  Welch Two Sample t-test
##
## data:  player.price[(playerNum == "Two Players" & player.transport_cost ==  and player.price[(player
## t = 3.7618, df = 69.34, p-value = 0.0003491
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  0.06211334 0.20235194
## sample estimates:
## mean of x mean of y
## 0.4487187 0.3164861
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  player.price[(playerNum == "Two Players" & player.transport_cost ==  and player.price[(player
## W = 2334, p-value = 0.00118
## 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.*





	Shopping Cost	N	Mean Price	Median Price	Standard Error
Four Players	0.10	72	0.171	0.082	0.022
Four Players	0.25	72	0.182	0.126	0.018
Four Players	0.50	72	0.240	0.188	0.016
Four Players	0.75	72	0.286	0.269	0.013
Four Players	1.00	72	0.316	0.298	0.015
Two Players	0.10	48	0.449	0.374	0.032
Two Players	0.50	48	0.462	0.412	0.021

	Shopping Cost	N	Mean Price	Median Price	Standard Error
Two Players	0.75	48	0.566	0.501	0.027
Two Players	1.00	48	0.625	0.601	0.024

- `n` that's each subject was exposed to 3 treatments of each shopping cost level. The two-player game had 16 subjects and the four-player had 24.

Initial Look at Two-Player Game

First, within the two player game, comparing prices in `t = 0.1` and `t = 1.0` (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 0.000029.
- 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 0.0002061.

```
##
##  Welch Two Sample t-test
##
## data:  mean_price[player.transport_cost == 0.1] and mean_price[player.transport_cost == 1]
## t = -4.4084, df = 88.447, p-value = 2.918e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.25562210 -0.09677373
## sample estimates:
## mean of x mean of y
## 0.4487187 0.6249167
```

```
## Warning in wilcox.test.default(mean_price[player.transport_cost == 0.1], :
## cannot compute exact p-value with ties
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  mean_price[player.transport_cost == 0.1] and mean_price[player.transport_cost == 1]
## W = 645, p-value = 0.0002061
## 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, appears stronger.

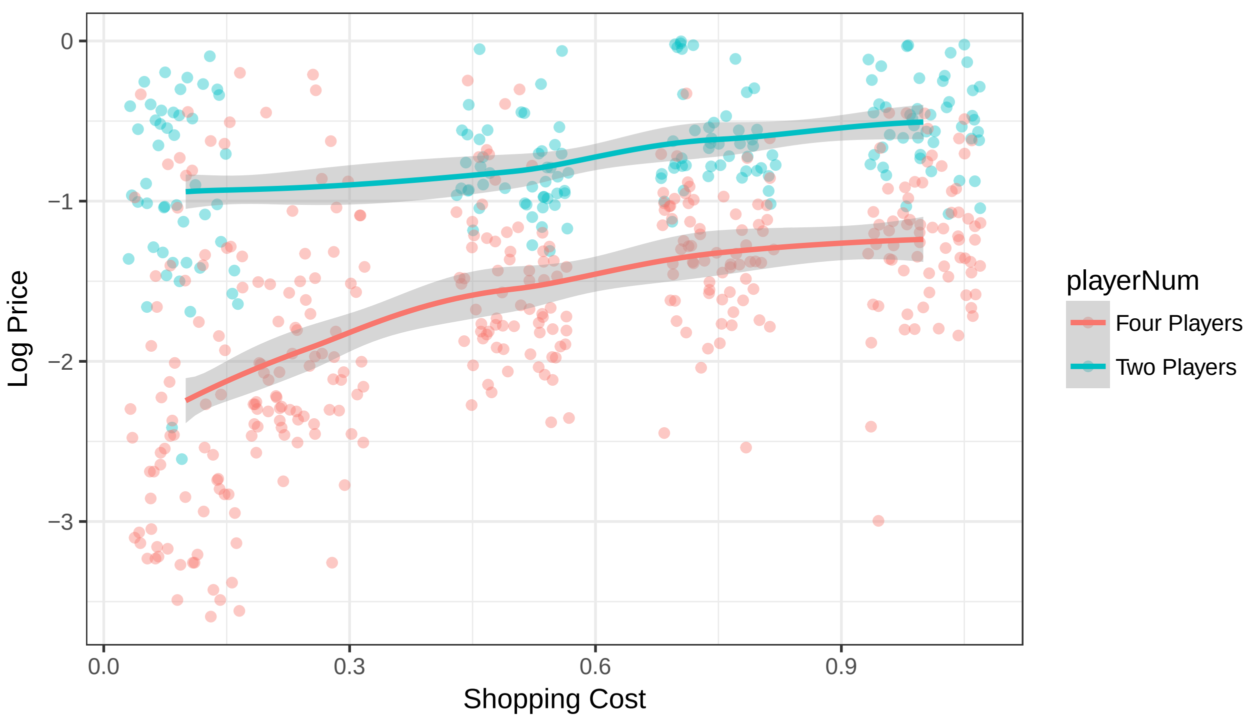
- A t test comparing prices between min and max shopping costs. Prices are average price at the session, participant, and period level. P-value 0.00000023.
- A MW rank sum test comparing prices between min and max shopping costs. Prices are average price at the session, participant, and period level. P-value < 0.000001

