Testing Economic Ideas by Using a Simulation of an Economy

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Grade: 10

School: Lower Moreland High School

Year in PJAS: 4th

Raitionale

“Nobody ever had really actually estimated a demand curve … I literally could not find a good example where we could put it in a box … to say, ‘This is what a demand curve really looks like in the real world,’”

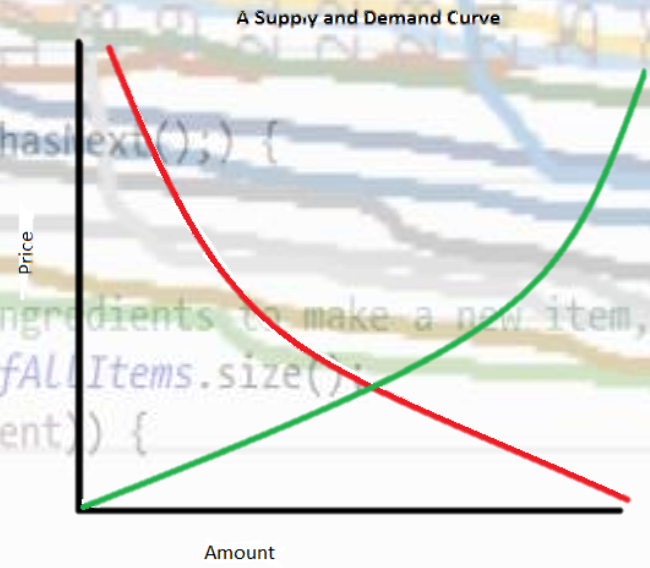
-Steve Levitt, Professor of Economics at University of Chicago

Problem

Will the revenue of companies selling one product be greater when a monopoly on the product exists, compared to when competition occurs?

Research I: Economics Basics

- Demand: How much people want an item
  - Demand curve: Plot price over products and see how much is demanded for each price
- Supply: The amount of an item companies make
  - Supply Curve: Plot price over products and see how much is supplied for each price
- Intersection of the two curves: Optimal price and amount of a product



Research II: On the Margins

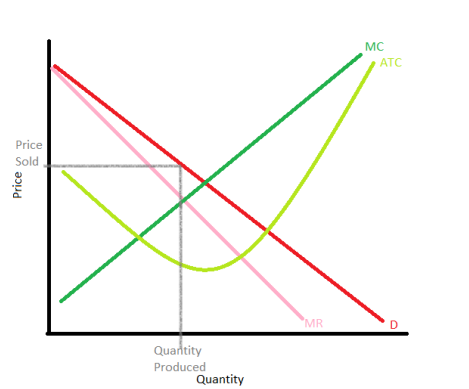
- **Marginal Cost (MC) – The cost of adding one more of something**
  - **For firms: The cost of producing one more good**
- **Marginal Benefit (MB) – The benefit of one additional thing**
  - **For firms: The price of the next good that is sold**
- **The Law of Diminishing Returns – As the amount of a product increases, MB decreases (not necessarily total benefit)**
- **Intersection of MC and MB: Ideal amount of anything to produce**

Research III: Firm Theory

- Price (P) – How much a good costs
- Quantity (Q) – Amount of products produced
- Marginal Revenue (MR) – Revenue that changes based on the amount of products sold, revenue of selling one more product (similar to MB)
- Marginal Cost (MC) – Change in total cost of making one more item
- Variable Cost – Cost of producing that changes based on amount of goods
  - Examples: Ingredients, Labor
- Fixed cost (FC) – Cost that does not change based on amount of goods
  - Example: Rent
- Total Cost (TC) – VC + FC
- Average Cost – TC / Q

