

Strategic Oligopoly Model for Industrial Economics

by

Timothy C. Daniels
B.A. Economics
University of Pennsylvania, 2004

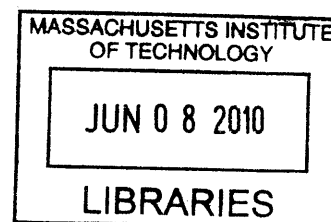
Submitted to the MIT Sloan School of Management in
partial fulfillment of the requirements for the degree of

Master of Business Administration
at the
Massachusetts Institute of Technology

June 2010

© Timothy C. Daniels. All rights reserved.

ARCHIVES



The author hereby grants to MIT permission to reproduce and to distribute
publicly paper and electronic copies of this thesis document in whole or in part.

Signed by

Timothy C. Daniels
MIT Sloan School of Management
May 7, 2010

Certified by

Robert S. Pindyck, Thesis Supervisor
Bank of Tokyo-Mitsubishi Professor of Economics and Finance
MIT Sloan School of Management

Accepted by

Debbie Berechman
Executive Director, MBA Program
MIT Sloan School of Management

Strategic Oligopoly Model for Industrial Economics

by

Timothy C. Daniels

Submitted to the MIT Sloan School of Management on May 7, 2010
in partial fulfillment of the requirements for the degree of
Master of Business Administration

ABSTRACT

Several years ago, Professor Robert Pindyck of the MIT Sloan School of Management created an oligopoly strategy game for use in his course 15.013: Industrial Economics for Strategic Decisions. This game divided the class up into “firms” (generally consisting of two students each) and randomly formed industries, each consisting of three firms. Students competed throughout the semester in a fictitious market for a heterogeneous good, each firm providing price and production inputs on a weekly basis. The purpose of the game was to provide a hands-on tool to teach students how industry competitors interact, and how forces such as signaling, collusion, demand fluctuations, and emotion affect industry and firm performance.

Although the game was carried out successfully for several years, issues surfaced over time. In particular, the Excel model used to run the weekly calculations was set up awkwardly and was therefore difficult to use. Additionally, the memo distributed to students to explain the game was disorganized, lacked sufficient examples, and contained errors. Finally, Professor Pindyck desired to implement the game in other courses with other professors, and this was not possible without a thorough document containing instructions for running the game as well as in-depth background information on the theory behind the calculations.

The work carried out for this thesis aimed to fix these problems. Specifically, I rebuilt the Excel model to operate in a simpler and more user-friendly fashion. Additionally, I revised the student memo to rectify the issues described above. Finally, I created a new manual to allow professors and TAs run the game in their courses.

Thesis Supervisor: Robert S. Pindyck

Title: Bank of Tokyo-Mitsubishi Professor of Economics and Finance

The work for this thesis was conducted in support of a strategic oligopoly game used to teach industrial economics. The game was created several years ago by Professor Robert Pindyck for his course 15.013: Industrial Economics for Strategic Decisions at the MIT Sloan School of Management. While the game quickly proved to be a valuable pedagogical tool, years of use brought to light a variety of issues that required refining. Professor Pindyck aimed to rectify these items, and to prepare the game in a form such that other professors at MIT and elsewhere could easily implement it in their courses.

The tasks required to achieve these goals were split into three separate work streams:

1. **Rebuild the Excel model used to run the game:** The original Excel model was effective at producing accurate results, but was difficult to set up at the beginning of the semester and quite complicated to use week to week. Therefore, the first task was to rebuild the model such that teams could be added easily and a TA or professor could be taught to run the game with minimal effort.
2. **Refine a memo explaining the game to students:** TAs from prior years had assembled a memo to help students understand the logistics and basic theory of the game. While this memo was helpful, years of use had shown that it did not adequately prepare students for game play. Specifically, it was disorganized, lacked examples to explain key concepts, and contained various errors. The second task was to revise the memo such that it thoroughly prepared students to play the game.
3. **Write a manual explaining the game to TAs and other professors:** While the student memo described above is helpful, it does not provide enough information to instruct a TA or professor to run the game. In particular, the student memo does not explain how to use the Excel file, and it goes into limited detail on the theory behind the numbers. Therefore, the third task was to write an in-depth memo (the “TA manual”) clarifying these issues.

Below, I provide background information on the strategy game, followed by sections dedicated to these three work streams. Please note that screenshots from the rebuilt Excel model can be found in

Appendix 1, and copies of the finalized student memo and TA manual are included in Appendices 2 and 3.

Background Information: The Oligopoly Strategy Game

Microeconomics courses often rely on simple models (such as the Bertrand and Cournot models) to explain theoretical concepts. The oligopoly strategy game takes this technique a step farther by combining a more complicated, realistic mathematical model with live game play taking place over a ten-week period. The goal is to help students understand the complexities involved in competition within a small industry. The students must make decisions regarding pricing, production, signaling, and collusion, and take ownership of the outcomes these decisions bring about (the latter is accomplished by making game performance a component of the students' final course grade).

The logistics of the game are as follows:

- The class is split into several “firms.” A firm consists of two students (or three in some cases if the class size is not divisible by six), and the pool of firms is randomly divided into industries, each containing three firms. Each firm has no idea which students comprise the other two firms in the industry. Thus, firms cannot discuss strategies, a factor intended to emulate antitrust laws.
- The three firms compete in a market for a heterogeneous good (i.e., a good that is similar across the three firms, but not identical). An example of such a good would be an ink-jet printer. No product is superior to the others, but different consumers have a “taste” for a particular firm’s product. The result of this is that a decrease in price increases demand, but the firm with the lowest price does *not* capture the entire market (as would be the case with a homogeneous, or identical, product).

- Each week for ten weeks, each firm must submit a price and production amount. The model uses the prices to apportion demand among the three firms, and the firms fulfill this demand with the current-period production and inventory remaining from production in prior weeks (firms must pay an inventory carrying cost to hold units until future weeks). If the firms have ample units available for sale, they satisfy their demand and carry inventory into the next period. However, if they run out of units (“stock out”), a portion of the demand they fail to satisfy can be captured by the competing firms in the industry.
- The three firms compete against each other directly, but each team’s final grade is determined by comparing the cumulative profits at the end of week ten to those of *all other firms in the economy* (i.e., all other firms in all sections of the course). Therefore, being the worst firm in a good industry may be better than being the best firm in a bad industry. In this sense, the three firms compete against each other, but can benefit from working together.

Further detail on game logistics can be found in Appendix 1.

The oligopoly strategy game is a valuable tool for teaching industrial economics for several reasons. First, as mentioned previously, it uses complicated formulas that accurately model how events would unfold in the real world. This provides a realistic scenario that students can relate to, as opposed to an overly simplistic setup that loses touch with reality.

Second, the strategy game takes into account the “learning curve.” As companies create their products, they steadily refine their production methods and lower costs accordingly. A real-world example of this is automobiles. Building a car is an extremely complicated process, but firms can learn from their experience over time and eventually work the “kinks” out of the production cycle. This learning is an important competitive tool, as firms with more experience and knowledge can achieve significant cost advantages over other firms. Most models used in economics courses ignore this effect,

but the oligopoly strategy game includes it to maintain legitimacy and teach students about an important economic concept.

Finally, the oligopoly strategy game gives students a chance to deal first-hand with an important element often ignored in economic courses: emotion. Simplified models generally view competitors as rational, profit maximizing entities, but this is often not the case in reality. In the real world, firms send signals, cooperate, “cheat” on this cooperation, punish their competitors for cheating, and make judgments on other firms’ actions in light of fluctuations in market demand. The result is a highly complicated landscape of competitors that may or may not behave as expected. There is no better way to understand this concept than trial and error, and the oligopoly strategy game provides this opportunity.

Task 1: Rebuild the Excel Model

The original Excel model for the strategy game had several issues that made it difficult to set up and use on a weekly basis. First, the model used a different worksheet for each week of price and production data, which made it very tedious to view the data across time periods. Additionally, this setup required the TA to edit ten separate worksheets at the beginning of the semester to accommodate the new group of firms. This was a time-consuming process that was extremely error-prone and difficult to explain to a new TA or professor. Also, the formulas used on these ten worksheets were inconsistent, requiring extreme care and attention when making edits. To fix this issue, I combined all of the data onto one worksheet and made the formulas consistent so that the user could simply copy the calculations down to accommodate a new week’s worth of data. This significantly decreased setup time at the beginning of the semester and allowed for quick and easy copy-and-paste entry of new price and production data.

Second, the original model used a very complicated procedure for creating and sending weekly summary emails to students. These emails are necessary to inform students of what happened during the past week, how the industry participants are performing, and what the demand shock is for the coming

week (please see Appendix 1 for more information on demand shocks). The old model required the TA to export an additional Excel file, import that file into Outlook, and run a Visual Basic procedure to send the emails. This worked fine once the TA figured out the process, but the routine took several steps and was difficult to explain to a new TA. To fix this, I built all of the functionality into the strategy game Excel file, so that the entire operation could be carried out without exporting files or running code from Outlook. The new model simply requires Outlook to be open, and summary emails to all students are sent in less than a minute with the simple click of a button. I also added similar functionality for a summary email to be sent to the professor and the other TA(s).

Third, the old model provided no method for creating summary PowerPoint slides used to illustrate game standings at the mid-point and end of the game. The PowerPoint files from previous years could be used as examples, but the TA had to recreate the charts and slides for the current year by hand. This took significant time, entailed the risk of errors in the calculations, and allowed for limited consistency in the exhibits across years. To rectify this issue, I built an Excel/Visual Basic procedure to create the charts and export them automatically to a PowerPoint template file. This allowed the entire process of creating the summary slides to be completed in roughly 15 seconds.

Fourth, one of the scenarios in the original model was flawed. It aimed to show the optimal long-run cooperative solution, or the best outcome an industry could achieve if each player behaved identically and cooperated with the other industry participants. However, the scenario relied on the assumption that all demand shocks are known at the beginning of the game, which is not the case in actuality. Rather, information on demand shocks is released week by week, so the assumption of perfect information in the original model gave theoretical firms an unrealistic advantage. I fixed this issue by editing the procedure such that only the demand shock for the current week is known, and all future shocks are assumed to be zero (a reasonable assumption given the game characteristics). I then programmed the analysis to repeatedly run Solver for each of the ten weeks, mimicking the behavior a firm would carry out to find the solution. Although the difference (in terms of profits) that this change entailed was slight, fixing the flaw helped the model to more accurately reflect reality.

Fifth, the original model provided no way to quickly and accurately print final handouts for the students. These handouts are distributed during the final class and detail everything that happened in a given industry throughout the course of the game, including pricing, production, inventory, demand, unit sales, and profits. The handouts also indicate the names of all of the students in the industry. In prior years, TAs compiled this information by hand and printed the handouts manually, which was an error-prone process that took an incredible amount of time. To improve this situation, I created a template in the Excel file that pulls all of the appropriate information for a given student name inputted by the TA. This allows for on-screen viewing and simple printing of a handout. Also, I wrote a procedure that separates the list of student names by section, alphabetizes them, and iterates through the list of names one by one, printing the handouts automatically for each student in the course. Although the actual printing process may take a great deal of time (due to the fact that the handouts are in color and the course may contain many students), the TA or professor can simply click the button and focus on another task while the printing takes place.

Sixth (and finally), the old model relied on a variety of assumptions that were scattered throughout the Excel file. This made it very difficult to edit these assumptions, and it was unclear whether or not a given change flowed through to the various calculations taking place within the “brain” of the model. In the updated model, I included all of these assumptions on a labeled worksheet and provided clear instructions regarding how to edit them. Additionally, on this sheet I added an array of cells for the TA to input the due dates and times for each of the ten weekly plays. This allows the model to automatically determine if a play was submitted late and assign a penalty fee if necessary (a task that had to be carried out by hand in the old model).

The end result of these changes is an oligopoly strategy game model that is easier to set up and much simpler to use throughout the course of the game. I am confident that it, along with the TA manual, will provide enough guidance for another professor or TA to implement the strategy game into a new course with ease. For screenshots of the updated model, please see Appendix 1.

Task 2: Refine the Student Memo

The original student memo was a helpful tool for teaching students about the strategy game, but it had several weaknesses. First, it lacked clear organization. By nature, the strategy game is extremely complicated, and the old memo simply launched into discussions of specific topics without giving a thorough outline of the big picture. Second, the memo lacked sufficient examples. Particularly for the explanation of demand calculations, it is helpful to present several examples for the students to work through, and although the old memo contained a few, many more were necessary. Finally, the original memo contained multiple mistakes and misleading explanations, as well as charts that were tricky to interpret.

I conducted a thorough revision of the student memo to fix all of these issues. Additionally, I added a summary graphic and cleaned up a demand flow chart that is a prime resource in helping students to understand the model's complex calculations. Please see Appendix 2 for the revised version of the student memo.

Task 3: Create a TA Manual

The student memo provides vital information on the logistics of the strategy game, but for a TA or professor, this information is insufficient. In order to allow for the strategy game to be implemented in new courses, an additional document was needed to provide further information at a much greater level of detail. In particular, this document needed to explain, in a precise, clear fashion, how to set up the Excel file at the beginning of the semester and how to run the game each week. Furthermore, it needed to provide in-depth background information on the theory behind the game so that professors and TAs would understand the logic at a much greater level of detail than the students. This would allow them to educate their students more effectively and understand tricky nuances that may surface from time to time.

The TA manual included in Appendix 3 accomplishes all of these goals. To make the explanations as clear as possible, I added several screenshots from the model, Google web forms, and PowerPoint summary slides. Additionally, I provided numerous charts in the appendices of the manual, as well as step-by-step derivations of two cooperative solutions that students could utilize. This document will thoroughly prepare professors and TAs to set up and run the oligopoly strategy game in future versions of their courses.