```
##
##  Welch Two Sample t-test
```

```
##
## data:  mean_price[player.transport_cost == 0.1] and mean_price[player.transport_cost == 1]
## t = -5.4696, df = 127.71, p-value = 2.285e-07
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.19866656 -0.09311122
## sample estimates:
## mean of x mean of y
## 0.1705972 0.3164861
```

```
##
##  Wilcoxon rank sum test with continuity correction
##
## data:  mean_price[player.transport_cost == 0.1] and mean_price[player.transport_cost == 1]
## W = 1030.5, p-value = 4.458e-10
## alternative hypothesis: true location shift is not equal to 0
```

Model



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) ~ twoPlayer + log(player.transport_cost),
##     data = df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.66483 -0.32582 -0.05272  0.29873  1.93067
##
```

```
## Coefficients:
##                            Estimate Std. Error t value Pr(>|t|)    
## (Intercept)                -1.33090    0.03873  -34.36   <2e-16 ***
## twoPlayer                   0.89671    0.04922   18.22   <2e-16 ***
## log(player.transport_cost)  0.34693    0.02753   12.60   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 0.5497 on 549 degrees of freedom
## Multiple R-squared:  0.4873, Adjusted R-squared:  0.4854 
## F-statistic: 260.9 on 2 and 549 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.

In this specification, the coefficient β_2 measures the average effect of being assigned to the less competitive two-player treatment group. With $\beta_2 = 0.350138$, a 1% increase in shopping costs leads to a 0.35% increase 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) ~ twoPlayer + log(player.transport_cost) + 
##     twoPlayer:log(player.transport_cost), data = df)
## 
## Residuals:
##      Min       1Q   Median       3Q      Max 
## -1.76522 -0.32544 -0.03681  0.30700  2.07778 
## 
## Coefficients:
##                                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)                          -1.23051    0.04273 -28.800  < 2e-16
## twoPlayer                             0.65329    0.06791   9.620  < 2e-16
## log(player.transport_cost)            0.45442    0.03424  13.273  < 2e-16
## twoPlayer:log(player.transport_cost) -0.28173    0.05543  -5.083 5.11e-07
## 
## (Intercept)                          ***
## twoPlayer                            ***
## log(player.transport_cost)           ***
## twoPlayer:log(player.transport_cost) ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 0.5377 on 548 degrees of freedom
## Multiple R-squared:  0.5104, Adjusted R-squared:  0.5077 
## F-statistic: 190.4 on 3 and 548 DF,  p-value: < 2.2e-16
```

The coefficient β_2 estimates that a 1% increase in shopping costs will leave to a 0.45% increase in prices in the four-player game. The β_3 coefficient indicates *a one unit increase in shopping cost leads to a 28% decrease in prices in the two-player game relative to the 4-player game*".

We have strong evidence that mark-ups are less responsive to tranpostation cost changes in the less competitive treatment than the more competitive treatment.

Dependent Var: $ln(P_{ip})$	Hypoth 2 Model		Hypoth 3 Model	
δ_i (two-player)	0.897	***	0.653	***
	(0.049)		(0.068)	
$ln(ShoppingCost)$	0.347	***	0.454	***
	(0.028)		(0.034)	
$\delta_i \cdot ln(ShoppingCost)$			-0.282	***
			(0.055)	
N	552		552	