Research IV: Competition

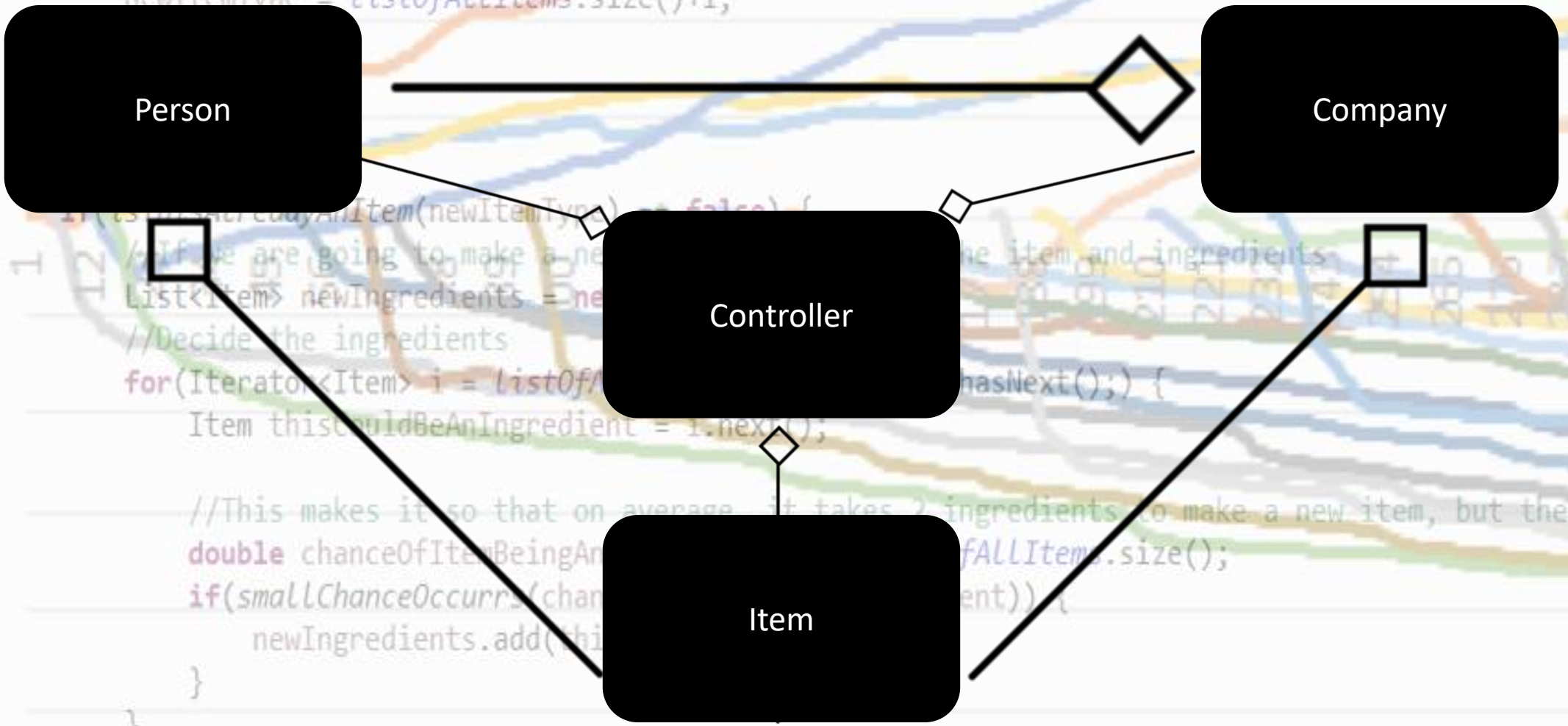
- Perfect Competition – Infinite number of companies producing same exact good
  - Competitive firms – Companies under competition
  - P=MC=MB
  - Does not actually exist
- Monopoly – Industry in which one company produces a good
  - Output effect – When quantity increases, revenue increases
  - Price effect – When quantity increases, price decreases
  - P>MC=MR
  - Monopolies can make P>MC
- Since P can be greater than MC in monopoles, they can get more revenue than competitive firms



Hypothesis

- **Based on the research, in a simulation of an economy in which one company sells a product, or a monopoly, company will have a higher average revenue per market run than if companies were under competition.**
  - **Null hypothesis: in a simulation of an economy in which one company sells a product, or a monopoly, companies will have the same average revenue per market run than if companies were under competition.**

Experiment I: Classes



Experiment II: Class Descriptions

- Controller
  - Only class that is run
  - Contains list of all people, items, and companies
  - Manages most relationships between objects
- Person
  - Has money
  - Gets money by receiving it from companies
  - Spends money by trying to buy all Items as cheap as possible
  - Has willingness to pay for every item
- Item
  - Has market price
  - Can have ingredients (other items)
- Company
  - Gets money by selling items
  - Produces one type of item
  - Has a list of employees
  - If amount of employees decreases, wages increase (otherwise, they decrease)
  - Manages price it sells by increasing price if it previously gave revenue, decreasing otherwise
  - Has optimal amount of products to produce (to simulate MC curve)

Experiment III: Starting Condition

- 3 lists created
  - One with 100 people (each with $10)
  - One with 2 items
  - One with 2 companies (one per item)

Experiment IV: Pre-Market Runs

- All companies pay fixed cost ($100)
- Companies produce optimal amount of products
  - Products require buying ingredients and labor
  - Ingredients are bought directly from other companies
  - For each product produced, less labor is required (MC going down)
  - For each hour of labor, an employee is payed the company salary

Experiment V: Market Runs

- All people cycle through each item
  - For each item, see which company sells it
  - Find the company that sells the item for the cheapest price
  - Try to buy from that company
    - If the person is willing to pay for the item and can afford to buy it, the transaction is made