Appendix 1

Model Screenshots

Teams Worksheet

Strategy Game 2009 SCREENSHOTS - Microsoft Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M
	Team #	Industry	Industry Team	Name 1	Email 1	Name 2	Email 2	Name 3	Email 3	Section			
1													
2	9827	1		1 Mary Smith	msmith@mit.edu	Kathryn Coler	kcoleman@mit.edu			A			
3	9197	1		2 Patricia Johns	pjohnson@mit.edu	Louise Jenkins	ljenkins@mit.edu			A			
4	5470	1		3 Linda Williams	lwilliams@mit.edu	Sara Perry	sperry@mit.edu			A			
5	6629	2		1 Barbara Jones	bjones@mit.edu	Anne Powell	apowell@mit.edu			A			
6	1746	2		2 Elizabeth Brov	ebrown@mit.edu	Jacqueline Loi	ljong@mit.edu			A			
7	2174	2		3 Jennifer Davis	jdavis@mit.edu	Wanda Patter	wpatterson@mit.edu	Cathy Spence	cspencer@mit.edu	A			
8	6444	3		1 Maria Miller	miller@mit.edu	Bonnie Hughe	bhughes@mit.edu			A			
9	8817	3		2 Susan Wilson	swilson@mit.edu	Julia Flores	jflores@mit.edu			A			
10	3408	3		3 Margaret Moc	mnoore@mit.edu	Ruby Washing	rashington@mit.edu			A			
11	1038	4		1 Dorothy Taylo	dtaylor@mit.edu	Lois Butler	lbutler@mit.edu			A			
12	5274	4		2 Lisa Anderso	landerson@mit.edu	Tina Simmons	tsimmons@mit.edu			A			
13	7281	4		3 Nancy Thoma	nthomas@mit.edu	Phyllis Foster	pfoster@mit.edu			A			
14	4348	5		1 Karen Jackso	kjackson@mit.edu	Norma Gonzal	ngonzales@mit.edu			A			
15	9821	5		2 Betty White	bwhite@mit.edu	Paula Bryant	pbryant@mit.edu			A			
16	3419	5		3 Helen Harris	hharris@mit.edu	Diana Alexan	dalexander@mit.edu			A			
17	8662	6		1 Sandra Martin	smartin@mit.edu	Annie Russell	arussell@mit.edu			A			
18	1414	6		2 Donna Thomp	dthompson@mit.edu	Lillian Griffin	lgriffin@mit.edu			A			
19	6798	6		3 Carol Garcia	cgarcia@mit.edu	Emily Diaz	ediaz@mit.edu			A			
20	2051	7		1 Ruth Martinez	rmartinez@mit.edu	Robin Hayes	rhayes@mit.edu			A			
21	9734	7		2 Sharon Robins	srobinson@mit.edu	Peggy Myers	pmyers@mit.edu			A			
22	2205	7		3 Michelle Clark	mclark@mit.edu	Crystal Ford	cford@mit.edu			A			
23	5125	8		1 Laura Rodrigu	lrodriguez@mit.edu	Gladys Hamilt	ghamilton@mit.edu			A			
24	7603	8		2 Sarah Lewis	slewis@mit.edu	Rita Graham	rgraham@mit.edu			A			
25	9258	8		3 Kimberly Lee	klee@mit.edu	Dawn Sullivan	dsullivan@mit.edu			A			
26	8033	9		1 Deborah Wall	dwalker@mit.edu	Connie Wallac	cwallace@mit.edu			A			
27	9707	9		2 Jessica Hall	jhall@mit.edu	Florence Woo	fwoods@mit.edu			A			
28	4302	9		3 Shirley Allen	sallen@mit.edu	Tracy Cole	tcole@mit.edu			A			
29	3551	10		1 Cynthia Youn	cyoung@mit.edu	Edna West	ewest@mit.edu			A			
30	2997	10		2 Angela Herna	ahernandez@mit.edu	Tiffany Jordar	tjordan@mit.edu			A			
31	2712	10		3 Melissa King	mking@mit.edu	Carmen Ower	cowens@mit.edu			A			
32	1270	11		1 David Wick	dwick@mit.edu	Debra							

Teams Data Email Prof Email Students Shocks & Assumptions Scenarios Charts Final Handout

Ready 100%

Data Worksheet

Strategy Game 2009 SCREENSHOTS - Microsoft Excel

NOTE: Be careful not to edit/delete formulas or column titles.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	NOTE: Be careful not to edit/delete formulas or column titles.							Submitted					
2	Timestamp	Team #	Student Names	Production	Price	Comment	Week	Late?	Section	Industry	Industry Team	Team ID	Team ID.
3	10/1/2009 11:11:31	7605	Ann Evans, Ca	177	73.52	Assume C	1	-	B	16	3 16-3	16-3	1
4	10/1/2009 17:54:34	4084	Frances Parke	200	70	This week	1	-	B	16	2 16-2	16-2	1
5	10/1/2009 21:48:20	2006	Teresa Rogers	250	60	We used t	1	-	B	18	3 18-3	18-3	1
6	10/2/2009 15:09:41	6629	Barbara Jones,	132	80.14	Our team	1	-	A	2	1 2-1	2-1	1
7	10/2/2009 15:39:26	9197	Patricia Johnsc	200	75	From our i	1	-	A	1	2 1-2	1-2	1
8	10/2/2009 18:03:06	2712	Melissa King, C	132	80.2	We assum	1	-	A	10	3 10-3	10-3	1
9	10/2/2009 21:48:18	3061	Kathy James, J	250	61	We want t	1	-	B	24	2 24-2	24-2	1
10	10/2/2009 23:26:54	8174	Martha Gonzal	133	80	Assuming	1	-	A	13	2 13-2	13-2	1
11	10/3/2009 14:31:03	2937	Christina Rami	194	71	Week one	1	-	B	24	1 24-1	24-1	1
12	10/3/2009 14:37:31	1770	Brenda Wright	250	64.49	We built a	1	-	A	11	1 11-1	11-1	1
13	10/3/2009 20:09:12	5156	Denise Kelly, C	200	70	We will gc	1	-	B	25	2 25-2	25-2	1
14	10/4/2009 1:56:00	1424	Julie Sanchez,	140	79	Under ass	1	-	B	18	1 18-1	18-1	1
15	10/4/2009 12:13:02	5351	Amanda Carte	200	70	For the fir	1	-	B	14	1 14-1	14-1	1
16	10/4/2009 12:58:39	1170	Judy Gray, Da	200	70	We want t	1	-	B	23	3 23-3	23-3	1
17	10/4/2009 13:40:20	8796	Diane Collins, J	145	80	Since we r	1	-	B	17	2 17-2	17-2	1
18	10/4/2009 14:32:32	6798	Carol Garcia, E	167	75	Our team	1	-	A	6	3 6-3	6-3	1
19	10/4/2009 14:37:13	2844	Judith Cox, Lu	170	80	The one-p	1	-	B	22	1 22-1	22-1	1
20	10/4/2009 15:53:32	1746	Elizabeth Brow	200	70	We choos	1	-	A	2	2 2-2	2-2	1
21	10/4/2009 17:02:44	9130	Irene Price, D	230	61	At this P s	1	-	B	26	1 26-1	26-1	1
22	10/4/2009 18:35:46	7661	Carolyn Perez,	240	72	Maximizin	1	-	B	14	3 14-3	14-3	1
23	10/4/2009 18:49:42	7532	Janice Ward, J	170	75	In setting	1	-	B	22	3 22-3	22-3	1
24	10/4/2009 20:53:19	5274	Lisa Anderson	200	70	The price	1	-	A	4	2 4-2	4-2	1
25	10/4/2009 21:03:08	9514	Doris Reed, A	200	70	We create	1	-	B	19	1 19-1	19-1	1
26	10/4/2009 21:33:54	2383	Alice Stewart,	196	70.75	Based on	1	-	B	17	3 17-3	17-3	1
27	10/4/2009 21:42:05	6585	Janet Phillips, I	300	66	Climbing d	1	-	B	15	3 15-3	15-3	1
28	10/4/2009 21:47:57	7281	Nancy Thoma	230	70	Our revis	1	-	A	4	3 4-3	4-3	1
29	10/4/2009 23:17:54	8930	Theresa Watsc	233	65	This is a c	1	-	B	24	3 24-3	24-3	1
30	10/4/2009 23:55:45	1486	Amy Lopez, C	176	74	We develc	1	-	A	11	2 11-2	11-2	1
31	10/5/2009 0:32:04	9707	Jessica Hall, F	204	65	We assum	1	-	A	9	2 9-2	9-2	1

Teams Data Email Prof Email Students Shocks & Assumptions Scenarios Charts Final Handout

Ready 100%

Email Professor Worksheet

Strategy Game 2009 SCREENSHOTS - Microsoft Excel

Home Insert Page Layout Formulas Data Review View Developer

A1 =Week "&L13&" Summary

	Minimum	Maximum	Average	Standard Deviation
Period's Production	0	475	228	72
Price	\$40.00	\$79.00	\$59.56	\$6.06
Production + Old Inventory	100	475	259	63
Unit Sales	100	475	252	67
New Inventory Level	0	129	7	23
Profit	(\$6,149)	\$14,148	\$2,861	\$2,292
Cum. Profit	\$4,620	\$24,176	\$16,726	\$4,515
Industry Avg. Profit	(\$593)	\$5,376	\$2,861	\$1,257
Industry Avg. Cum. Profit	\$8,247	\$22,195	\$16,726	\$3,323

Week 10 Summary
Shock: 0

Instructions:

- 1) Paste in quotes consecutively below the "Quotes" cell below
- 2) Edit week if necessary (most recent should show automatically)
- 3) Edit prof's email address or subject line if necessary
- 4) Click "Send Prof Email" button

NOTE: the formulas to the left (except the averages) are array formulas, and must be entered with CTRL+SHIFT+ENTER. If they are correct, they will have brackets ({}) around the formula.

NOTE: there are hidden columns to the right for macros and calculations.

Week: 10
Prof TA Email Addresses: jgardner@mit.edu
Subject Line: Week 10 Strategy Game Stats

Send Prof Email

Quotes:

19 Huge price drops: "And... boom goes the dynamite." "Go big or go home "

20 Sorry, just bragging rights: "Thanks, it's been fun. Is there a prize for dead last?"

21 Passive aggressive?: "Thank you everybody for teaching that for a rational guy, it is hard to survive in the real world."

22 Have fun on Wednesday!: "Can't wait to meet our competitors...it will get bloody." "Can't wait to meet the folks on the other end..."

Teams Data Email Prof Email Students Shocks & Assumptions Scenarios Charts Final Handout

Ready 100%

Email Students Worksheet

Line Title	Value	Format	As It Will Look
Team Membr	Lori Wood & General		Team Members: Lori Wood & Jill Hawkins
Team #	8398	General	Team = 8398
Shock for Tl	0	=,##0;-,##0	Shock for THIS period: 0
Shock for N	N.A	=,##0;-,##0	Shock for NEXT period: N.A
Your Produc	230	=,##0;-,##0	Your Production: 230
Your Price	\$61.00	=\$,##0.00;-\$	Your Price: \$61.00
Your New I	4	=,##0;-,##0	Your New Level of Inventory: 4
Your Unit S	251	=,##0;-,##0	Your Unit Sales: 251
Your Deman	251	=,##0;-,##0	Your Demand: 251
Your Profit	\$3,673	=\$,##0;-\$,##	Your Profit: \$3,673
Your Cumul	2,862	=,##0;-,##0	Your Cumulative Production (incl. 32 initial units): 2,862
Your Cumul	\$4,620	=\$,##0;-\$,##	Your Cumulative Profits: \$4,620
A's Price (r	\$59	=\$,##0;-\$,##	A's Price (rounded to nearest integer): \$59
A's Unit Sale	270	=,##0;-,##0	A's Unit Sales (rounded to nearest 10): 270
A's Inventor	0	=,##0;-,##0	A's Inventory (rounded to nearest 10): 0
B's Price (r	\$59	=\$,##0;-\$,##	B's Price (rounded to nearest integer): \$59
B's Unit Sale	290	=,##0;-,##0	B's Unit Sales (rounded to nearest 10): 290
B's Inventor	0	=,##0;-,##0	B's Inventory (rounded to nearest 10): 0
Industry Ave	\$5,045	=\$,##0;-\$,##	Industry Average Profit: \$5,045
Industry Ave	\$8,247	=\$,##0;-\$,##	Industry Average Cumulative Profit: \$8,247
Economy A	\$2,861	=\$,##0;-\$,##	Economy Average Profit: \$2,861
Economy M	\$2,699	=\$,##0;-\$,##	Economy Median Profit: \$2,699
Standard De	\$2,306	=\$,##0;-\$,##	Standard Deviation of Economy Profit: \$2,306
Economy A	\$16,726	=\$,##0;-\$,##	Economy Average Cumulative Profit: \$16,726
Economy M	\$17,863	=\$,##0;-\$,##	Economy Median Cumulative Profit: \$17,863
Standard De	\$4,543	=\$,##0;-\$,##	Standard Deviation of Economy Cumulative Profit: \$4,543

Instructions:

- 1) Make sure the info on the "Teams" sheet is correct
- 2) Make sure the data on the "Data" sheet is accurate and
- 3) Make sure the formulas on the "Data" sheet are copied
- 4) Paste in quotes consecutively below the "Quotes" cell b
- 5) Edit week if necessary (most recent should show autor
- 6) Edit subject line if necessary
- 7) Click "Send Student Emails" button

NOTE: there are hidden columns to the right for macros

Week: 10
 Subject Line: Strategy Game, Week 10

Send Student Emails

Shocks & Assumptions Worksheet

The screenshot shows an Excel spreadsheet with the following data:

Week	Shock	Submission Deadlines
1	0	Monday, 10/5/2009 17:01:00
2	200	Monday, 10/12/2009 17:01:00
3	100	Monday, 10/19/2009 17:01:00
4	(200)	Monday, 10/26/2009 17:01:00
5	300	Monday, 11/2/2009 17:01:00
6	(300)	Monday, 11/9/2009 17:01:00
7	200	Monday, 11/16/2009 17:01:00
8	200	Monday, 11/23/2009 17:01:00
9	(100)	Monday, 11/30/2009 17:01:00
10	0	Friday, 12/4/2009 17:01:00

Assumptions	
Beginning Cumulative Production	32
Constant P Price	\$70.00
Constant Q Quantity	200
Inventory Carrying Cost per Unit	\$2.00
Ending Inventory Value per Unit	\$40.00
Penalty for Late Play Submission	\$500.00

Instructions (from yellow box):
 Edit shocks (if necessary) on this page and they will flow through to the other sheets. Make sure that the submission deadlines are accurate. You can also adjust the assumptions if necessary. If you change the shocks or beginning cumulative production, Solver will run to update the Long Run Cooperative scenarios. If you are changing several shocks, you may want to paste the new shocks in AS VALUES (copy, then Alt E, S, V) so Solver only runs once.