Hypothesis 4

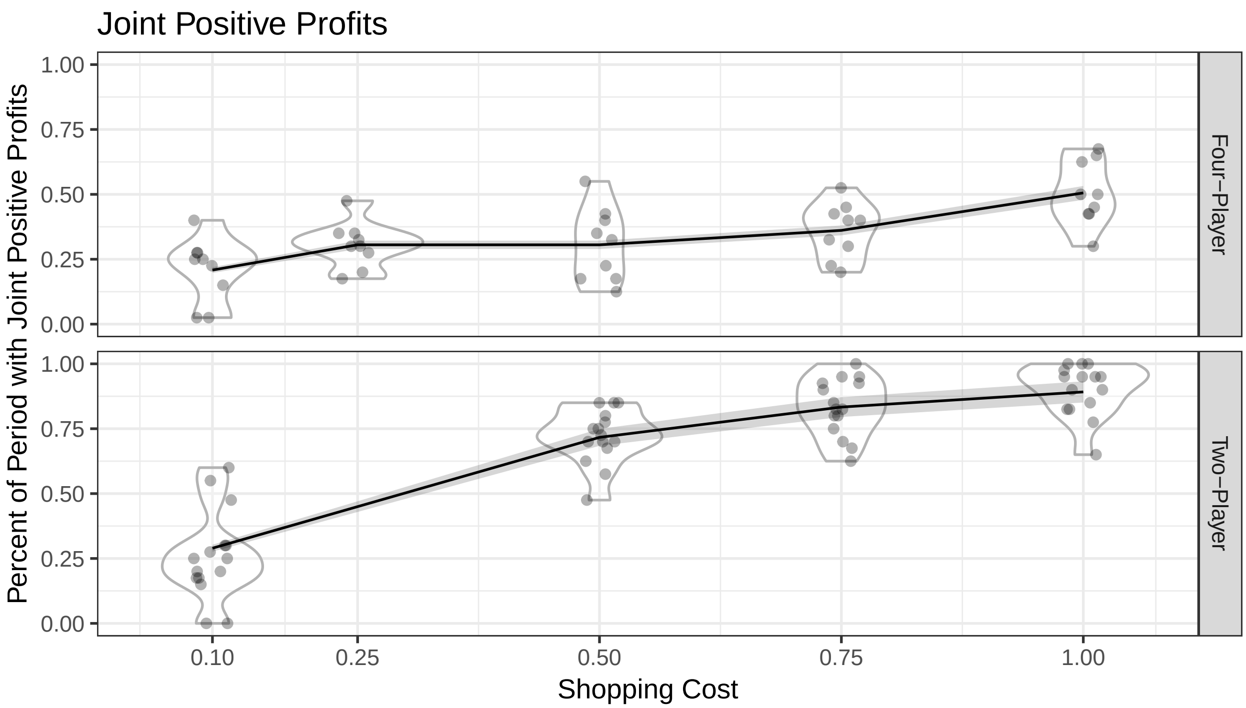
Hypothesis 4. *Collusion will be easier to form in low shopping cost environments*

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.

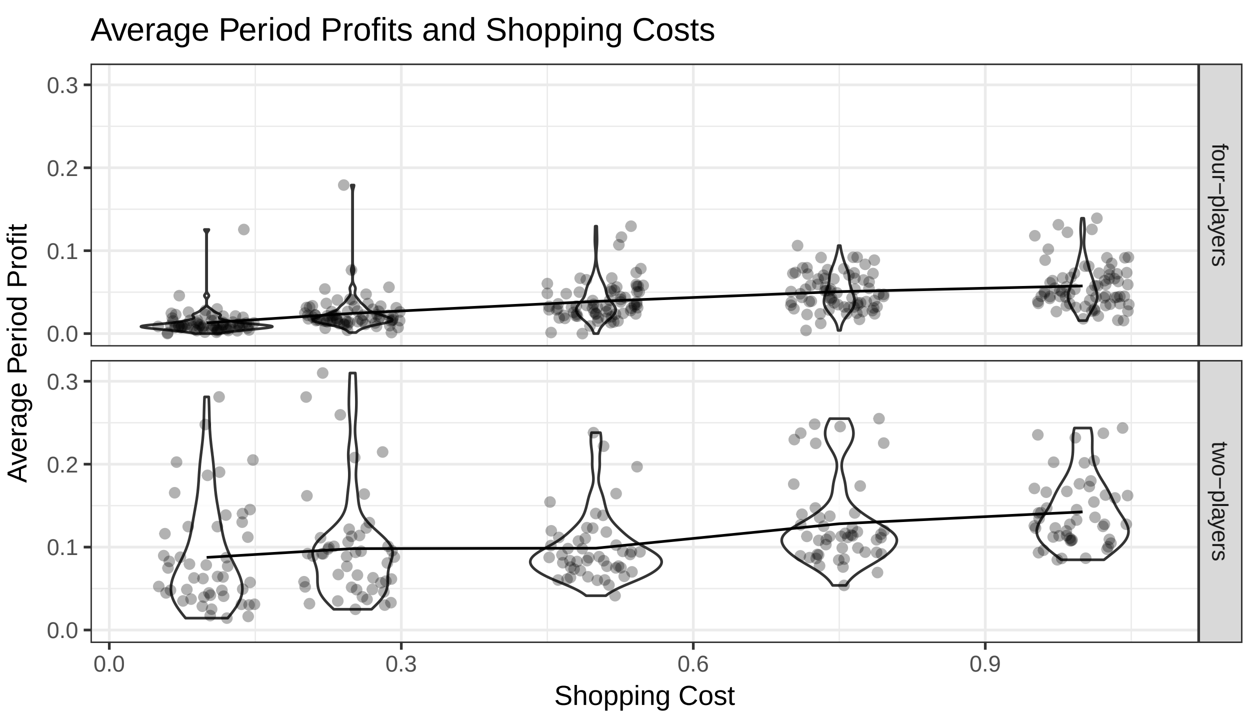
	Shopping Cost	Percent of Period Joint Positive Profits	Period Group Obvservation
Two-Player	0.10	0.2895833	15
Two-Player	0.50	0.7166667	15
Two-Player	0.75	0.8333333	15
Two-Player	1.00	0.8916667	15
Four-Player	0.10	0.2083333	9
Four-Player	0.25	0.3055556	9
Four-Player	0.50	0.3055556	9
Four-Player	0.75	0.3611111	9
Four-Player	1.00	0.5055556	9



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.



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

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