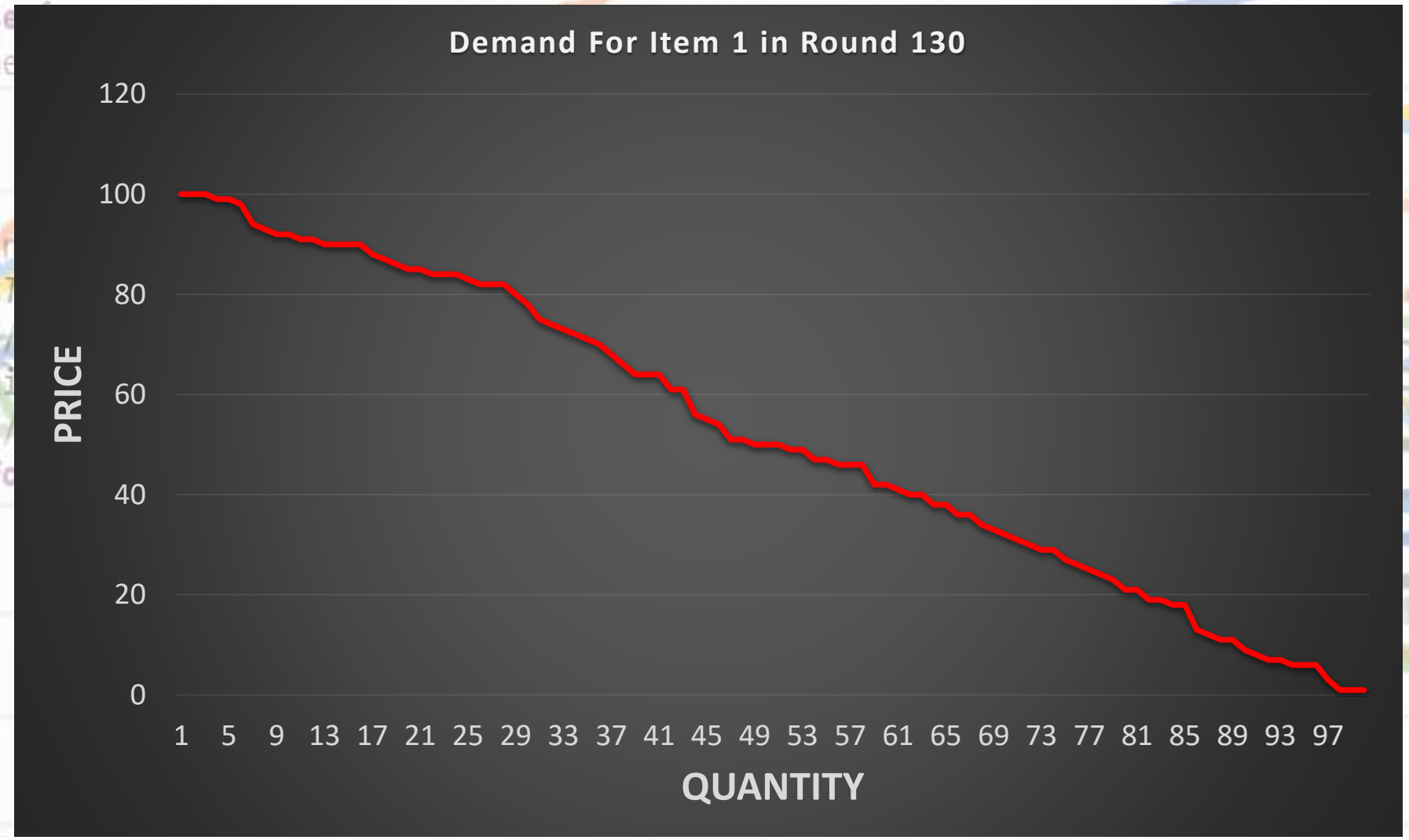
Experiment VI: Post-Market Runs

- Refresh People statistics
  - Every 10 rounds, people choose new company to work for (highest wage)
  - Every 10 rounds, people create new willingness to pay for all items
  - Different time for every person, same length of time before refresh
- Produce new companies
  - Every round, there is a 5% chance that a new company is formed
  - If monopoly mode is off, it produces a random item (one option per existing item, one option for making a new item)
  - If monopoly mode is on, I produces a new item
- Monopoly mode is a Boolean value that can be turned on or off before execution