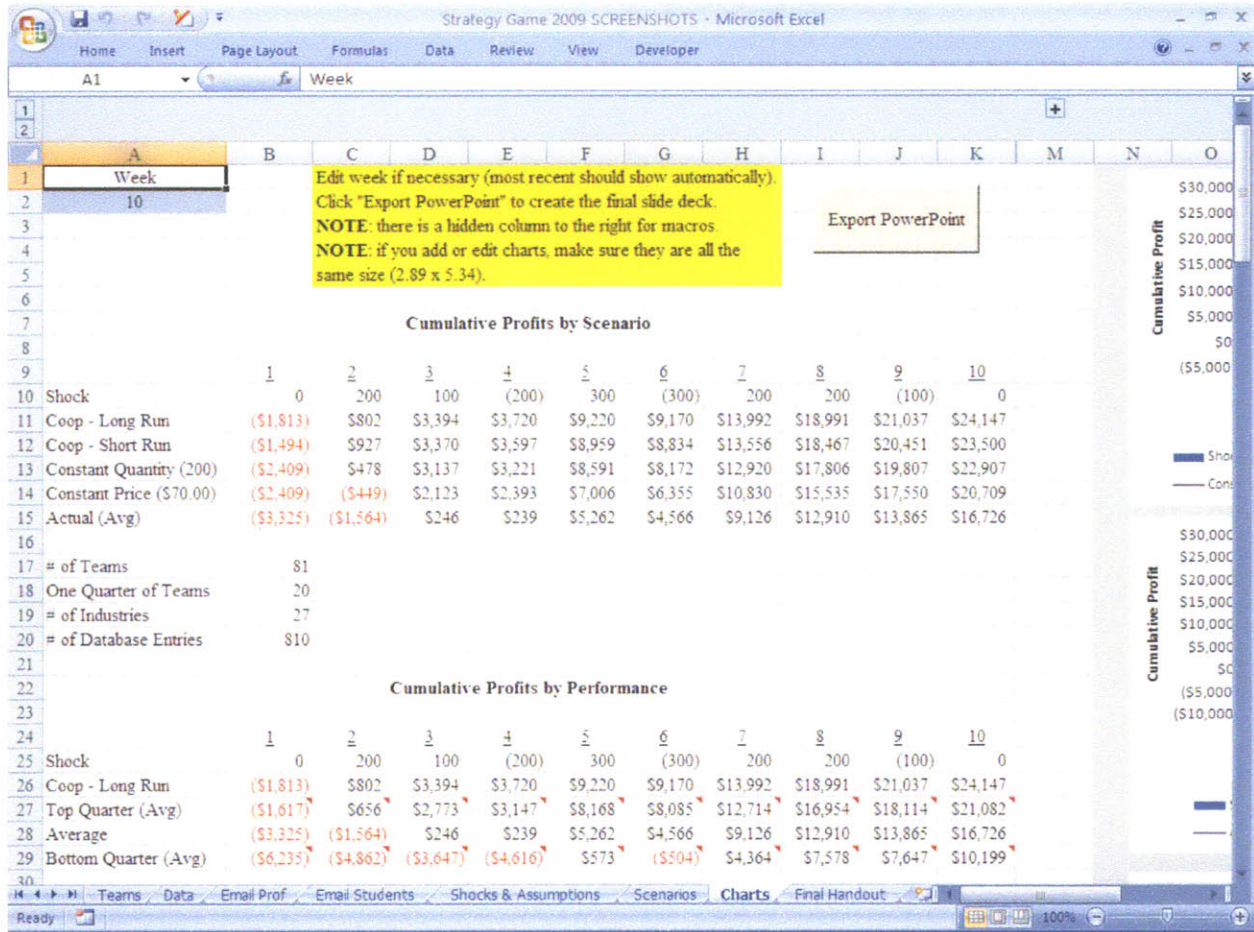
Scenarios Worksheet

Strategy Game 2009 SCREENSHOTS - Microsoft Excel

	A	B	C	D	E	F	G	H	I	J	K	L
	Week											
	1	2	3	4	5	6	7	8	9	10		
Shock	0	200	100	(200)	300	(300)	200	200	(100)	0		
Long-Run Cooperative – Assuming Zero Shocks												
Quantity (Industry)	517	585	595	599	600	601	602	603	603	603		
Quantity	172	195	198	200	200	200	201	201	201	201		
Price	\$74.15	\$70.74	\$70.25	\$70.07	\$69.98	\$69.93	\$69.89	\$69.87	\$69.85	\$69.84		
Total Revenue	\$12,778	\$13,798	\$13,934	\$13,982	\$14,006	\$14,019	\$14,028	\$14,034	\$14,039	\$14,043		
Cumulative Production	32	204	399	598	797	997	1,198	1,399	1,599	1,800		
Alpha	0.4704	0.3143	0.2716	0.2488	0.2337	0.2226	0.2139	0.2068	0.2008	0.1957		
Total Cost	\$14,591	\$13,032	\$12,355	\$11,956	\$11,680	\$11,472	\$11,307	\$11,171	\$11,056	\$10,957		
Profit	(\$1,813)	\$766	\$1,579	\$2,026	\$2,326	\$2,547	\$2,721	\$2,864	\$2,983	\$3,086		
Cumulative Profit	(\$1,813)	(\$1,047)	\$532	\$2,558	\$4,884	\$7,431	\$10,153	\$13,016	\$15,999	\$19,085		
Long-Run Cooperative – All Shocks Known												
Quantity (Industry)	520	658	633	527	712	491	677	678	567	604		
Quantity	173	219	211	176	237	164	226	226	189	201		
Price	\$73.99	\$77.10	\$73.34	\$63.67	\$79.38	\$60.44	\$76.13	\$76.10	\$66.67	\$69.79		
Total Revenue	\$12,831	\$16,910	\$15,479	\$11,175	\$18,850	\$9,897	\$17,190	\$17,198	\$12,592	\$14,055		
Cumulative Production	32	205	425	636	811	1,049	1,213	1,438	1,664	1,853		
Alpha	0.4704	0.3139	0.2680	0.2455	0.2328	0.2202	0.2133	0.2055	0.1991	0.1945		
Total Cost	\$14,662	\$14,290	\$12,884	\$10,848	\$13,348	\$9,946	\$12,366	\$12,199	\$10,544	\$10,944		
Profit	(\$1,831)	\$2,621	\$2,596	\$327	\$5,502	(\$49)	\$4,824	\$5,000	\$2,048	\$3,110		
Cumulative Profit	(\$1,831)	\$789	\$3,385	\$3,712	\$9,214	\$9,165	\$13,989	\$18,989	\$21,037	\$24,147		
Long-Run Cooperative – Current Shock Known (Realistic)												

Teams Data Email Prof Email Students Shocks & Assumptions Scenarios Charts Final Handout

Charts Worksheet



Final Handout Worksheet

Strategy Game 2009 SCREENSHOTS - Microsoft Excel

Strategy Game Final Handout Industry 4

		Competitors			Members		
Team #	A	B					
Team 1	1038	Team 2	Team 3	Dorothy Taylor & Lois Butler			
Team 2	5274	Team 1	Team 3	Lira Anderson & Tina Simmons			
Team 3	7281	Team 1	Team 2	Nancy Thomas & Phyllis Foster			

Week	Shock	1's Production	2's Production	3's Production	1's Price	2's Price	3's Price	1's Inventory	2's Inventory	3's Inventory	1's Profit	2's Profit	3's Profit	1's Cum. Profit	2's Cum. Profit	3's Cum. Profit
1	0	250	200	230	\$62.50	\$70.00	\$70.00	0	0	14	(\$4,261)	(\$2,409)	(\$3,373)	(\$4,261)	(\$2,409)	(\$3,373)
2	200	300	200	250	\$62.00	\$80.00	\$70.00	0	0	0	\$30	\$2,886	\$2,912	(\$3,950)	\$478	(\$461)
3	100	200	200	240	\$77.00	\$75.00	\$70.00	9	0	0	\$2,684	\$2,660	\$2,744	(\$1,266)	\$3,137	\$2,283
4	(200)	190	200	120	\$84.00	\$85.00	\$73.00	0	13	28	\$1,472	\$213	(\$1,900)	\$206	\$3,350	\$383
5	300	360	200	200	\$72.00	\$85.00	\$80.00	0	44	0	\$6,382	\$2,646	\$6,656	\$6,588	\$5,997	\$7,040
6	(300)	150	200	200	\$62.00	\$64.95	\$55.00	0	66	0	\$40	(\$1,328)	(\$382)	\$6,628	\$4,668	\$6,658
7	200	350	200	210	\$67.00	\$80.50	\$78.50	0	107	1	\$5,178	\$2,944	\$4,766	\$11,806	\$7,612	\$11,424
8	200	320	200	220	\$70.00	\$85.00	\$77.00	0	0	33	\$6,040	\$8,840	\$2,498	\$17,847	\$16,453	\$13,922
9	(100)	330	200	190	\$81.00	\$85.00	\$80.00	66	21	0	(\$696)	\$594	\$2,810	\$17,160	\$17,046	\$16,732
10	0	200	200	220	\$63.00	\$61.00	\$55.00	0	0	0	\$6,108	\$2,581	\$420	\$23,268	\$19,628	\$17,152
Average	40	265	200	208	\$66.05	\$71.15	\$68.85	8	27	8	\$2,327	\$1,963	\$1,715			
														Industry Average Cumulative Profit		\$20,016

Production & Shocks

Prices & Cumulative Profit

Ready Teams Data Email Prof Email Students Shocks & Assumptions Scenarios Charts Final Handout 70%

Appendix 2

Student Memo

THE STRATEGIC OLIGOPOLY GAME

You and your partner manage a firm that is about to battle it out with two tough competitors. Your firm and your two competitors have entered the market at the same time. Your goal is to *maximize your cumulative profits* (no discounting) by setting a price and production level in each of ten periods. Each of your competitors has the same objective. When making your pricing and production decisions, you must consider how your actions will affect your competitors, and how they are likely to react.

The demand for your product depends on the prices which you and your competitors set. However, because of the lead time in your production process, you must decide how much to produce *before* you actually know what your demand will be. Thus you might not produce enough to meet demand, or you might be left with some unsold inventory. In the latter case, you can sell that inventory later, but you will incur *inventory carrying costs*. In addition, your marginal and total costs will decrease as you move down a *learning curve*. While you start out with the same cost function as your competitors, their future costs might differ from yours depending upon their cumulative production.

Your grade for the game will be based on your cumulative profits at the end of ten weeks relative to the other firms in the *entire economy* – i.e., all firms in all sections of the course (not just your own industry).

RULES AND LOGISTICS

Choosing a Partner

You and your partner will work together to make weekly production and pricing decisions for your firm. Choosing a partner is an important part of this game. You should think strategically in making this choice. Will you be more successful with a person who thinks the way you do, or who thinks differently? If you are a risk-averse individual, do you want a partner who is similarly risk-averse, or one who is more risk-loving? Do you want a partner who is more or less aggressive than you?

Before the first play of the game, students must choose a partner, and submit this choice through a Google web form that will be set up by the TA. Alternatively, students wishing to be

paired by the TA can email a brief description of what they would like in the partner they will be assigned.

Industry Formation

For the purpose of this game, you and your partner will be randomly matched with two other competing firms in your section. However, you will not know the identities of your two competitors. One rule which we impose on the game is that *you may not make any attempts to discover the identities of your competitors*. This is our way of simulating the antitrust laws and avoiding collusive behavior. Students found violating this rule will have treble damages assessed against their cumulative profits.

Submitting a Play

Each week you *or* your partner should submit your play through another Google web form. The link will be posted on your course website (for MIT Sloan, the course website is called Stellar). You do not need a Google account to access the form. If there are any problems accessing the site, submit your play by emailing it to your TA. Game plays must be submitted on time. If a team is late in submitting its game play, *\$500 will be subtracted from its profits*.

A play consists of a price and a production quantity, together with a few sentences explaining the reasoning behind your choices. After the game master evaluates the market outcome, you will be informed of your demand, sales, inventory, and profits for the period, as well as your cumulative profits to date. You will also be given information about your two competitors' prices, production levels, and inventories (but not their exact values, in order to preserve anonymity), along with information about the performance of your industry, as well as the "economy" (the entire class, all sections) as a whole.

If you submitted a play and would like to change the price and/or quantity before the deadline, you may do so by simply submitting another entry through the Google web form. You may submit new plays as many times as you like prior to the deadline – only your most recent play will be included in the game. Once the deadline hits, you may not change your play.

Trial Play

A trial play of the strategy game will be run prior to the first actual game play. This trial play will allow teams to take part in a dry run of play submission without affecting their performance in the real game. *Every team must submit a trial play.* If you are confused and are not sure what numbers to enter for the price and/or quantity, please speak with your TA for clarification. *It is essential that you take this trial play seriously* and determine your price and quantity carefully – it is a valuable learning opportunity that should not be wasted.

After the trial play, all industries and teams will be reshuffled. In other words, the teams will be randomized and matched with different competitors for the actual game. Teams will *not* be reshuffled after this point (in other words, you will face new competitors after the trial play, but have the same competitors for the 10 weeks of actual game play).

Remember, your objective is to *maximize the total sum of profits* over the semester (no discounting). Grading will be based on your performance (cumulative profits at the end of week 10) and on the explanations you give for your weekly strategies. Your grade will depend *not* on a comparison with the two competitors in your industry, but rather on your performance compared to the “economy” as a whole, i.e., *all other firms in all sections of the course*.

DEMAND

The three firms in the industry are treated symmetrically: firms that have the same price and the same quantity available for sale have the same demand and the same sales. Industry demand depends on a weighted average industry price with weights equal to the market shares of each of the three firms in the industry. Each firm’s market share depends on its price relative to the prices charged by its competitors. For each firm, the quantity available for sale can come from production and/or from inventory.

If a firm’s demand exceeds the quantity it has available for sale, its demand is rationed among its competitors. Sales for the firm are then equal to the quantity it has available for sale, and the unsatisfied demand is picked up by the other firms in the industry. The means by which this unsatisfied demand is allocated to the other firms in the industry is explained below.

Distinction Between Production, Unit Sales, and Demand

Production is the number of new units you produce in the period. *Unit Sales* is the number of units that are actually purchased at your asking price during a period. *Demand* is the number of units customers are willing to purchase at your asking price. The following two examples should help to clarify this distinction.

Suppose you currently have no inventory. If your production is less than your demand, you can sell all you produced and your unit sales will equal your production. If you produce *more* than your demand, your unit sales will equal your demand, and the excess production becomes part of your inventory. You will incur a carrying cost each period for this inventory, which is deducted from your profits in the period. However, you may sell your inventory at any time in the future without incurring any additional production cost.

Suppose you currently have an inventory of 50 units, and you decide to produce 70 units this period, bringing your total units available for sale to 120. If demand is 130 units, your unit

sales will be 120 units and your inventory will drop to zero. You will then incur no inventory carrying costs for the period. Your excess demand of 10 units will be picked up by your competitors, to the extent that they have sufficient supplies to meet this excess demand.

To help explain how demand is calculated, we will introduce several variables. The data collected from the firms each week are:

P_i = Firm i 's price

Y_i = Firm i 's production

for $i = 1, 2,$ and 3 . These inputs should be submitted through the Google web form created by the TA.

For simplicity, we will introduce the remaining variables for Firm 1 only, although the same logic extends to Firms 2 and 3. The market demand function, the market share allocating rule, and the computations performed to determine demands and sales are as follows:

Q = total industry demand

P = weighted average market price used to compute industry demand

Q_1 = Firm 1's initial demand (before adjusting for excess demand from other firms)

S_1 = Firm 1's initial market share (before adjusting for excess demand from other firms)

X_1 = Firm 1's production plus its ending inventory from last period (i.e., the number of units available for sale in the current period)

I_1 = Firm 1's inventory

Z_1 = Firm 1's unit sales

w_1 = weighting factor used to determine market share (before excess demand adjustments), where

$$w_1 = e^{\left(-6 \times \frac{2P_1 - P_2 - P_3}{P_1 + P_2 + P_3}\right)}$$

Once the weighting factors are determined, initial market share and demand for Firm 1 are computed as follows:

$$S_1 = w_1 / (w_1 + w_2 + w_3)$$

$$P = S_1 P_1 + S_2 P_2 + S_3 P_3$$

$$Q = 2000 - 20P + \varepsilon = 2000 - 20(S_1 P_1 + S_2 P_2 + S_3 P_3) + \varepsilon \quad [\text{see below for more on } \varepsilon]$$

$$Q_1 = S_1 Q \quad (\text{rounded to the nearest integer})$$

$$X_1 = Y_1 + I_1$$

Z_1 = the minimum of units available for sale (X_1) and Firm 1's final demand after all adjustments (see below for a discussion of adjustments for excess demand)

Here, ε is a random shock to the market demand. It will be announced for the coming week, as the results of the prior play are being distributed. This random shock means that *you must respond each week to shifts in market demand*. (Positive shocks to demand could be the result of an increase in income levels; negative shocks could result from an economic downturn, weather conditions, etc.) Shocks range from roughly -400 to 400 and average close to zero over the 10 weeks (the average is intentionally slightly different from zero so students cannot back out what the shock will be in the last week). **In all of the examples that follow, we let $\varepsilon = 0$ for simplicity.**

Note that each firm must use caution when interpreting changes in pricing exhibited by competitors. At first glance, a decrease in price may seem like undercutting, but it could also be a logical and industry-optimal reaction to a negative demand shock. Determining the intentions of your competitors is part of the challenge in navigating a volatile competitive environment.

Adjusting each firm's demand for excess demand unfulfilled by other industry players is a complicated process that is illustrated in detail below. The following scenarios can occur (please refer to the flow chart at the end of this memo for a visual representation):

- **Case 1:** Units available for sale exceed demand for all three firms. In this scenario, all industry players have ample supply, so they simply sell their respective quantities demanded.
- **Case 2:** *Demand exceeds units available for sale for one firm only.* Part of this excess demand (denoted Q') "spills over" and is divided between the two remaining firms based on their prices. After adjusting for these increases in demand for the other two firms, three sub-cases can occur:
 - **Case 2A:** *Units available for sale exceed demand for both remaining firms.* Here, both remaining firms have ample supply, so they simply sell their respective adjusted demands.
 - **Case 2B:** *Demand exceeds units available for sale for one of the two remaining firms only.* The firm that "stocks out" simply sells its units available, and part of the new excess demand (denoted Q'') spills over to the one remaining firm based on its price. That firm sells the lesser of its

units available for sale and its demand, which has now been adjusted up twice.

