

# Simulating oligopoly to enhance student learning

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## Introduction

How well do students understand price theory, market power, strategic interaction, and oligopoly theory? We describe Virtual Corporate Reality (VCR), an extra-classroom activity designed to engage students' contemplation of and experience with these ideas. Students compete in teams over the course of the semester in a price and location game based on Salop's (1979) circular city. Our experience is that VCR increases students' internalization of concepts such as sunk cost, best-response, Nash equilibrium, differentiated products, and even concepts as seemingly straightforward as pricing above marginal cost. They find it both entertaining and edifying, and come to class better prepared to understand the assumptions, structure, and predictions of oligopoly theory. Students receive significant feedback on their success at mastering and internalizing these concepts.

## Learning objectives

Understand the profit incentive

- *Effect of price changes on revenues*
- *Cost/benefit of investment decisions*
- *Sunk cost of past decisions*
- *$P > MC$  for firms with market power*
- *Other firms' losses not always your firm's gain*

Understand details of product differentiation

Anticipate others' strategic decisions

Understand the intuition behind the theory

- *Best response*
- *Nash equilibrium*

Communicate insights in writing.

Work as a team

## Finances

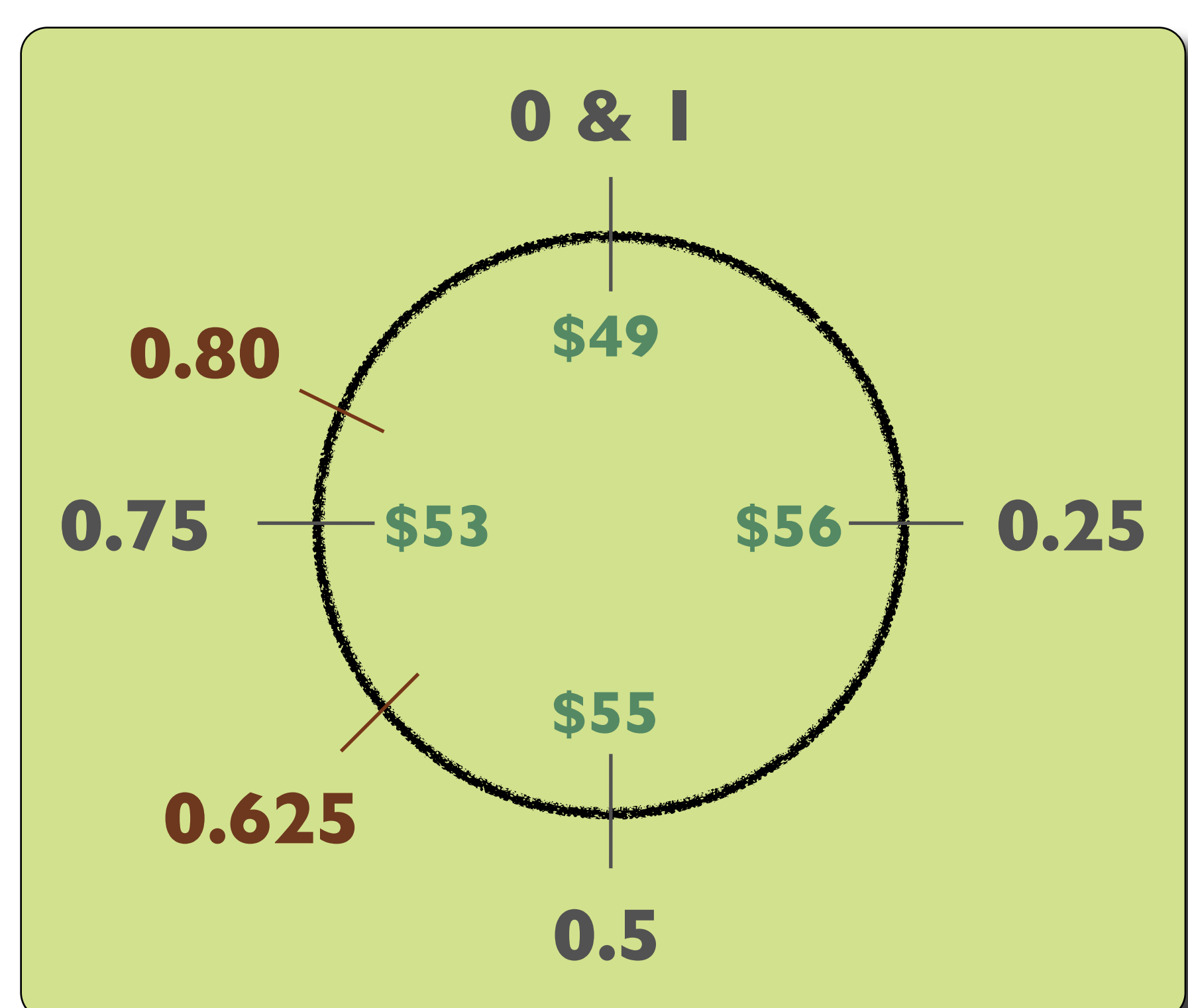
Along with one product, each team starts the game endowed with \$25,000,000. Each period, the team is charged as follows:

- [+] 5% interest on period's cash balance
- [+] revenue on all the firm's products
- [-] cost of firm's production
- [-] cost-reducing investment
- [-] # of product introductions  $\times$  \$5,000,000
- [+] # of products withdrawn  $\times$  \$1,000,000
- [-] # of product relocations  $\times$  \$2,500,000
- [+/-] Other sales or purchases (auctions)

There are no loans, no bankruptcy law.

## Overview of the game

Student teams are endowed with one product, located evenly around the unit circle. During each period, they make decisions on price(s) for existing products, invest in cost-reducing innovation, and can introduce, withdraw, or relocate products. The game is deterministic, like chess, and go. Anti-trust laws apply: students are warned that collusion is equivalent to cheating, with similar punishments.



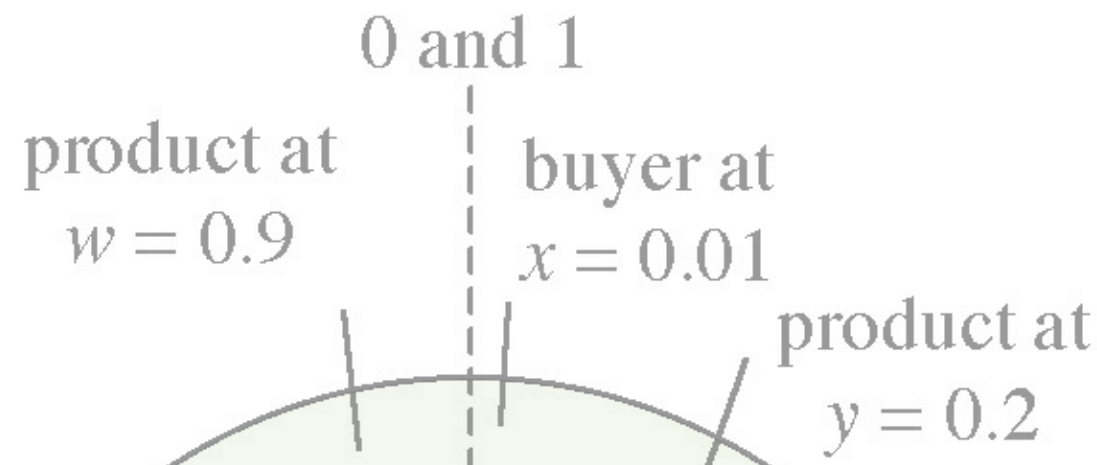
**In the example pictured above**, there are four teams, each initially endowed with a product spaced evenly around the unit circle (0/1, 0.25, 0.5, 0.75). Each team has announced a price for their existing products (shown inside the circle), and two product introductions have been made at 0.80 and 0.625.



# Specifying the market

Consumers are uniformly distributed over the circle. Each buys one unit, the one providing the highest net surplus. A consumer's willingness to pay decreases in distance to the product. As compared to the line model of Hotelling (1929), the circle avoids the asymmetries created by the space having boundaries.

## Consumers' decision



When  $p_w = p_y$ , a customer at  $x$  prefers the product at  $w$  because it is closer to  $x$ :  $d(w, x) = 1.01 - 0.9 = 0.11 < 0.19 = 0.2 - 0.01 = d(y, x)$ . If  $p_w \neq p_y$ , then the customer's choice takes this into account: if the price of product  $y$  is enough lower than the price of product  $w$ , then the customer at  $x$  will instead prefer  $y$ .

## Total market demand

with  $n$  products

$$s = -110,000 + 120,000 \cdot n - 1,500 \cdot n^2$$

## Costs

\$/unit

Fixed cost per location per period: \$500,000.

Marginal cost:

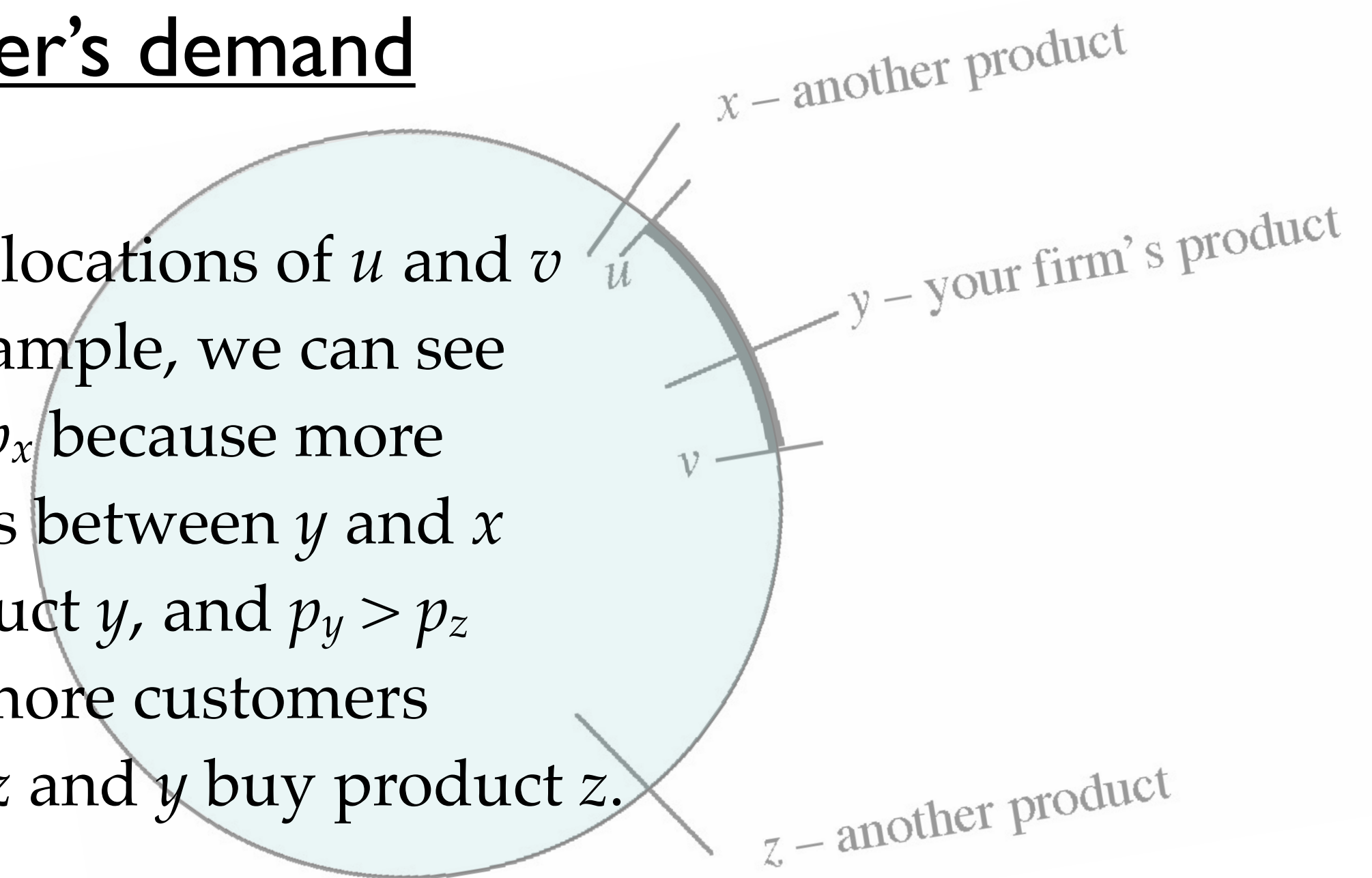
$$MC = \$50 \cdot \frac{50,000,000}{X + 50,000,000}$$

$X$ : product-specific cost-reducing investment

- particular to a product & irreversible (sunk)
- private information

## Producer's demand

From the locations of  $u$  and  $v$  in this example, we can see that  $p_y < p_x$  because more customers between  $y$  and  $x$  buy product  $y$ , and  $p_y > p_z$  because more customers between  $z$  and  $y$  buy product  $z$ .



# Playing the game

In each period, a firm decides what price to set for each existing product, how much to invest in reducing each one's marginal cost, whether to introduce products (at a fixed cost), and whether to withdraw products (which can be relocated elsewhere). In deciding on investment and product introductions, a firm is constrained to finance it through cash.

Current Screen: **Current Decisions**  
Navigator Menu: [Select a destination...]

Scenario: [ ]

**Current Decisions for Period: 8, Team: 2, Industry 1**

Location Pricing & Investment						Other Actions*			
Location	Team	Product Price	Marginal Cost	Existing Investment	New Investment	Scrap	Move	Auction	None
0	1	-	-	-	-	-	-	-	-
0.1665	3	-	-	-	-	-	-	-	-
0.333333	2	\$72.5	\$47.1698	\$3000000	\$0	0	0	0	0
0.495	1	-	-	-	-	-	-	-	-
0.666667	3	-	-	-	-	-	-	-	-
0.75	1	-	-	-	-	-	-	-	-
0.833345	2	\$65	\$49.0196	\$1000000	\$0	0	0	0	0

Select Decisions: Remember to submit decisions above BEFORE leaving this screen.