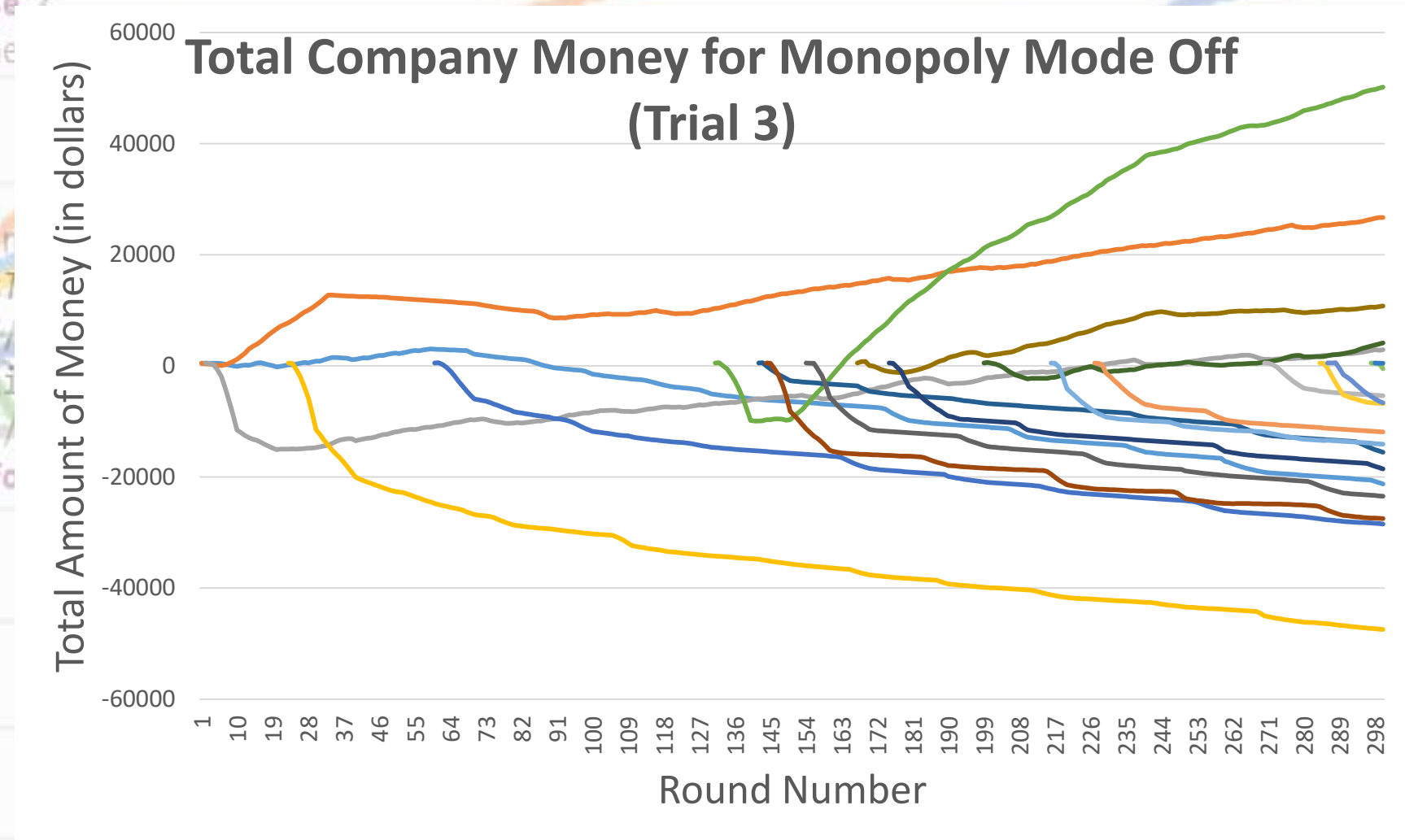
Experiment VII: Additional Setup Information

- One round definition
  - Pre-market run
  - Market run
  - Post-market run
- 300 rounds per trial
- 10 trials per group of trials
- 2 groups of trials
  - Monopoly mode off
  - Monopoly mode on