- **Case 2C:** *Demand exceeds units available for sale for both remaining firms.* Both firms have excess demand, but no one is left to capture it. Each firm simply sells its units available for sale.
- **Case 3:** *Demand exceeds units available for sale for two of the three firms.* In this case, a portion of the combined excess demand (denoted Q''') from the two firms that stocked out is allocated to the remaining firm based on its price. The two firms that stocked out simply sell their units available for sale, and the remaining firm sells the lesser of its units available for sale and its adjusted demand.
- **Case 4:** *Demand exceeds units available for sale for all three firms.* All three firms stock out, so there is no one left to capture the excess demand. Each industry player simply sells its units available for sale.

These scenarios are explained in further detail below:

Case 1 (units available for sale exceed demand for all three firms): In this simple scenario, units available for sale exceed demand for each firm, so each firm just sells its demand. (Algebraically, $X_1 > Q_1$, $X_2 > Q_2$, and $X_3 > Q_3$, so unit sales for Firms 1, 2, and 3 are Q_1 , Q_2 , and Q_3 respectively.) This is illustrated by Example 1 below.

Example 1 (Case 1)

	Inputs		Inventory Accounting	
	Price (P_i)	Production (Y_i)	Inventory (I_i)	Units Available (X_i)
Firm 1	60	295	125	420
Firm 2	70	250	0	250
Firm 3	75	65	135	200

Outputs (Computed by the Game)				
	Weighting (w_i)	Share (S_i)	Demand (Q_i)	Unit Sales (Z_i)
Firm 1	2.08	0.59	418	418
Firm 2	0.86	0.25	174	174
Firm 3	0.56	0.16	112	112

To be thorough, we will show the game calculations for the weighting factors, shares, and demands for Firm 1. Note that the calculations in the remaining examples are similar.

For the weighting factor:

$$w_1 = e^{\left(-6 \times \frac{2P_1 - P_2 - P_3}{P_1 + P_2 + P_3}\right)} = e^{\left[-6 \times \frac{2(60) - 70 - 75}{60 + 70 + 75}\right]} = 2.08$$

For the share:

$$S_1 = \frac{w_1}{w_1 + w_2 + w_3} = \frac{2.08}{2.08 + 0.86 + 0.56} = 0.59$$

For the demand (remember that $\varepsilon = 0$):

$$Q = 2000 - 20(S_1P_1 + S_2P_2 + S_3P_3) = 2000 - 20[(0.59)(60) + (0.25)(70) + (0.16)(75)] = 703$$

$$Q_1 = S_1Q = (0.59)(703) = 418$$

Now take the more complicated case in which one or more firms have a quantity available for sale that is insufficient to satisfy demand. There are several possibilities, which we will go through one by one, and which are illustrated in the flow chart at the end of this memo.

Case 2 (demand exceeds units available for sale for Firm 1 only): Suppose $Q_1 > X_1$, but $Q_2 < X_2$ and $Q_3 < X_3$. Then unit sales for Firm 1 are X_1 , and part of the excess demand for Firm 1 is allocated to Firms 2 and 3.

Since only Firm 1 stocked out, we have:

Q' = additional demand split between Firms 2 and 3 based on their prices

We now introduce several new variables:

S'_2 = market share of Firm 2 of the additional demand for Firms 2 and 3

S'_3 = market share of Firm 3 of the additional demand for Firms 2 and 3

Q'_2 = adjusted demand for Firm 2 given that $Q_1 > X_1$

Q'_3 = adjusted demand for Firm 3 given that $Q_1 > X_1$

These variables are calculated as follows:

$$S'_2 = w_2 / (w_2 + w_3)$$

$$S'_3 = w_3 / (w_2 + w_3)$$

$$Q' = [1 - (X_1 / Q) - S_2 - S_3][2000 - 20(S'_2 P_2 + S'_3 P_3) + \varepsilon]$$

$$Q'_2 = S'_2 Q' + Q_2$$

$$Q'_3 = S'_3 Q' + Q_3$$

We must now consider three possibilities:

- (1) Case 2A (units available for sale exceed demand for both firms): If the demands for Firms 2 and 3 (as calculated above) are smaller than the quantities available for sale for each of these firms, then the unit sales of these two firms are equal to their respective demands (i.e., if $Q'_2 < X_2$ and $Q'_3 < X_3$ then unit sales for Firms 2 and 3 are respectively Q'_2 and Q'_3). This case is illustrated by Example 2 below.

Example 2 (Case 2A)

As $Q'_2 = 231 < X_2 = 250$ and $Q'_3 = 149 < X_3 = 200$, unit sales for Firms 2 and 3 are respectively 231 and 149. (Again, remember that for this example, $\varepsilon = 0$). Unit sales for Firm 1 are $X_1 = 300$:

Inputs			Inventory Accounting	
	Price (P_i)	Production (Y_i)	Inventory (I_i)	Units Available (X_i)
Firm 1	60	175	125	300
Firm 2	70	250	0	250
Firm 3	75	65	135	200

Outputs (Computed by the Game)						
	Weighting (w_i)	Initial Share (S_i)	Demand (Q_i)	Residual Share (S'_i)	Revised Demand (Q'_i)	Unit Sales (Z_i)
Firm 1	2.08	0.59	418	–	–	300
Firm 2	0.86	0.25	174	0.61	231	231
Firm 3	0.56	0.16	112	0.39	149	149

- (2) Case 2B (demand exceeds units available for sale for Firm 2 only): If the demand for Firm 2 is larger than the quantity it has available for sale, it sells the quantity it has available. (Algebraically, if $Q'_2 > X_2$, then Firm 2 sells X_2 .)

Since Firm 2 has now stocked out, we have:

Q'' = Firm 2's excess demand that will be apportioned to Firm 3

Mathematically:

$$Q'' = \frac{(2000 - 20P_3 + \varepsilon)(Q'_2 - X_2)}{2000 - 20(S'_2P_2 + S'_3P_3) + \varepsilon}$$

$$Q'_3 = Q'_3 + Q''.$$

Examples 3 and 4 help to clarify this scenario. In Example 3, Firm 3 has enough units available to fulfill its adjusted demand. In Example 4, Firm 3's adjusted demand exceeds its units available for sale, so it stocks out.

Example 3 (Case 2B)

In this example, $Q_3'' < X_3$:

Inputs			Inventory Accounting	
	Price (P_i)	Production (Y_i)	Inventory (I_i)	Units Available (X_i)
Firm 1	60	175	125	300
Firm 2	70	180	0	180
Firm 3	75	65	135	200

Outputs (Computed by the Game)							
	Weighting (w_i)	Initial Share (S_i)	Initial Demand (Q_i)	Residual Share (S_i')	Revised Demand (Q_i')	2 nd Rev. Demand (Q_i'')	Unit Sales (Z_i)
Firm 1	2.08	0.59	418	–	–	–	300
Firm 2	0.86	0.25	174	0.61	231	–	180
Firm 3	0.56	0.16	112	0.39	149	194	194

Example 4 (Case 2B)

In this example, $Q_3'' > X_3$:

Inputs			Inventory Accounting	
	Price (P_i)	Production (Y_i)	Inventory (I_i)	Units Available (X_i)
Firm 1	60	175	125	300
Firm 2	70	180	0	180
Firm 3	75	45	135	180

Outputs (Computed by the Game)							
	Weighting (w_i)	Initial Share (S_i)	Initial Demand (Q_i)	Residual Share (S'_i)	Revised Demand (Q'_i)	2 nd Rev. Demand (Q''_i)	Unit Sales (Z_i)
Firm 1	2.08	0.59	418	–	–	–	300
Firm 2	0.86	0.25	174	0.61	231	–	180
Firm 3	0.56	0.16	112	0.39	149	194	180

- (3) Case 2C (demand exceeds units available for sale for both firms): If the demands for *both* Firms 2 and 3 are higher than the quantities they have available for sale, each firm sells only what it has available (i.e., if $Q'_2 > X_2$ and $Q'_3 > X_3$ then unit sales for Firms 2 and 3 are respectively X_2 and X_3). This is illustrated by Example 5 below.

Example 5 (Case 2C)

Inputs			Inventory Accounting	
	Price (P_i)	Production (Y_i)	Inventory (I_i)	Units Available (X_i)
Firm 1	60	175	125	300
Firm 2	70	180	0	180
Firm 3	75	5	135	140

Outputs (Computed by the Game)						
	Weighting (w_i)	Share (S_i)	Demand (Q_i)	Residual Share (S'_i)	Revised Demand (Q'_i)	Unit Sales (Z_i)
Firm 1	2.08	0.59	418	–	–	300
Firm 2	0.86	0.25	174	0.61	231	180
Firm 3	0.56	0.16	112	0.39	149	140

Case 3 (demand exceeds units available for sale for Firms 1 and 2): Now suppose that $Q_1 > X_1$, $Q_2 > X_2$, and $Q_3 < X_3$. Then sales for Firms 1 and 2 are X_1 and X_2 respectively, and part of the combined excess demand for Firms 1 and 2 is allocated to Firm 3.

Since Firm 3 is the only player that did not stock out, we have:

Q''' = additional demand apportioned to Firm 3 based on its price

Mathematically:

$$Q''' = [1 - (X_1 / Q) - (X_2 / Q) - S_3](2000 - 20P_3 + \varepsilon)$$

$$Q_3''' = Q''' + Q_3.$$

This case is illustrated by Examples 6 and 7 below. In Example 6, Firm 3 has enough units available to fulfill its adjusted demand. In Example 7, Firm 3's adjusted demand exceeds its units available for sale, so it stocks out.

Example 6 (Case 3)

In this example, $Q_3''' < X_3$:

Inputs			Inventory Accounting	
	Price (P_i)	Production (Y_i)	Inventory (I_i)	Units Available (X_i)
Firm 1	60	175	125	300
Firm 2	70	170	0	170
Firm 3	75	5	195	200

Outputs (Computed by the Game)					
	Weighting (w_i)	Share (S_i)	Demand (Q_i)	Revised Demand (Q_i''')	Unit Sales (Z_i)
Firm 1	2.08	0.59	418	–	300
Firm 2	0.86	0.25	174	–	170
Firm 3	0.56	0.16	112	198	198

Example 7 (Case 3)

In this example, $Q_3''' > X_3$:

Inputs			Inventory Accounting	
	Price (P_i)	Production (Y_i)	Inventory (I_i)	Units Available (X_i)
Firm 1	60	175	125	300
Firm 2	70	170	0	170
Firm 3	75	5	145	150

Outputs (Computed by the Game)					
	Weighting (w_i)	Share (S_i)	Demand (Q_i)	Revised Demand (Q_i''')	Unit Sales (Z_i)
Firm 1	2.08	0.59	418	–	300
Firm 2	0.86	0.25	174	–	170
Firm 3	0.56	0.16	112	198	150

Case 4 (demand exceeds units available for sale for all three firms): Finally, suppose there is excess demand for all three firms. Each firm simply stocks out by selling all of the units it has available. (Algebraically, $X_1 < Q_1$, $X_2 < Q_2$, and $X_3 < Q_3$, so unit sales for Firms 1, 2, and 3 are X_1 , X_2 , and X_3 respectively.) This is illustrated by Example 8.

Example 8 (Case 4)

Inputs			Inventory Accounting	
	Price (P_i)	Production (Y_i)	Inventory (I_i)	Units Available (X_i)
Firm 1	60	175	125	300
Firm 2	70	170	0	170
Firm 3	75	5	105	110

Outputs (Computed by the Game)				
	Weighting (w_i)	Share (S_i)	Demand (Q_i)	Unit Sales (Z_i)
Firm 1	2.08	0.59	418	300
Firm 2	0.86	0.25	174	170
Firm 3	0.56	0.16	112	110

PRODUCTION COST

Now that we have explained the demand side of the market, we turn to the cost side. The *marginal* cost function has two components: a constant term which decreases with learning, and a linear term which implies that marginal cost increases with quantity.

The total and marginal cost functions are given by the following equations:

$TC_i(t)$ = Firm i 's total cost function in period t

$MC_i(t)$ = Firm i 's marginal cost function in period t

$Y_i(t)$ = Firm i 's production quantity in period t

$N_i(t)$ = Firm i 's *cumulative* production at the *beginning* of period t (as explained below, this is equal to 32 in the first period, i.e., $t = 1$)

$\alpha_i(t)$ = Firm i 's "learning factor" (which determines movement down the learning curve) in period t

These variables are calculated as follows:

$$TC_i(t) = 5000 + 100\alpha_i Y_i(t) + 0.05Y_i^2(t)$$

$$MC_i(t) = 100\alpha_i + 0.1Y_i(t)$$

$$\alpha_i = (0.86)^{\log_2 N}$$

$$N_i(t+1) = N_i(t) + Y_i(t)$$

The expression for learning is based on the following: each time cumulative production doubles, the "learning factor" α is multiplied by 0.86. The learning factor for the first unit is 1; for the second unit it is 0.86, for the fourth unit it is $(0.86)^2$, for the eighth unit it is $(0.86)^3$, etc. The learning factor α for an arbitrary N th unit is given by the formula above.

To keep the computations simple, the current period's learning factor depends only on cumulative production up to the beginning of the current period. For example, if in period 3 your cumulative production to date is $N(3) = 100$, and you produce $Y(3) = 50$ units for the current period, the N used to calculate the learning factor α is 100 for the *entire current period*, even though there is some learning during the current period. However, the N used to calculate the learning factor for the *next period* will be 150.

Some additional assumptions: when you start the game you will already have produced 32 units. Thus, the cumulative production upon which your first-period costs are based is $N(1) = 32$. This means that you and your competitors will have moved slightly down the learning curve beginning in period 1. You should also assume that you and your competitors have *no inventory and no profits* from this "pre-game" production of 32 units.

Please note that the \$5,000 fixed cost (the constant in the total cost function above) must be paid each week *regardless of how much you produce*. Therefore, if you have accumulated significant inventory and would like to produce zero, you still must bear the \$5,000 fixed cost.

INVENTORY AND PROFITS

Our discussion of inventory requires a bit more clarification. To this point, we have referred to inventory simply as the units available for sale from previous production. To make this explanation more complete, we must account for the element of timing. To be specific, the inventory for any particular firm i is written as:

$I_i(t)$ = Firm i 's inventory at the *end of period* t

We now define:

$Q_i^f(t)$ = Firm i 's final demand in period t (after all adjustments for excess demand)

$L_i(t)$ = a binary variable to account for a late play submission by Firm i in period t (= 0 if

Firm i submits the play for period t on time and 1 if it submits the play late)

$F(t)$ = a binary variable to account for inventory valuation in the final week (= 0 if $t = 1$ through 9 and 1 if $t = 10$)

Also, recall that:

$X_i(t)$ = Firm i 's units available for sale in period t (old inventory plus current production)

$Y_i(t)$ = Firm i 's production in period t

$Z_i(t)$ = Firm i 's unit sales in period t

We then calculate sales and inventory as follows:

$$X_i(t) = I_i(t-1) + Y_i(t)$$

$$Z_i(t) = \min\{X_i(t), Q_i^f(t)\}$$

$$I_i(t) = X_i(t) - Z_i(t)$$

Profits are calculated as revenue, minus production cost, minus an *inventory carrying cost* of \$2 per unit of inventory, plus a \$40 payout per unit on leftover inventory at the end of the game, minus a \$500 penalty fee if the play is submitted late. Therefore, profits for Firm i at the end of period t are given by:

$$\pi_i = P_i Z_i - TC_i - 2I_i + 40I_i F - 500L_i$$

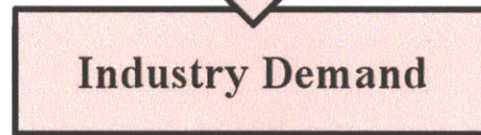
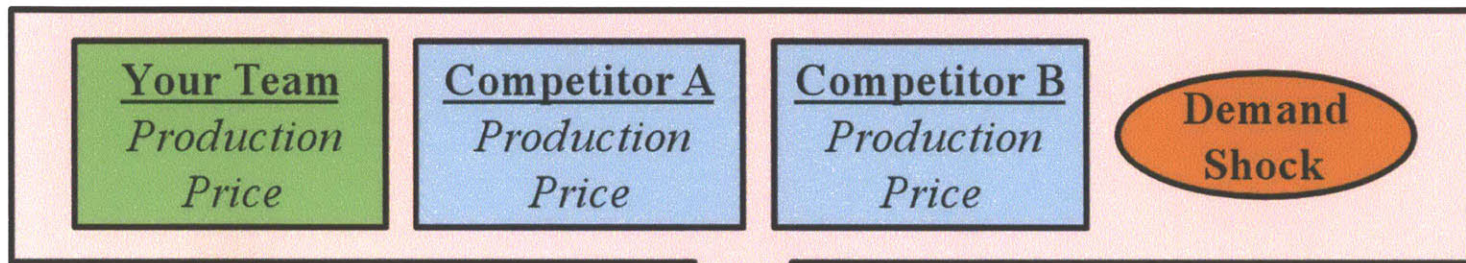
Again, remember that you want to maximize *cumulative profits*, not profits in each period. It might be useful in this regard to review what you were taught about the learning curve. It also might also be helpful to examine the graphs at the end of this memo. The first graph shows your average and marginal cost curves for different amounts of cumulative production. The second graph shows your demand curve for different values of your competitors' prices.