Manage Introductions

Scheduled Introductions

Location	Initial Investment
0.2	\$1000000

CASH FLOW:

Cash balance at end of previous period: \$59910999  
Cash charges due to announcements and investment: \$6000000  
Cash balance after costs due to stated announcements and new investment: \$53910999

\*Notes about changes other than price and investment:

- You need to choose a price for the current location (in the first column).
- Changes in location are only announcements of your decision.
- You do not need to price the items marked with an asterisk until next period.

Screen for entering the current period's decisions.

**Introductions Management**

Cash balance will be affected THIS period, new location comes into play NEXT period.

Location (a decimal between 0 & 1, inclusively): 0.8

Initial Investment (0 if left blank): \$2000000

Click ONCE to add location introduction

Note: You MUST click the above button to make changes!

Here is a list of your submitted introductions for period 8:

Location	Initial Investment	Delete?
0.2	\$1000000	<input type="checkbox"/>

Delete selected introductions

To change location and/or to modify investment to an introduction, delete the introduction in question and reintroduce with the correct location and/or correct investment

Click here to return to Current Decisions without taking any action

The product introduction interface.

Current Screen: **Financial History**  
Navigator Menu: [Select a destination...]

Select Period: [All Periods]

Period	Team	Profit*	Cash Balance
7	1	\$4350586	\$45520155
7	2	\$3003243	\$59910999
7	3	\$3109706	\$65383243
6	1	\$1541906	\$39209113
6	2	\$4324038	\$55150244
6	3	\$4017902	\$59308130
5	1	\$1843900	\$40635435
5	2	\$4370262	\$48405910
5	3	\$4091573	\$52657360

Publicly available financial history, chosen here to display several past periods.

Current Screen: **Public History**  
Navigator Menu: [Select a destination...]

Select Period: [Period 7]

Period	Location	Owner	Price	Demand	Scrapped?	Moved to	Auctioned?
7	0	1	\$68	129053	No	No	No
7	0.333333	2	\$84	75005	No	No	No
7	0.666667	3	\$74	50879	No	No	No
7	0.1665	3	\$80	96287	No	No	No
7	0.833345	2	\$68	68933	No	No	No
7	0.75	1	\$60	90820	No	No	No
7	0.495	1	\$68	145524	No	No	No

Publicly available decisions history, shown here for the most recent period.

Current Screen: **Private History**  
Navigator Menu: [Select a destination...]

Select Period: [Period 7]

Period	Location	Price	Demand	Revenue	Existing Investment	Marginal Cost	Total Variable Expense	Profit*
7	0.333333	\$84	75005	\$6300420	3000000	\$47.1698	\$3537970.849	\$2262449
7	0.833345	\$68	68933	\$4687444	0	\$50	\$3446650	\$740794

\*Note: The calculation of profit includes only total production cost (total fixed cost and total variable cost) associated with locations. New investment and other decisions (scrapping, moving, etc.) are not included in the calculation. These items are reflected in the cash balance.

Privately available decisions history, chosen here to display the most recent period.



# Student reactions

Students may need to unlearn mistaken preconceptions before learning new ideas and new models (Bain 2004). An attractive complement to the usual lecture format is for students to experience those concepts through decision making in a simulated environment. Classroom demonstrations and simulated markets help students learn economic concepts first-hand by making decisions with the intent to achieve some economic objective such as maximizing profit.

“... owning a company is much harder than I had assumed.”

“The experience has better prepared us to cooperate with others while exercising key decision making skills.”

“Despite the fact that we [the members of the group] are all friends, we still managed to battle about ideas and theories.”

“This project prepares us for when we do make mistakes. Mistakes are kind of like sunk costs, and this project has helped to realize we have to find another method to fix the mistakes, or start from where we left off and find the best decision there before moving forward.”

“... we invested a lot of money early on. It seems as though some groups didn't catch on to this as quickly. While they had a lot of cash, they were not making any profits.”

“... VCR provided me with an opportunity to try and use the economics that we have learned”

“It also helped in playing the game, when we were talking about game theory in class.”

“The really interesting aspect of the game was that we were introduced to new concepts of Industrial Organization without even realizing it. It was a real life abstract challenge that I always frequently contemplated in my head. It also gave a different 'spin' to homework.”

“VCR should be played by everyone majoring in this department.”

## References

Hotelling, Harold (1929), “Stability in Competition,” *Economic Journal* 39 p41-57.

Bain, Ken (2004) *What the Best College Teachers Do*, Cambridge, Mass: Harvard University Press.

Salop, Steven (1979) “Monopolistic Competition with Outside Goods”, *The Bell Journal of Economics* 10(1): 141-156.

Want to learn more? Get the paper here.

<http://sites.lafayette.edu/ruebeckc/vcr/>

Want to play? Contact us here.

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Value of firms over time