Data I: The Demand Curve



Data II: Total Company Money



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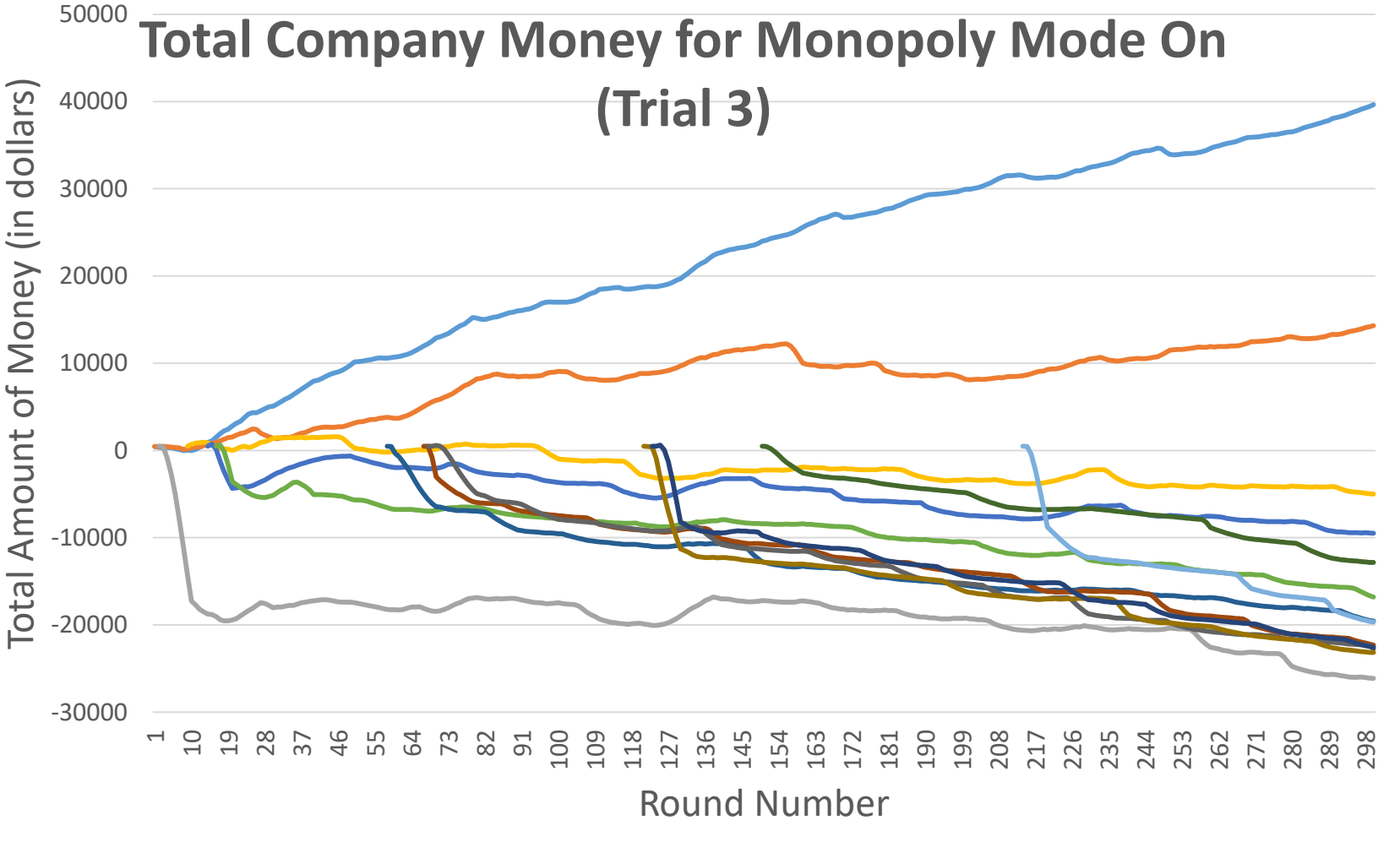
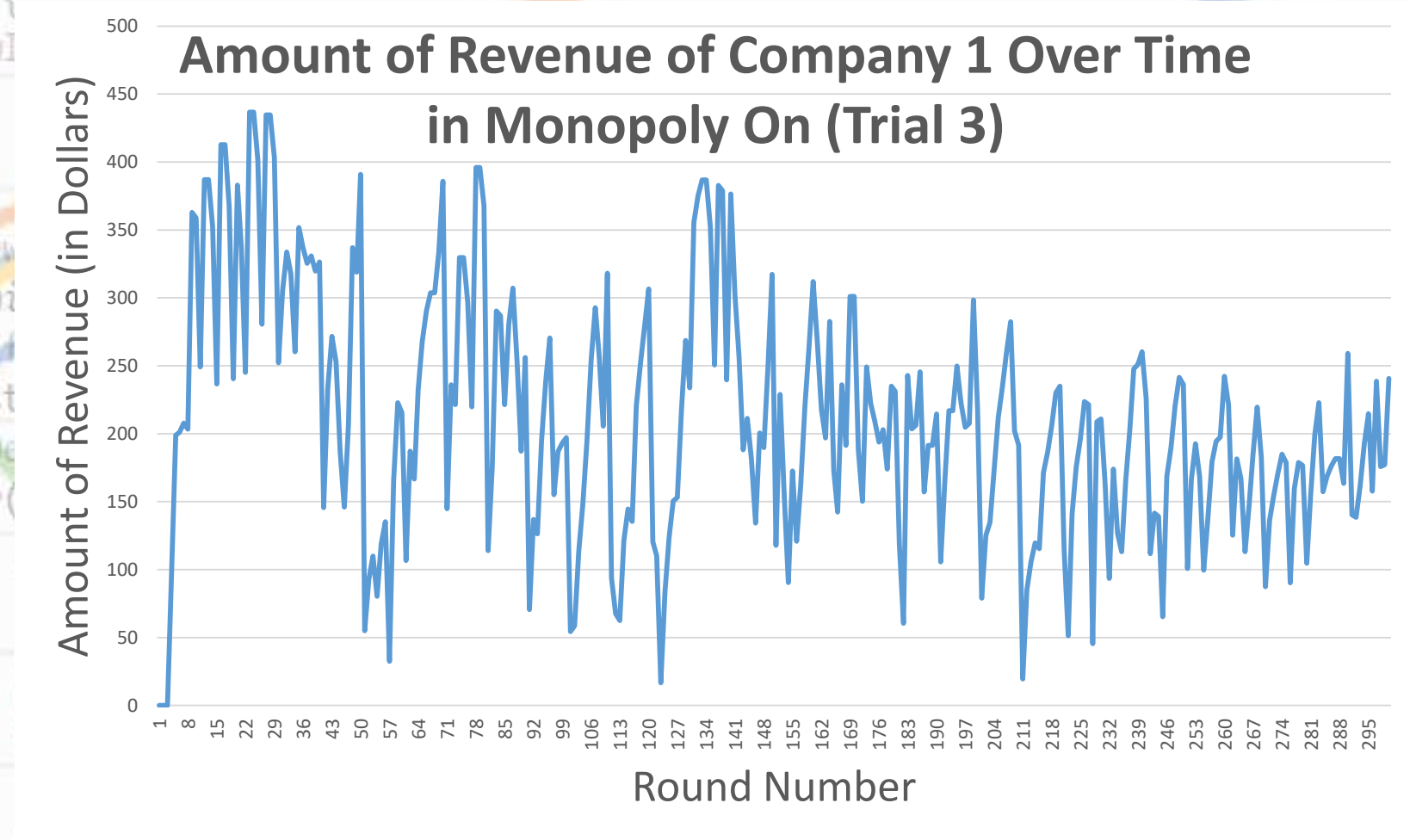