Notice in the profit function above that all inventory at the end of the game is valued at \$40 per unit, *irrespective of the prices charged by the three firms*. Also, note that inventory carrying costs *do* apply in the last week.

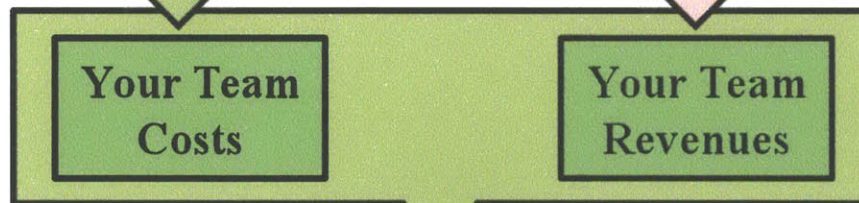
It is important to understand that inventory can be viewed as a competitive weapon. If one team builds up a considerable inventory, it can potentially undercut its competitors and capture a significant portion of market demand. Therefore, it is helpful to pay attention to the inventory levels at the competing firms in your industry. Also, remember that due to the upward sloping marginal cost curve, it is cheaper to accumulate inventory over time than to produce a large amount in a single period. This “cost smoothing” is another advantage of efficient inventory usage.

Summary of Strategy Game

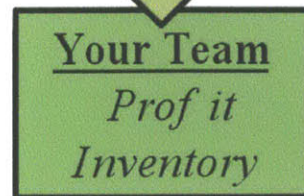
INPUTS



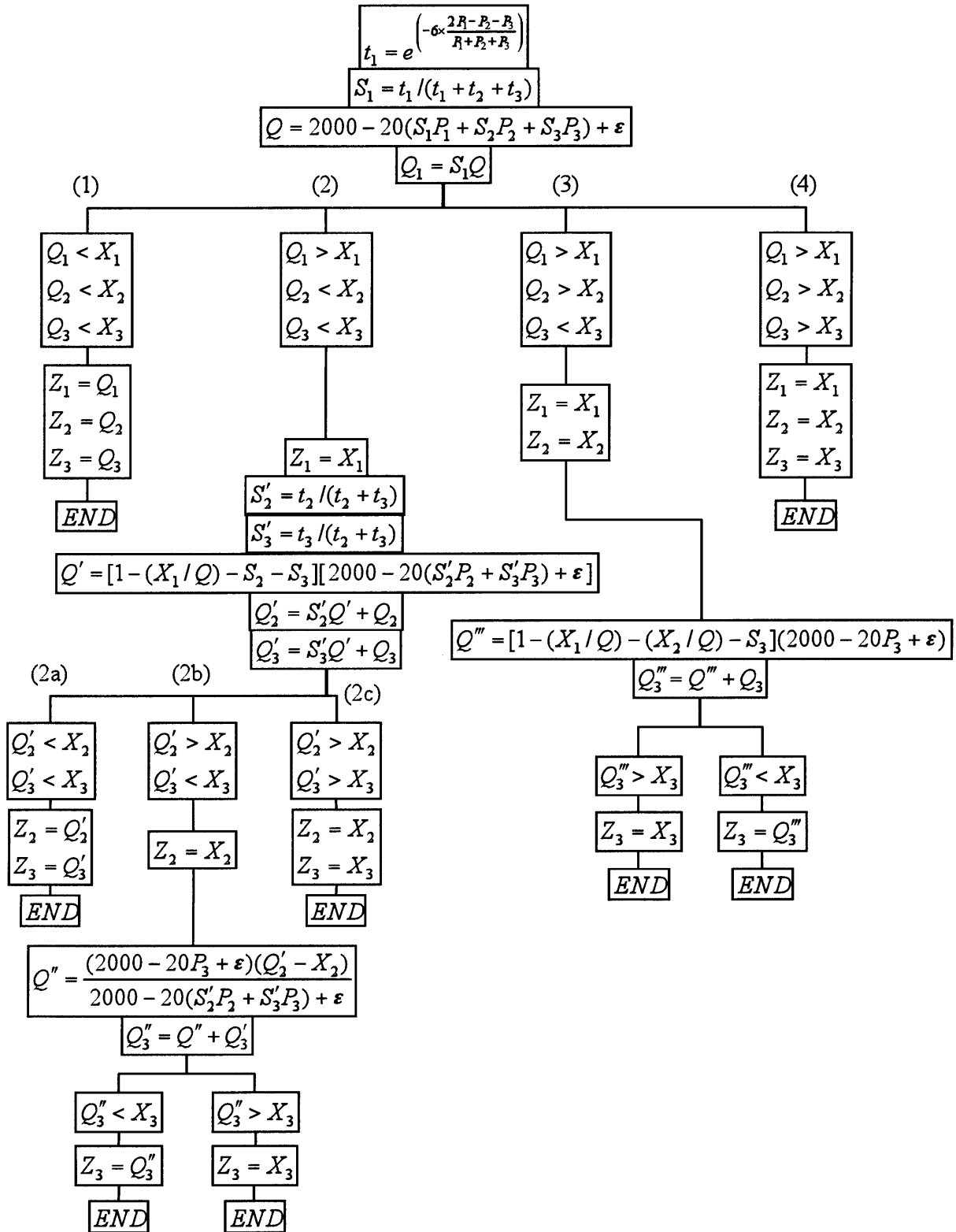
CALCULATIONS



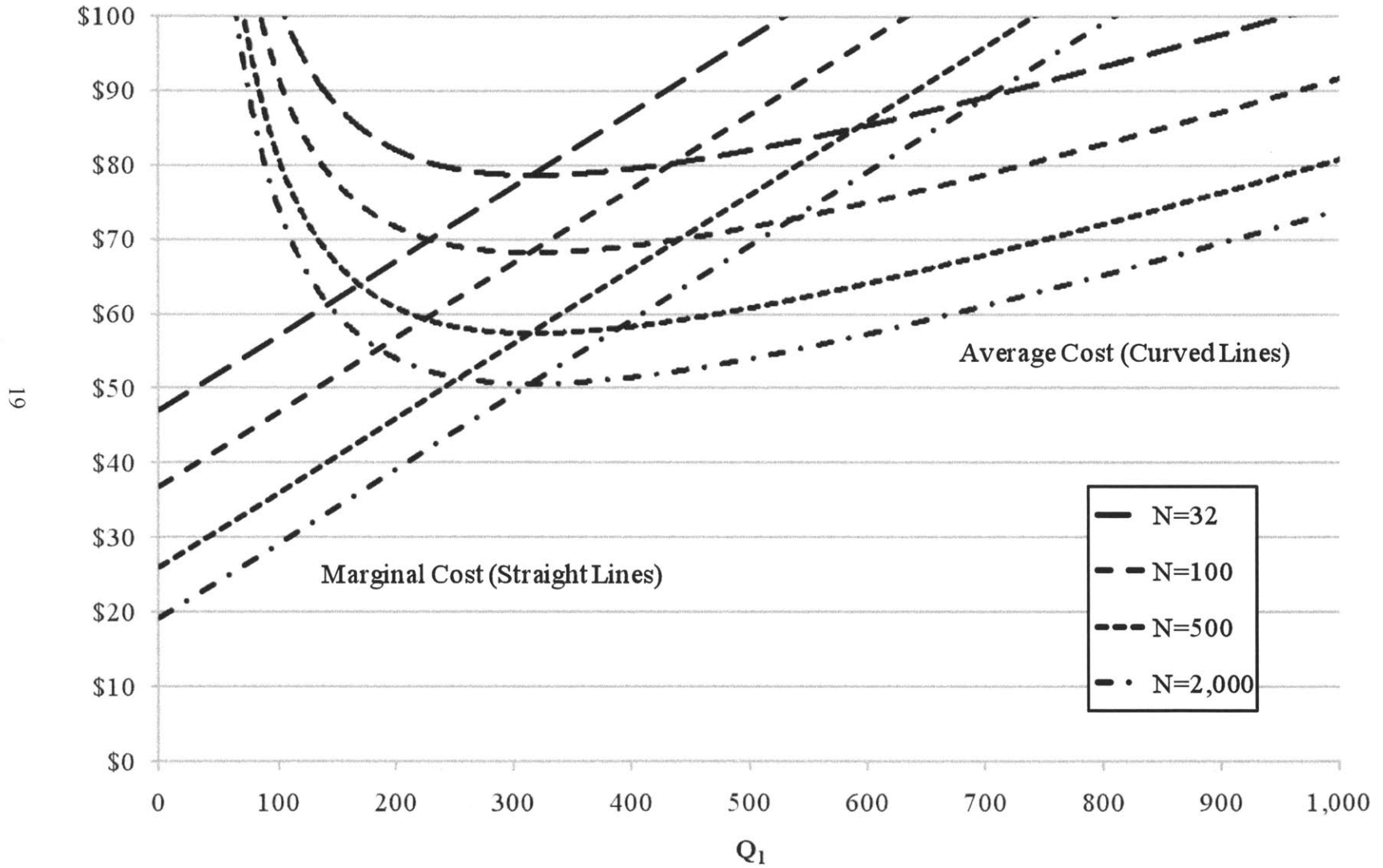
OUTPUT



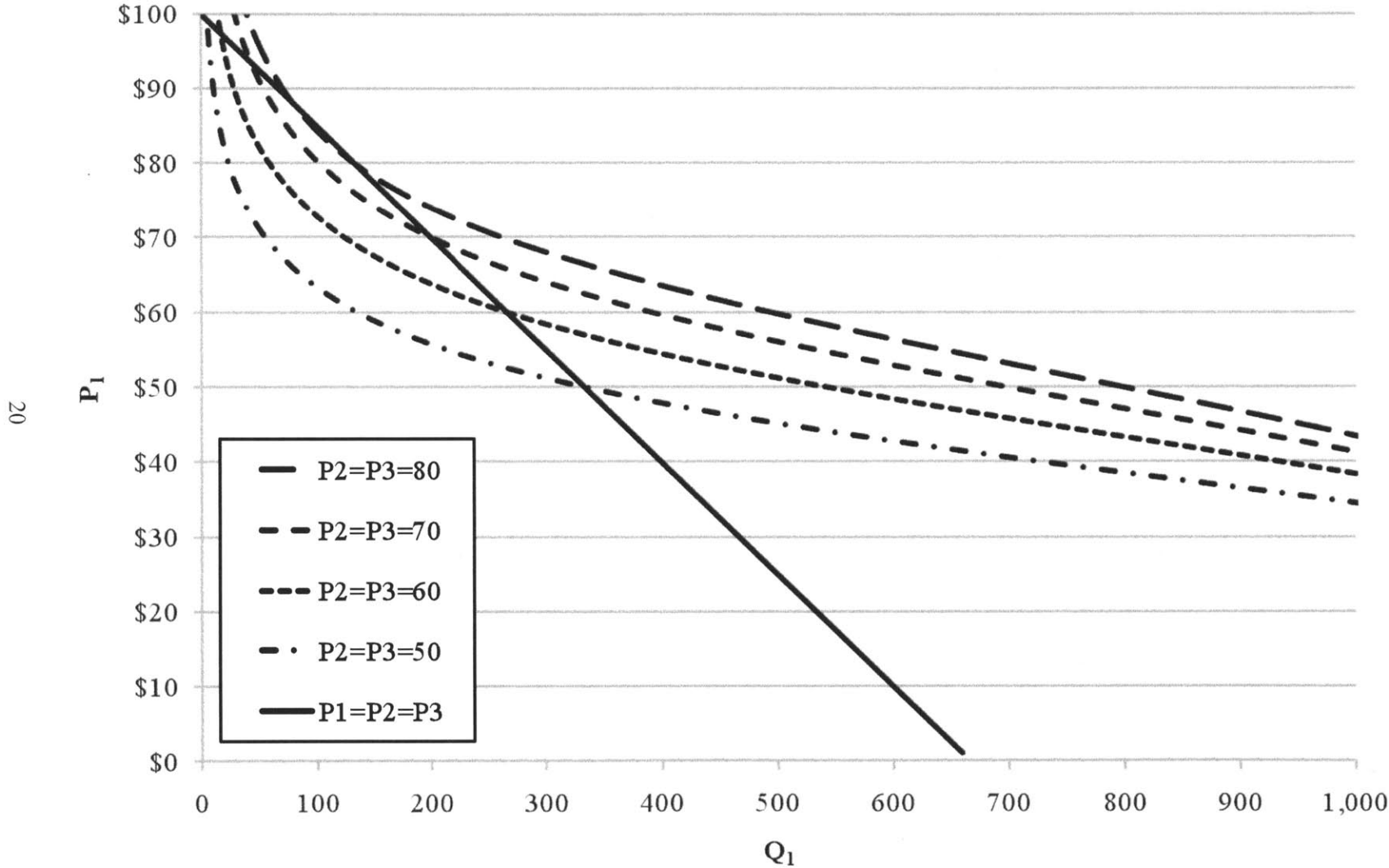
Demand & Unit Sales Flow Chart



Marginal & Average Cost as a Function of Cumulative Production (N)



Firm 1's Demand as a Function of It's Own Price



Appendix 3

TA Manual

TA MANUAL FOR THE STRATEGIC OLIGOPOLY GAME

The student memo for the Strategic Oligopoly Game provides a thorough explanation of the game and how it is played week to week. This information is important, but for the TA, much more clarification is needed. This manual provides an in-depth explanation of the game as well as detailed instructions on how to run the game from start to finish. The TA should read this manual carefully before starting the game.

BACKGROUND INFORMATION

Although slightly more complicated arithmetically, the Strategic Oligopoly Game has much more educational value than simple competition models used in introductory microeconomics courses. First, it allows for analysis of competition involving *heterogeneous* goods (i.e., goods that are similar but not identical). Such goods are common in the marketplace and therefore provide a realistic lens with which to examine competitive forces. For instance, one could view the industries in the strategy game as quite similar to that of ink-jet printers. A few key players dominate the industry, but none wield excessive market power relative to the others. The products they sell are similar and serve the same purpose, but they are not identical. As such, price is a key lever in the eyes of consumers, but it is not the only one. A given consumer may have extensive experience with Hewlett-Packard printers for example, and therefore prefer that brand over Epson and Canon. Thus, if one of the industry players undercuts the others on price, it will capture more of the market, but not the entire market (unlike the case of a homogeneous product).

Second, the strategy game accounts for the learning that takes place as firms produce more and more units. To use an automobile producer as an example, it is reasonable to assume that Honda's manufacturing costs decline as it produces more cars. Each additional car allows the company to further refine its production process, and a competitive advantage can be obtained from using this learning process wisely. The strategy game takes this learning effect into account.

Third, and perhaps most importantly, simple models view game players as rational, profit-maximizing decision makers. They rely on basic assumptions, such as the assertion that all players will follow the path that leads to the highest expected value. Unfortunately, the real world is much more complicated. Market competition involves a notable human element, and the effects (for better or worse) of emotion, tacit signaling, and luck can be witnessed in real-

world events taking place every day. There is no better way to understand these forces than to experience them for oneself. The game provides this opportunity.

INITIAL TASKS

The following instructions will help you to set up the strategy game Excel file for game play. Please note that instructions are given throughout the workbook in yellow cells, and that the user should *only edit the blue cells*.

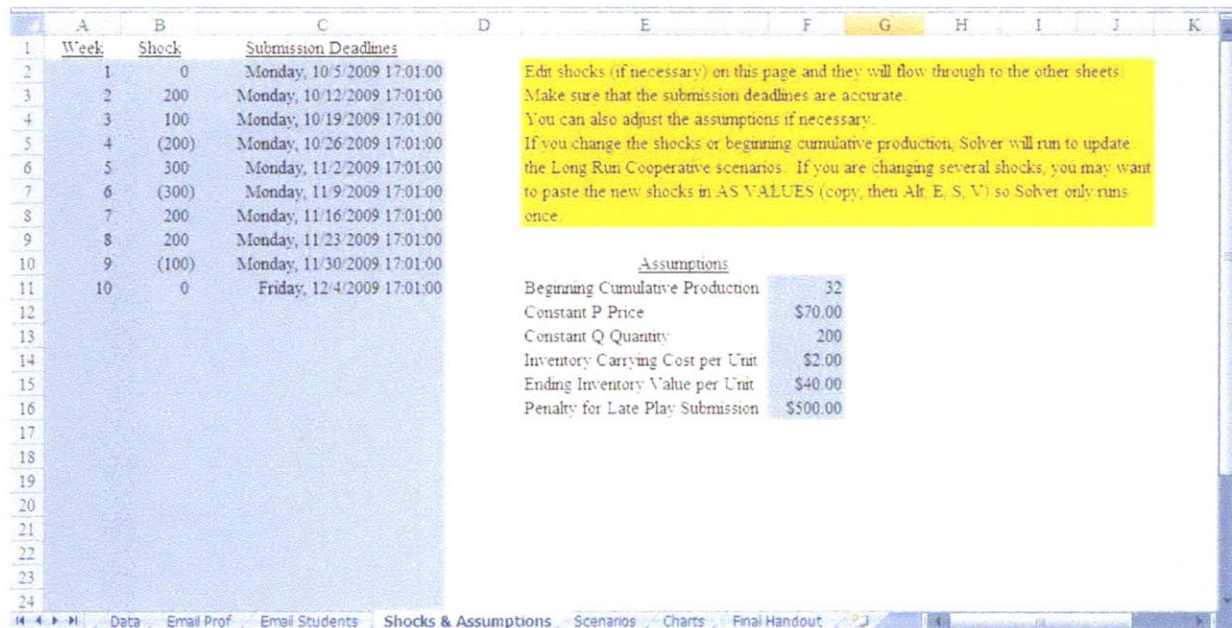
Discuss Assumptions with Professor

Before the game begins, it is important to discuss several assumptions with the professor. This step should be done as early as possible (potentially even before the semester starts). The assumptions are listed on the Shocks & Assumptions worksheet of the strategy game Excel file. Most notably, you will want to change the shocks so that students cannot gain an advantage by collecting information from the prior year.

There are no set rules for creating shocks, but it is generally a good idea to keep the week 1 shock equal to zero, the range of shocks between -400 and 400 (as indicated in the student memo), and the average of all 10 shocks between -40 and 40. Each time a shock is changed, Excel's Solver will automatically run to update the long-run cooperative scenarios. To save time, you may want to enter all 10 of the new shocks in a blank workbook and paste them *as values* (for more explanation, please see Excel's help manual) into the Shocks & Assumptions worksheet all at the same time so that Solver only runs once.

After editing the shocks, be sure to update the submission deadlines on the same worksheet. These should also be confirmed with the professor. If the submission dates are entered correctly, the model will automatically determine if a team submits a play late and apply a penalty fee if necessary.

The additional assumptions to check with the professor are listed in column F. It is unlikely that these will change, but you should check with the professor to make sure. The shocks and assumptions listed on this worksheet flow through to the rest of the model, so calculations will be updated automatically (remember, you should *only edit the blue cells*).



Please note that the strategy game model is set up to run for 10 weeks. In some cases, a professor may want to run the game for a shorter period of time due to an abbreviated course timeframe, etc. This can be accomplished by simply ending the game at whichever week the professor chooses. It is not possible, however, to run the game for more than 10 periods.

If you choose to run the game for fewer than 10 periods, you must manually adjust the final handout to capture only the relevant weeks. To do this, please follow these steps:

1. In the strategy game Excel file, click on the Final Handout worksheet at the far right.
2. You will notice “#N/A” error symbols in the data for the weeks that you skipped. For instance, if you only carried out the game through week 7, you will see errors in the data for weeks 8, 9, and 10. You will also see errors in the Average row, which is row 27 in the spreadsheet. To fix the latter errors, edit the formulas in each cell of the Average row to encompass only the data for the period you covered. Keeping with the prior example, if you skipped weeks 8, 9, and 10, edit the formulas such that they encompass rows 17 through 23 instead of 17 through 26. After making this change, you will notice that the errors in the Average row are replaced with numbers.
3. Click on the “+” symbol above the column header for column BA. This will display several hidden columns. You will notice that the cells in column AZ (titled “Scaling”) also have errors. Fix these as you did before, by editing the formulas to encompass only the relevant data.

4. Click on the Production & Shocks chart and then use the horizontal scroll bar to scroll over to the source data, which is to the left of the Scaling column. You will see that the data used in the chart is outlined in purple, blue, and green boxes. Click the bottom left-hand square of the blue box and drag it upward to encompass only the relevant data. Do the same for the other chart on the handout.
5. Click on the “-” sign above column header BA to hide this area again.
6. Select the rows of the weeks you skipped by clicking on the row headers at the far left. For instance, if you skipped weeks 8, 9, and 10, you should select rows 24, 25, and 26. Group these rows by clicking on Data → Group → Group..., or by using the keyboard shortcut ALT, d, g, g.
7. Click on the “-” sign to the left of row header 27 to hide the weeks you skipped. The handout should now exclude data for the weeks you skipped. You can view the handout in print preview mode to see how it will look when printed.

Assemble Teams

Ideally, the number of students in the course will be a multiple of 6, so that all of the industries will have three firms, with two students per firm. Realistically, the number of students is unlikely to be a multiple of 6. Then it may be necessary for one or two teams to consist of three students, or, if you are short two students, have the TA play the game as one of the firms.

Correctly assembling a list of team is a somewhat complex process. Please follow the steps below carefully:

1. Collect information on teams using a Google web form. This information should include names, email addresses, and sections. Most teams will consist of two students, although teams of three will work if necessary. Please see Appendix 6 for more details on how to create a Google web form.
2. Add the team information to the Teams worksheet. To do this, download the data from the Google web form into Excel and paste it *as values* (to maintain formatting of the destination sheet) into the appropriate columns of the Teams worksheet. Leave the other columns blank for now. Note that if your class size is not divisible by six, it might make sense to add a team that will be played by you or one of the other TAs (although you can also deal with this problem by adding a third player to one or more teams).

	A	B	C	D	E	F	G	H	I	J	K
1	Team #	Industry	Industry Team	Name 1	Email 1	Name 2	Email 2	Name 3	Email 3	Section	
2				Joe Smith	jsmith@mit.edu	Paul Hang	phang@mit.edu			A	
3				Jack Church	jchurch@mit.edu	Ryan Honda	rhonda@mit.edu			A	
4				Suzy Brown	sbrown@mit.edu	Molly Gross	mgross@mit.edu	Jim Hillpor	jhillpor@mit.edu	A	
5				Phil Chu	pchu@mit.edu	Tessa Simms	tsimms@mit.edu			A	
6				Margaret McGrath	mncgrath@mit.edu	Nir Gola	ngola@mit.edu			A	
7				Dan Schill	dschill@mit.edu	Abdul Metzger	ametzer@mit.edu			A	
8				Ethan Stein	estein@mit.edu	Ann Vonn	avonn@mit.edu			A	
9				Tom Cahill	tcahill@mit.edu	Bernard Wong	bwong@mit.edu			A	
10				Bethany Hall	bhall@mit.edu	Chris Limm	climm@mit.edu			A	
11				Kathryn Murphy	kmurphy@mit.edu	Yukari Kimoto	ykimoto@mit.edu			B	
12				Charlotte King	cking@mit.edu	Todd Black	tblack@mit.edu			B	
13				Han Tan	htan@mit.edu	Jenn Chapman	jchapman@mit.edu			B	
14				Marcello Rondo	mrondo@mit.edu	Matt Stern	mstern@mit.edu			B	
15				Louise Kim	lkim@mit.edu	Sayaka Rue	srue@mit.edu			B	
16				Chan Hong	chong@mit.edu	Melinda Chang	mchang@mit.edu			B	
17				Carlos Rodriguez	crodriguez@mit.edu	Julie Phillips	jphillips@mit.edu			B	
18				Chad Johnson	cjohnson@mit.edu	Gerard Williams	gwilliams@mit.edu			B	
19				Andre Cropp	acropp@mit.edu	Josh Thomson	jthomson@mit.edu			B	
20											
21											

- In column K (which should be the leftmost empty column on the Teams worksheet – it is OK to perform “scratch work” in this column even though it is not blue), use the =RAND() formula to create random numbers for each team. Copy and paste these numbers as values. Sort all of the data in the Teams sheet by section first (ascending) and these numbers second (ascending or descending), and then delete the numbers. This will put the list in random order but separated by section (to ensure that all teams within an industry are in the same section). If you are unsure about how to use the sort feature, please refer to Excel’s help manual.

	A	B	C	D	E	F	G	H	I	J	K
1	Team #	Industry	Industry Team	Name 1	Email 1	Name 2	Email 2	Name 3	Email 3	Section	
2				Dan Schill	dschill@mit.edu	Abdul Metzger	ametzer@mit.edu			A	0.225349
3				Jack Church	jchurch@mit.edu	Ryan Honda	rhonda@mit.edu			A	0.348632
4				Phil Chu	pchu@mit.edu	Tessa Simms	tsimms@mit.edu			A	0.408252
5				Margaret McGrath	mncgrath@mit.edu	Nir Gola	ngola@mit.edu			A	0.623009
6				Ethan Stein	estein@mit.edu	Ann Vonn	avonn@mit.edu			A	0.643737
7				Tom Cahill	tcahill@mit.edu	Bernard Wong	bwong@mit.edu			A	0.644979
8				Bethany Hall	bhall@mit.edu	Chris Limm	climm@mit.edu			A	0.717855
9				Suzy Brown	sbrown@mit.edu	Molly Gross	mgross@mit.edu	Jim Hillpor	jhillpor@mit.edu	A	0.820162
10				Joe Smith	jsmith@mit.edu	Paul Hang	phang@mit.edu			A	0.95294
11				Andre Cropp	acropp@mit.edu	Josh Thomson	jthomson@mit.edu			B	0.147688
12				Carlos Rodriguez	crodriguez@mit.edu	Julie Phillips	jphillips@mit.edu			B	0.218918
13				Han Tan	htan@mit.edu	Jenn Chapman	jchapman@mit.edu			B	0.427651
14				Chan Hong	chong@mit.edu	Melinda Chang	mchang@mit.edu			B	0.434531
15				Louise Kim	lkim@mit.edu	Sayaka Rue	srue@mit.edu			B	0.500181
16				Chad Johnson	cjohnson@mit.edu	Gerard Williams	gwilliams@mit.edu			B	0.610991
17				Marcello Rondo	mrondo@mit.edu	Matt Stern	mstern@mit.edu			B	0.658711
18				Charlotte King	cking@mit.edu	Todd Black	tblack@mit.edu			B	0.706437
19				Kathryn Murphy	kmurphy@mit.edu	Yukari Kimoto	ykimoto@mit.edu			B	0.774388
20											
21											

- Fill in the Industry column by numbering down the cells in groups of three (1, 1, 1, 2, 2, 2, etc.)

	A	B	C	D	E	F	G	H	I	J	K
1	Team #	Industry	Industry Team	Name 1	Email 1	Name 2	Email 2	Name 3	Email 3	Section	
2		1		Dan Schull	dschull@mit.edu	Abdul Metzger	ametzer@mit.edu			A	
3		1		Jack Church	jchurch@mit.edu	Ryan Honda	rhonda@mit.edu			A	
4		1		Phil Chu	pchu@mit.edu	Tessa Simms	tsimms@mit.edu			A	
5		2		Margaret McGrath	mcmgrath@mit.edu	Nir Gola	ngola@mit.edu			A	
6		2		Ethan Stein	estein@mit.edu	Ann Vonn	avonn@mit.edu			A	
7		2		Tom Cahill	tcahill@mit.edu	Bernard Wong	bwong@mit.edu			A	
8		3		Bethany Hall	bhall@mit.edu	Chris Limn	climn@mit.edu			A	
9		3		Suzy Brown	sbrown@mit.edu	Molly Gross	mgross@mit.edu	Jim Hillpor	jhillpor@mit.edu	A	
10		3		Joe Smith	jsmith@mit.edu	Paul Hang	phang@mit.edu			A	
11		4		Andre Cropp	acropp@mit.edu	Josh Thomson	jthomson@mit.edu			B	
12		4		Carlos Rodriguez	crodriguez@mit.edu	Julie Phillips	jphillips@mit.edu			B	
13		4		Han Tan	htan@mit.edu	Jenn Chapman	jchapman@mit.edu			B	
14		5		Chan Hong	chong@mit.edu	Melinda Chang	mchang@mit.edu			B	
15		5		Louise Kim	lkim@mit.edu	Sayaka Rue	srue@mit.edu			B	
16		5		Chad Johnson	cjohnson@mit.edu	Gerard Williams	gwilliams@mit.edu			B	
17		6		Marcello Rondo	mrondo@mit.edu	Matt Stern	mstern@mit.edu			B	
18		6		Charlotte King	cking@mit.edu	Todd Black	tblack@mit.edu			B	
19		6		Kathryn Murphy	kmurphy@mit.edu	Yukari Kimoto	ykimoto@mit.edu			B	
20											
21											

- Fill in the Industry Team column by repeatedly counting to three (1, 2, 3, 1, 2, 3, etc.)