Data III: Analysis of Revenue



Data III: Analysis of Revenue

- In each trial
  - Find the average revenue per round for each company (300 data points)
  - Average all of these numbers to find average revenue per round for entire trial
- Find the average revenue per round for each experimental group
  - Find the average revenue per round for each trial
  - Average all of those numbers to find the average for each experimental group

Data III: Analysis of Revenue

279	191.6994
280	112.9344
281	93.04071
282	98.1828
283	98.1828
284	87.48088
285	187.295
286	209.7704
287	199.7814
288	101.5992
289	196.5866
290	202.8606
291	115.0241
292	68.52566
293	122.4555
294	147.4464
295	172.4373
296	194.9291
297	217.4209
298	247.41
299	212.4227
300	81.58187
301	

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299	212.4227
300	81.58187
301	165.4905

279	191.6994	193.9243	120.4764	78.6838	60.24458	50.01144	59.16977	33.46215	24.1373	13.95636	2.667912	1.492362	1.518233	1.758313
280	112.9344	236.6534	171.0008	205.4521	77.96357	65.14808	49.30814	49.24619	36.20595	16.28242	15.60729	1.462213	4.099229	3.726108
281	93.04071	59.16336	0	0	62.01648	2.171603	25.95909	34.72488	0	0	0	0	0	3.888113
282	98.1828	51.48276	92.22129	44.02453	0	23.22496	0	0	15.16568	0	0	19.12489	4.067915	3.888113
283	98.1828	136.0858	53.20459	92.94068	2.484007	20.19561	13.43774	18.69068	10.1797	0	0	0.597653	1.355972	2.770281
284	87.48088	169.2775	118.9236	51.36196	2.484007	20.52039	24.80814	23.60928	0	0	0	0	0	0
285	187.295	146.0433	46.53534	123.5234	6.706818	2.280044	43.41424	19.6744	22.93311	0	0	0	0	1.082793
286	209.7704	187.2325	59.77664	38.60105	114.0159	22.39541	11.3704	14.4596	16.23355	3.442517	3.216958	15.96364	0	5.413967
287	199.7814	239.4835	91.4231	103.7526	46.94773	31.12582	44.07953	19.88888	8.521517	1.721259	3.216958	15.07677	9.143563	10.82793
288	101.5992	239.4835	119.5533	101.6352	71.66274	25.05249	11.01988	33.14813	12.20276	10.83958	4.342894	1.539785	3.516755	7.146436
289	196.5866	258.6421	126.5858	105.3467	50.16392	51.56694	39.88046	21.41879	12.84501	4.335832	15.92394	3.714956	18.74309	23.47406
290	202.8606	282.1551	123.0696	124.5006	66.11365	43.31623	18.35767	31.22392	10.27601	41.5976	26.05736	9.456251	30.67051	25.60807
291	115.0241	90.13287	5.383506	25.53859	29.0255	44.23503	0	0	0	0	0	18.23706	0	0
292	68.52566	96.15022	22.02252	69.31933	0	23.88692	22.90623	7.924708	4.859471	0	15.84616	0	2.629765	0
293	122.4555	76.92018	36.7042	69.31933	17.57055	4.421818	29.49569	44.50029	4.693808	8.983781	3.961539	0	0	0
294	147.4464	103.5278	80.74925	110.292	35.1411	27.88453	16.94433	0.609593	0	1.122973	0	0	0	0.434395
295	172.4373	153.0411	117.4534	86.89673	21.08466	32.31065	15.14106	3.949328	6.540378	2.156716	17.60564	0	0	13.03186
296	194.9291	189.0508	69.73798	125.2242	36.73392	42.93333	30.69731	17.77198	5.755533	4.313431	13.76073	1.308114	15.5932	11.29428
297	217.4209	229.5617	157.8253	58.03071	3.06116	42.49071	37.34839	3.949328	46.08369	0	1.380264	0	4.158187	0
298	247.41	279.075	169.0986	89.96917	70.79336	35.05851	28.65082	20.64776	14.9772	9.861066	11.63651	8.737475	10.60485	11.13532
299	212.4227	279.075	169.0986	59.97944	41.74993	41.19656	23.76508	22.67205	8.664776	6.104469	7.854648	8.065361	10.60485	10.27876
300	81.58187	295.7295	197.8453	128.5693	84.68429	42.91309	47.07259	38.86637	45.65846	50.79162	30.34111	31.07041	19.08873	10.94401
301	165.4905	243.3473	136.4176	154.6587	85.94696	62.72372	39.73142	36.5302	19.89145	28.04063	10.2551	10.16834	7.056051	3.765789

Data III: Analysis of Revenue

279	191.6994	193.9243	120.4764	78.6838	60.24458	50.01144	59.16977	33.46215	24.1373	13.95636	2.667912	1.492362	1.518233	1.758313
280	112.9344	236.6534	171.0008	205.4521	77.96357	65.14808	49.30814	49.24619	36.20595	16.28242	15.60729	1.462213	4.099229	3.726108
281	93.04071	59.16336	0	0	62.01648	2.171603	25.95909	34.72488	0	0	0	0	0	3.888113
282	98.1828	51.48276	92.22129	44.02453	0	23.22496	0	0	15.16568	0	0	19.12489	4.067915	3.888113
283	98.1828	136.0858	53.20459	92.94068	2.484007	20.19561	13.43774	18.69068	10.1797	0	0	0.597653	1.355972	2.770281
284	87.48088	169.2775	118.9236	51.36196	2.484007	20.52039	24.80814	23.60928	0	0	0	0	0	0
285	187.295	146.0433	46.53534	123.5234	6.706818	2.280044	43.41424	19.6744	22.93311	0	0	0	0	1.082793
286	209.7704	187.2325	59.77664	38.60105	114.0159	22.39541	11.3704	14.4596	16.23355	3.442517	3.216958	15.96364	0	5.413967
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291	115.0241	90.13287	5.383506	25.53859	29.0255	44.23503	0	0	0	0	0	18.23706	0	0
292	68.52566	96.15022	22.02252	69.31933	0	23.88692	22.90623	7.924708	4.859471	0	15.84616	0	2.629765	0
293	122.4555	76.92018	36.7042	69.31933	17.57055	4.421818	29.49569	44.50029	4.693808	8.983781	3.961539	0	0	0
294	147.4464	103.5278	80.74925	110.292	35.1411	27.88453	16.94433	0.609593	0	1.122973	0	0	0	0.434395
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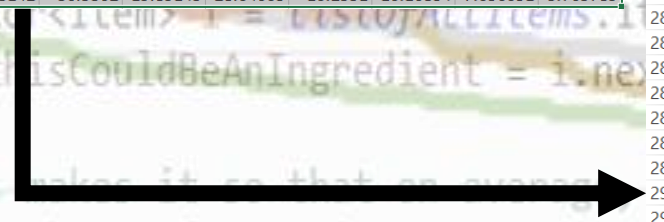
300	81.58187	295.7295	197.8453	128.5693	84.68429	42.91309	47.07259	38.86637	45.65846	50.79162	30.34111	31.07041	19.08873	10.94401
301	165.4905	243.3473	136.4176	154.6587	85.94696	62.72372	39.73142	36.5302	19.89145	28.04063	10.2551	10.16834	7.056051	3.765789