	A	B	C	D	E	F	G	H	I	J	K
1	Team #	Industry	Industry Team	Name 1	Email 1	Name 2	Email 2	Name 3	Email 3	Section	
2		1	1	Dan Schull	dschull@mit.edu	Abdul Metzger	ametzer@mit.edu			A	
3		1	2	Jack Church	jchurch@mit.edu	Ryan Honda	rhonda@mit.edu			A	
4		1	3	Phil Chu	pchu@mit.edu	Tessa Simms	tsimms@mit.edu			A	
5		2	1	Margaret McGrath	mcmgrath@mit.edu	Nir Gola	ngola@mit.edu			A	
6		2	2	Ethan Stein	estein@mit.edu	Ann Vonn	avonn@mit.edu			A	
7		2	3	Tom Cahill	tcahill@mit.edu	Bernard Wong	bwong@mit.edu			A	
8		3	1	Bethany Hall	bhall@mit.edu	Chris Limn	climn@mit.edu			A	
9		3	2	Suzy Brown	sbrown@mit.edu	Molly Gross	mgross@mit.edu	Jim Hillpor	jhillpor@mit.edu	A	
10		3	3	Joe Smith	jsmith@mit.edu	Paul Hang	phang@mit.edu			A	
11		4	1	Andre Cropp	acropp@mit.edu	Josh Thomson	jthomson@mit.edu			B	
12		4	2	Carlos Rodriguez	crodriguez@mit.edu	Julie Phillips	jphillips@mit.edu			B	
13		4	3	Han Tan	htan@mit.edu	Jenn Chapman	jchapman@mit.edu			B	
14		5	1	Chan Hong	chong@mit.edu	Melinda Chang	mchang@mit.edu			B	
15		5	2	Louise Kim	lkim@mit.edu	Sayaka Rue	srue@mit.edu			B	
16		5	3	Chad Johnson	cjohnson@mit.edu	Gerard Williams	gwilliams@mit.edu			B	
17		6	1	Marcello Rondo	mrondo@mit.edu	Matt Stern	mstern@mit.edu			B	
18		6	2	Charlotte King	cking@mit.edu	Todd Black	tblack@mit.edu			B	
19		6	3	Kathryn Murphy	kmurphy@mit.edu	Yukari Kimoto	ykimoto@mit.edu			B	
20											
21											

- Look over the list and make manual edits as you see fit. For instance, if you know two teams in the same industry are close friends, it might make sense to split them up.
- Fill in the Team # column using the function =RANDBETWEEN(1000,9999). This formula outputs a random integer in the range 1000 to 9999. Copy the formula down, copy and paste all of the team numbers as values, and make sure that there are no duplicate team numbers (you might find the =COUNTIF() formula helpful here – see Excel’s help manual for further explanation). If there

are duplicate numbers, fix them manually by choosing numbers between 1000 and 9999 that are not already in use. As a double check, copy the team numbers, paste them into a blank workbook, sort them from lowest to highest, and calculate the difference between each number and the number directly above it (starting with the second number in the list). Differences of zero indicate duplicates.

	A	B	C	D	E	F	G	H	I	J	K
1	Team #	Industry	Industry Team	Name 1	Email 1	Name 2	Email 2	Name 3	Email 3	Section	
2	8345	1	1	Dan Schull	dschull@mit.edu	Abdul Metzger	ametzer@mit.edu			A	
3	2210	1	2	Jack Church	jchurch@mit.edu	Ryan Honda	rhonda@mit.edu			A	
4	2072	1	3	Phil Chu	pchu@mit.edu	Tessa Simms	tsimms@mit.edu			A	
5	5444	2	1	Margaret McGrath	mcmgrath@mit.edu	Nir Gola	ngola@mit.edu			A	
6	6245	2	2	Ethan Stein	estein@mit.edu	Ann Vonn	avonn@mit.edu			A	
7	2741	2	3	Tom Cahill	tcahill@mit.edu	Bernard Wong	bwong@mit.edu			A	
8	4363	3	1	Bethany Hall	bhall@mit.edu	Chris Limm	climm@mit.edu			A	
9	2516	3	2	Suzy Brown	sbrown@mit.edu	Molly Gross	mgross@mit.edu	Jim Hillpor	jhillpor@mit.edu	A	
10	6900	3	3	Joe Smith	jsmith@mit.edu	Paul Hang	phang@mit.edu			A	
11	6475	4	1	Andre Cropp	acropp@mit.edu	Josh Thomson	jthomson@mit.edu			B	
12	9097	4	2	Carlos Rodriguez	crodriguez@mit.edu	Julie Phillips	jphillips@mit.edu			B	
13	1246	4	3	Han Tan	htan@mit.edu	Jenn Chapman	jchapman@mit.edu			B	
14	2495	5	1	Chan Hong	chong@mit.edu	Melinda Chang	mchang@mit.edu			B	
15	3138	5	2	Louise Kim	lkim@mit.edu	Sayaka Rue	srue@mit.edu			B	
16	9899	5	3	Chad Johnson	cjohnson@mit.edu	Gerard Williams	gwilliams@mit.edu			B	
17	6390	6	1	Marcello Rondo	mrondo@mit.edu	Matt Stern	mstern@mit.edu			B	
18	7290	6	2	Charlotte King	cking@mit.edu	Todd Black	tblack@mit.edu			B	
19	2907	6	3	Kathryn Murphy	kmurphy@mit.edu	Yukari Kinoto	ykinoto@mit.edu			B	
20											
21											

- You now have a randomized list of teams split into industries and separated by section. Once all columns of the Teams worksheet are filled in correctly as described above, the formulas elsewhere in the model will pull the data as needed. Note that the “Name 3” and “Email 3” columns will only contain data if teams of three exist in the economy.
- Remember that you will need to reshuffle the teams into new industries after the trial play. You can do this by repeating the process described above. Make sure that *each team has the same team number after the reshuffle* (the team numbers need to stay consistent from start to finish to avoid confusion).

Create a Team Roster

Once you have assembled the teams, you will need to create a roster and publish it on your course website so that the students know their team numbers. To do this, simply copy the information from the Teams worksheet into a new, blank worksheet and format it to look nice when printed. The only items that need to be included on the roster are:

- Team number
- Section
- Student 1’s name

- Student 2's name
- Student 3's name (if necessary)

If any TAs are playing the game due to a class size that is not divisible by six, it is not necessary to include these TAs on the roster (although they will need to know their team number so that they can enter weekly plays through the Google web form).

Once the roster is on the course website, it is very important *not to change the team numbers*. You must reshuffle the teams after the trial play, but be sure to keep the team numbers consistent or the students may become confused. Remember, the team number is simply a random 4-digit value, so it gives no information whatsoever as to whom a given team's competitors may be.

Strategy Game Teams				
<u>Team #</u>	<u>Name 1</u>	<u>Name 2</u>	<u>Name 3</u>	<u>Section</u>
2072	Phil Chu	Tessa Simms		A
2210	Jack Church	Ryan Honda		A
2516	Suzy Brown	Molly Gross	Jim Hillpor	A
2741	Tom Cahill	Bernard Wong		A
4363	Bethany Hall	Chris Limm		A
5444	Margaret McGrath	Nir Gola		A
6245	Ethan Stein	Ann Vonn		A
6900	Joe Smith	Paul Hang		A
8345	Dan Schill	Abdul Metzger		A
1246	Han Tan	Jenn Chapman		B
2495	Chan Hong	Melinda Chang		B
2907	Kathryn Murphy	Yukari Kimoto		B
3138	Louise Kim	Sayaka Rue		B
6390	Marcello Rondo	Matt Stern		B
6475	Andre Cropp	Josh Thomson		B
7290	Charlotte King	Todd Black		B
9097	Carlos Rodriguez	Julie Phillips		B
9899	Chad Johnson	Gerard Williams		B

Lead a Strategy Game Review Session (Optional)

Before the trial play of the game, it will be very useful for the TA(s) to hold a review session outside of class time. This session will go over the logic behind the game, rules, logistics, and grading, and help to ensure that the students fully understand the details of how the game works. (It may be necessary to hold two identical sessions on different days due to timing

conflicts.) Attendance at the review session need not be required but should be *highly* encouraged.

Please keep the following pointers in mind:

1. Instruct the students to read the student memo *thoroughly* before the review session.
2. If there are two TAs and two review sessions, it is ideal to have both TAs present at both sessions.
3. The PowerPoint presentation for the review session is called “Strategy Game Review Session.” You should post this to the course website *after* the session.
4. It is helpful to work through the derivation of the short-run cooperative scenario during the review session (see Appendix 1). This should look familiar to the students, as they all saw it in introductory microeconomics. While this is not the optimal solution to the game, it will give them a sense of how to analyze the situation, and what price and production ranges are reasonable.
5. Be explicit about prices that are unreasonable. For instance, excess inventory is valued at \$40 per unit at the end of the game, so there is no reason to ever price below \$40 (and this is an *extreme* minimum). If you price too low, your entire industry will be in trouble. Use the simple model derived in Appendix 1 to test different assumptions (i.e., set up a simple profit equation assuming all firms behave identically and see what happens with different pricing assumptions).
6. Go over the charts at the end of the student memo in *great detail*. If the students are completely confused by the calculations involved in the game, the charts should give them a sense of reasonable ranges for price and production.
7. After the review sessions, post the “Strategy Game Examples” spreadsheet on the course website so that students can check the accuracy of their models with real numbers.

Create a Google Web Form for Weekly Play Submission

The teams will submit their plays each week using a Google web form. Before the game begins, you must create this form and distribute the hyperlink to the students (it is helpful to post this link on the course website). Please see Appendix 6 for instructions and further details.

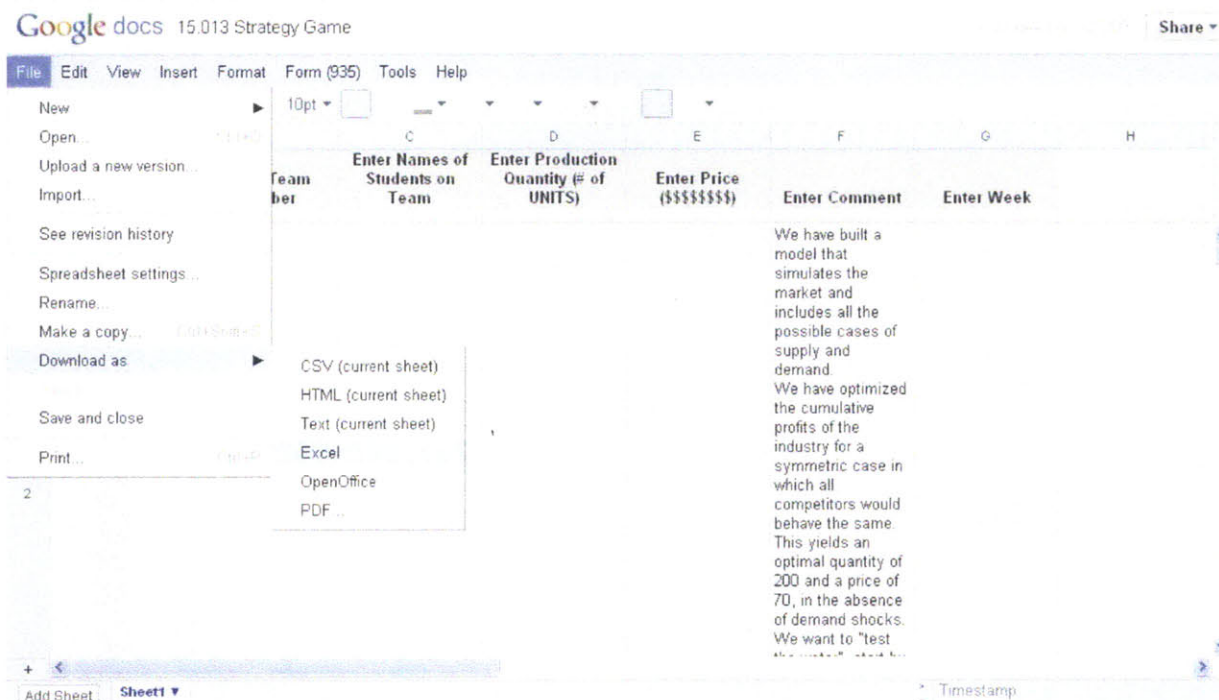
WEEKLY TASKS

Each week, teams will submit plays through a Google web form as described above. Once the deadline hits, it is the TA’s job to crunch the data and send out results as quickly as possible. To do this, please follow the instructions below.

Download and Paste in the New Data

Follow these steps to add new data to the model each week:

1. Download the data from the Google spreadsheet in Excel format by clicking on File → Download as → Excel.



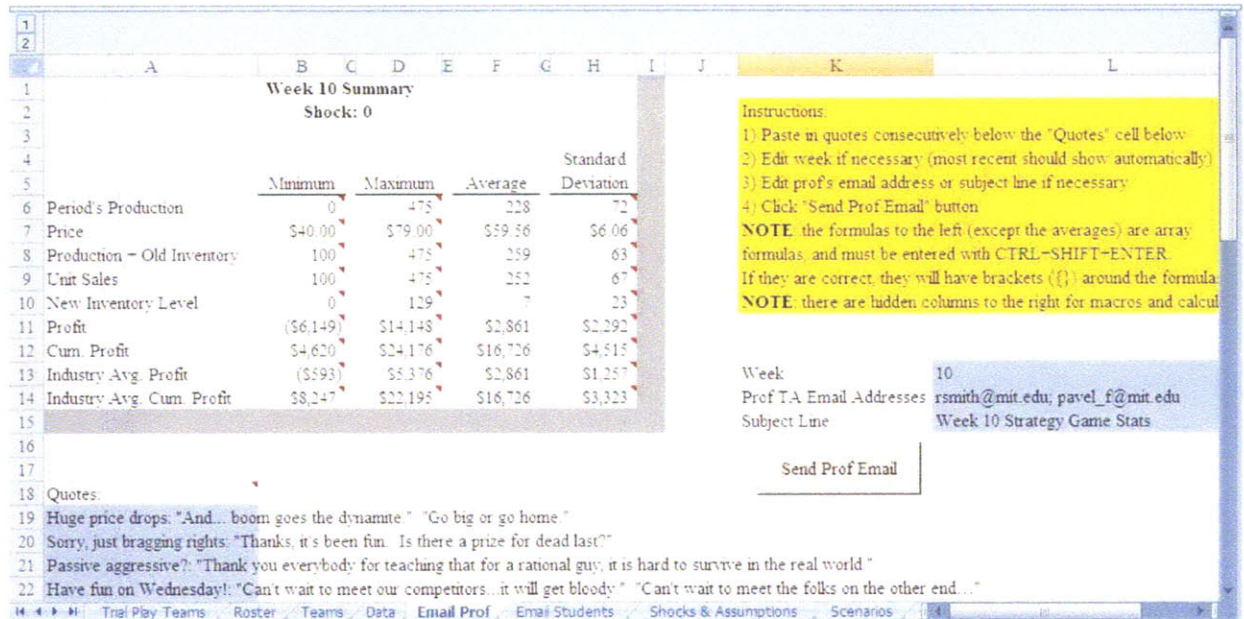
2. Check to make sure that all teams have submitted a play. One way to do this is to paste in the unique list of team numbers from the Teams worksheet and compare it to the teams that have entries in the current week. If one or more teams did not submit, contact the students immediately and have them submit a play as soon as possible through the Google web form. They will receive a penalty fee but their play will be included in the game nonetheless. If you cannot reach either team member for a considerable period of time, you will have to enter a play for the team yourself.
3. Scan the data manually to find mistakes or abnormalities. For instance, you may come across a price that is outside the normal range (in which case you may have to contact the team to seek clarification). It is somewhat common for students to switch their price and production entries – be very careful to catch this mistake as it can cause strange results if left unfixed.

4. When you are confident that the entries are complete and correct, copy and paste them *as values* into the appropriate columns of the Data worksheet. Stack week 2 under week 1, etc.
5. Copy down the formulas so that they extend to the bottom of the data you just pasted in (the easiest way is to select the bottom formula cells and the area you want to fill and press CTRL+d). All of the calculations should now be updated. As a quick audit, look at the values in the Economy Average Profit and Economy Average Cumulative Profit columns (the last two columns on the Data sheet). If these columns contain errors or values that don't make intuitive sense, go back and check the data.