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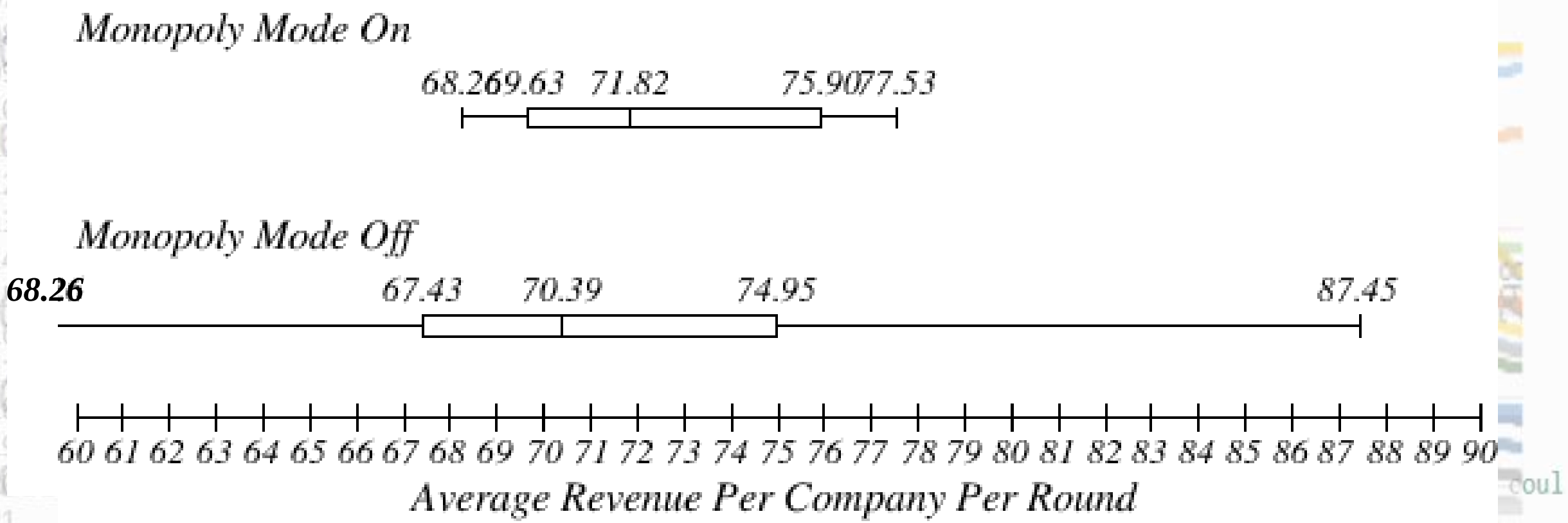
Data III: Analysis of Revenue

Monopoly Mode off									
71.20993	69.61965	67.58548	71.15215	59.25903	66.94451	83.63996	72.05477	87.45442	67.619
Monopoly Mode on									
71.71598	70.07242	71.02088	75.73776	76.40646	68.29898	71.92695	77.5265	73.7966	68.26062

										Average	Standard Deviation
Monopoly Mode off											
71.20993	69.61965	67.58548	71.15215	59.25903	66.94451	83.63996	72.05477	87.45442	67.619	71.65389	8.210516
Monopoly Mode on											
71.71598	70.07242	71.02088	75.73776	76.40646	68.29898	71.92695	77.5265	73.7966	68.26062	72.47632	3.288528

Data IV: Five-Number Summary



Data V: Testing the Hypothesis

- Average revenue per round with no monopolies: $71.65
  - Standard deviation: 8.21
- Average revenue per round with monopolies: $72.48
  - Standard deviation: 3.29
- Percentage difference: 1.14%
  - Not statistically significant

Conclusions I

- **Hypothesis: Rejected**
  - **Null hypothesis accepted**
  - **Reasoning: No statistically significant difference between revenues of companies under competition ($71.65) and monopolies ($72.48)**
- **Possible errors**
  - **Unrealistic simulation**
    - **Not everyone needs to buy everything**
    - **Optimal amount of products comes naturally, is not a random number**
  - **Simulation not long enough**
    - **Often companies would begin gaining money as trial ends**

Conclusions II

- If the experiment were to be repeated
  - Add dynamic population
    - Population fluctuates in the short run
    - Population exponentially grows in the long run
  - Add demand-side complexity
    - Indifference curves
    - Inferior goods
- Further study
  - How true is the Law of Supply?
  - How true is the Law of Demand?
  - How true is the Law of Diminishing Returns?
- Real world application
  - Economic policies can be tested using accurate simulations instead of theory
  - Predictions for the future of the economy can be predicted using accurate simulations

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