Email the Professor

After you enter the new data and copy down the formulas on the Data worksheet, summary statistics will automatically be updated on the Email Prof worksheet. To send this summary to the professor, follow these steps:

1. Select quotes from the Comment column on the Data sheet. You can choose as many quotes as you like, but roughly four should be sufficient. Paste the quotes in separate cells below the "Quotes:" cell on the Email Prof worksheet.
2. Edit the week if necessary. The most recent week should show automatically, so only change this if you want to resend information from an earlier week.
3. Make sure that the email address line is correct. This line should be formatted like the address line in an Outlook email (e.g., "jsmith@mit.edu; bjones@mit.edu"). If there is only one recipient (the professor), simply type the email address. If you would like to add additional recipients (such as the TAs), separate each address with a semicolon followed by a space.
4. Edit the subject line if necessary.
5. Click the Send Prof Email button. This will send the summary statistics and quotes to the recipient emails listed. You will receive a confirmation popup message if the email was sent successfully. Note that you need to have Outlook open and set up with your email account information for this process to work.



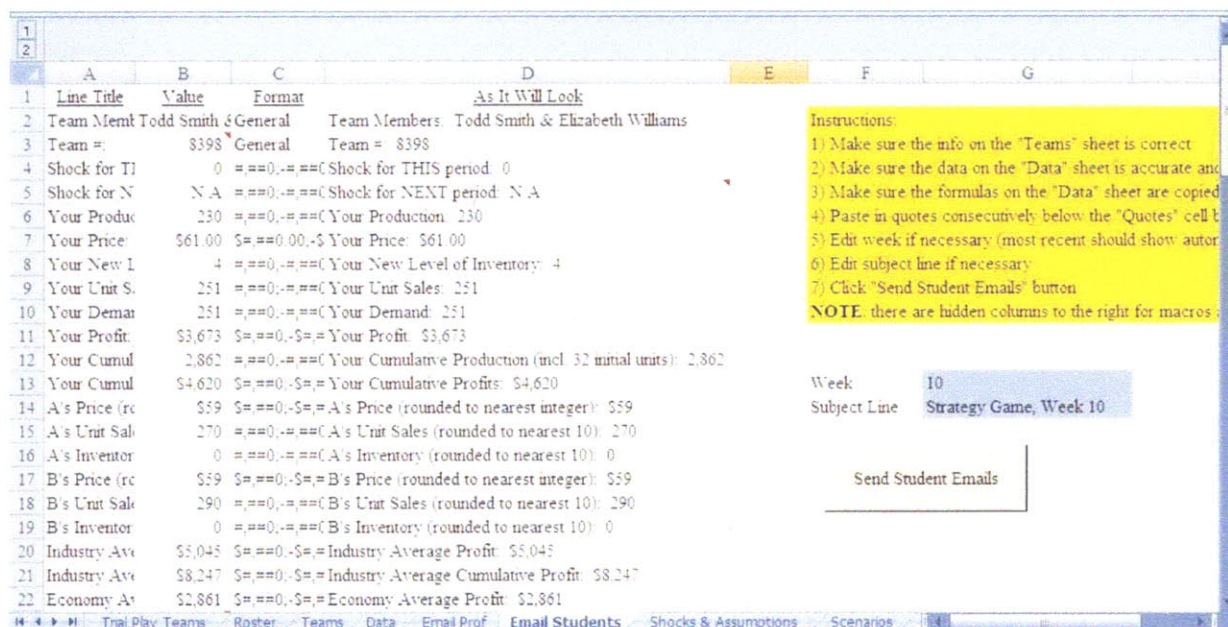
Email the Students

You will also need to send weekly update emails to the students. These emails are in a slightly different form than the summary email for the professor, but the idea is similar. To send the weekly update emails, follow the steps below:

1. Select quotes from the "Comment" column on the Data sheet. You can choose as many quotes as you like, but roughly four should be sufficient. Paste the quotes in separate cells below the "Quotes:" cell on the Email Students worksheet. Note that you need to enter quotes on *both* the Email Prof and Email Students worksheets. It is easiest to simply use the same quotes for both summaries.
2. Edit the week if necessary. The most recent week should show automatically, so only change this if you want to resend information from an earlier week.
3. Edit the subject line if necessary.
4. Click the Send Student Emails button. This will iterate through each team and email the weekly update statistics and quotes. You will receive a confirmation popup message if the process was carried out successfully. Note that you need to have Outlook open and set up with your email account information for this process to work.

Note #1: The student email procedure works by iteratively replacing cell B3 with the team numbers from the list on the Teams worksheet. You can view the weekly update information for a given team on-screen by simply typing the team number in cell B3.

Note #2: Before you send the student emails for the trial play, be sure to set the week 2 shock equal to zero so that the students will not know the week 2 shock until the real game begins. After sending the trial play emails, change the week 2 shock back to its intended value.



OTHER TASKS

In addition to the weekly tasks, you will have to carry out a few additional activities at certain points in the semester. Please see the sections below for explanations of these items.

Create Mid-Semester Result Slides

Around week 4 or 5, the professor will want to present summary slides to the class indicating how the game is proceeding (see Appendix 7). To create these slides, follow these steps:

1. Make sure that the information in the Data worksheet is up to date and accurate.
2. Edit the week (cell A2) if necessary. The most recent week should show automatically, so only change this if you want to only include information through an earlier week.
3. Click the Export PowerPoint button and follow the on-screen instructions. This procedure will automatically create and save a PowerPoint file containing the summary slides.
4. After the PowerPoint file has been created, be sure to delete slides 2 and 3 (since the final results are not yet available). You may also want to edit the title slide.

5. Project the slides in class, or pass the file to the professor's assistant to be printed on overhead transparencies.

Create Final Result Slides

After week 10, the professor will want to present final summary slides to the class. To create these, follow the steps outlined above. This time, keep slides 2 and 3, and edit them manually to display the necessary information.

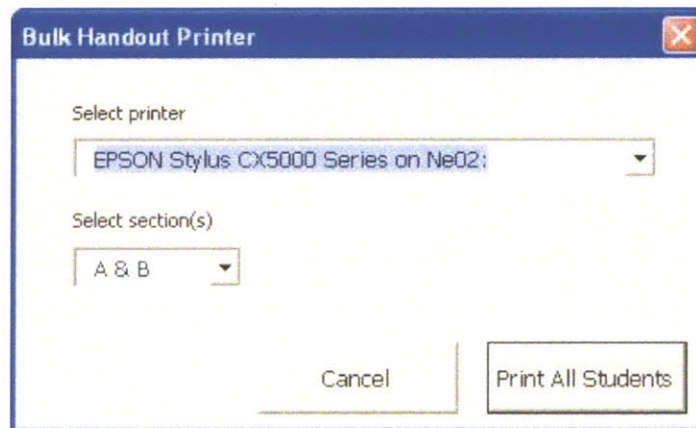
Print Final Handouts

After the game is over, you will need to print final handouts to give to the students on the last day of class. During this class, they will meet their competitors and discuss the strategies utilized during game play. The handout provides a detailed week-by-week summary of activity in the given industry.

You can print the handouts one at a time or in bulk. To print a handout for a particular student, simply type the student's name in cell AK2 on the Final Handout worksheet and then print the worksheet. The formulas will automatically pull the data for the student you entered. Be sure that the name you type matches the name on the Teams worksheet *exactly*, or the handout will be full of error cells.

To print in bulk, simply follow these steps:

1. Click the bulk handout printer on the Final Handout worksheet.
2. When the dialog box pops up, select the desired printer (make sure it prints color – you may need to coordinate this with the professor) and select section A, B, or A & B from the dropdown menu.



3. Click the Print All Students button and the procedure will begin. The handouts will print in alphabetical order by first name, separated by section if you selected both sections in the dialog box (section A will print first, followed by section B). Note that it may take several minutes for all of the sheets to print.
4. Hand the sheets out during the final class. The easiest way, although somewhat tedious, is to walk around the classroom and hand the sheets out in the order they printed.

Appendix 1: Derivation of Short-Run Cooperative Solution

Firms can optimize profits in the short run using tools from an introductory microeconomics course. This solution is helpful, but suboptimal due to the fact that it ignores the learning curve. Here, we derive the short-run cooperative solution, assuming that all three firms behave identically and set production equal to demand (no inventory):

Equation	Explanation
$Q = 2000 - 20P + \varepsilon$	Demand equation for the industry (assuming all firms behave identically)
$Q_i = \frac{2000 - 20P + \varepsilon}{3}$	Divide both sides by 3 to get the demand for each firm in the industry (Q_i)
$P = 100 - 0.15Q_i + 0.05\varepsilon$	Rearrange the above equation
$MR = 100 - 0.3Q_i + 0.05\varepsilon$	Marginal revenue equals the demand curve with double the slope
$\alpha(N) = (0.86)^{\log_2 N}$	“Learning factor” as given in the memo (where N is the cumulative production at the <i>beginning</i> of the current period)
$MC = 100\alpha(N) + 0.1Q_i$	Marginal cost for each firm as given in the student memo
$MC = 100(0.86)^{\log_2 N} + 0.1Q_i$	Combination of the two equations above
$100 - 0.3Q_i + 0.05\varepsilon = 100(0.86)^{\log_2 N} + 0.1Q_i$	Set marginal revenue equal to marginal cost
$100 - 100(0.86)^{\log_2 N} + 0.05\varepsilon = 0.4Q_i$	Add $0.3Q_i$ to both sides and subtract $100(0.86)^{\log_2 N}$ from both sides
$Q_i = 250 - 250(0.86)^{\log_2 N} + 0.125\varepsilon$	Divide both sides by 0.4 and flip the equation to put Q_i on the left

Since N is the cumulative production at the *beginning* of each period, it is a known number and therefore can be treated as a constant. Similarly, the shock ε is a constant that changes each week. For week 1, $N = 32$ by definition and $\varepsilon = 0$, so $Q_i = 132.4$. Subbing this into the equation in line 3 above, $P = 100 - 0.15Q_i + 0.05\varepsilon = \80.14 . Similar calculations can be carried out for weeks 2 through 10, updating N for each week. The results of these calculations are shown below, assuming $\varepsilon = 0$ for each week (although players could easily change this assumption by updating their models whenever the new shock is known):

Week	ε	N	Q_i	P
1	0	32	132	\$80.14
2	0	164	168	\$74.86
3	0	332	179	\$73.10
4	0	511	186	\$72.15
5	0	697	190	\$71.52
6	0	887	193	\$71.06
7	0	1,080	195	\$70.70
8	0	1,275	197	\$70.41
9	0	1,472	199	\$70.17
10	0	1,671	200	\$69.96

Appendix 2: Derivation of Long-Run Cooperative Algebraic Solution (No Shocks)

In the long-run, firms can increase profits by taking advantage of the learning curve. If all three firms in an industry behave identically and set production equal to demand (no inventory), the optimal weekly price and quantity plays can be calculated using Solver in Excel (this is done on the Scenarios worksheet in the strategy game model). Alternatively, one can calculate a close approximation of the optimal solutions (excluding shocks) algebraically, using the logic that profits are maximized when marginal revenue is set equal to *final* marginal cost (i.e., the marginal cost curve after all learning has taken place).

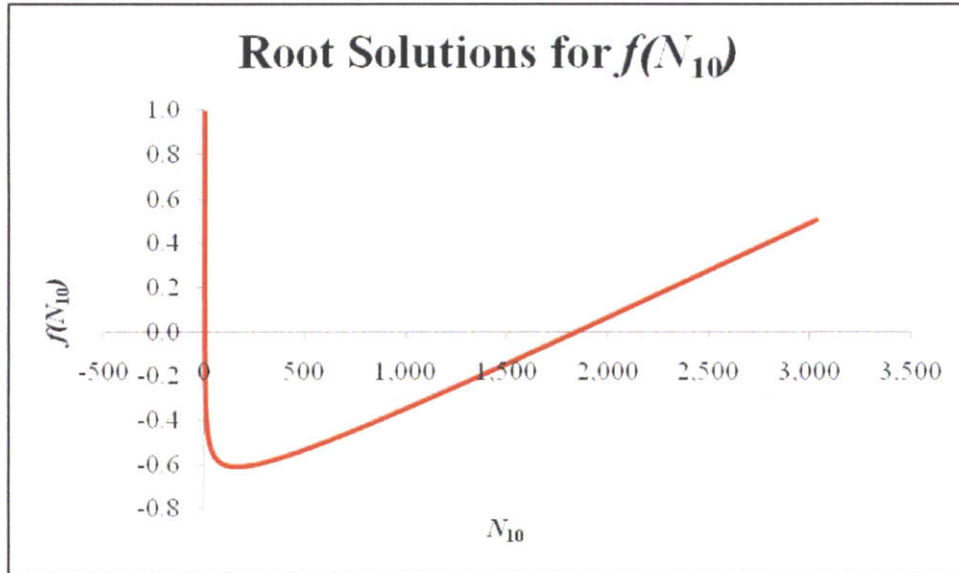
Note that this is *not* the true optimal solution, but rather a close approximation. The algebraic approach assumes that the firm benefits from learning immediately (i.e., learning from one unit lowers cost for the next), but this is not the case in actuality. Instead, the model relies on a simplification that only capitalizes on *learning that took place in prior weeks*. For further explanation, please see Appendix 5.

Equation	Explanation
$Q = 2000 - 20P$	Demand equation for the industry (assuming all firms behave identically)
$Q_i = \frac{2000 - 20P}{3}$	Divide both sides by 3 to get the demand for each firm in the industry (Q_i)
$P = 100 - 0.15Q_i$	Rearrange the above equation
$MR = 100 - 0.3Q_i$	Marginal revenue equals the demand curve with double the slope
$MR = 100 - 0.3\left(\frac{N_{10} - 32}{9}\right)$	Replace Q_i with the total number of units produced in weeks 1 through 9 ($N_{10} - 32$) divided by 9 (remember that the firm has 32 units worth of “learning” at the start of the game and that the learning that takes place in week 10 does not benefit the firm, so we exclude this week from the calculation – see explanation below)
$MR = 100 - \frac{3}{90}(N_{10} - 32)$	The above equation simplified
$\alpha(N) = (0.86)^{\log_2 N}$	“Learning factor” as given in the memo (where N is the cumulative production at the <i>beginning</i> of the current period)
$MC = 100\alpha(N) + 0.1Q_i$	Marginal cost for each firm as given in the student memo

$MC = 100(0.86)^{\log_2(N_{10})} + \frac{1}{90}(N_{10} - 32)$	Combination of the two equations above, replacing N with N_{10} and subbing in $\frac{N_{10} - 32}{9}$ for Q_i
$100 - \frac{3}{90}(N_{10} - 32) = 100(0.86)^{\log_2(N_{10})} + \frac{1}{90}(N_{10} - 32)$	Set marginal revenue equal to marginal cost
$100 - \frac{4}{90}(N_{10} - 32) = 100(0.86)^{\log_2(N_{10})}$	Subtract $\frac{1}{90}(N_{10} - 32)$ from both sides
$1 - \frac{4}{9000}(N_{10} - 32) = (0.86)^{\log_2(N_{10})}$	Divide both sides by 100
$\log_2 \left[1 - \frac{4}{9000}(N_{10} - 32) \right] = \log_2 \left[(0.86)^{\log_2(N_{10})} \right]$	Apply \log_2 to both sides
$\log_2 \left[1 - \frac{4}{9000}(N_{10} - 32) \right] = \log_2(N_{10}) \times \log_2(0.86)$	Apply log rule $[\log_b(m^n) = n \times \log_b(m)]$
$\log_2 \left[1 - \frac{4}{9000}(N_{10} - 32) \right] = \log_2(N_{10})^{\log_2(0.86)}$	Apply same log rule as above
$2^{\log_2 \left[1 - \frac{4}{9000}(N_{10} - 32) \right]} = 2^{\log_2(N_{10})^{\log_2(0.86)}}$	Apply an exponent base of 2 to both sides
$1 - \frac{4}{9000}(N_{10} - 32) = (N_{10})^{\log_2(0.86)}$	Simplify using log rule $a^{\log_a x} = x$
$f(N_{10}) = (N_{10})^{\log_2(0.86)} + \frac{4}{9000}N_{10} - \frac{1141}{1125} = 0$	Rearrange and label function $f(N_{10})$

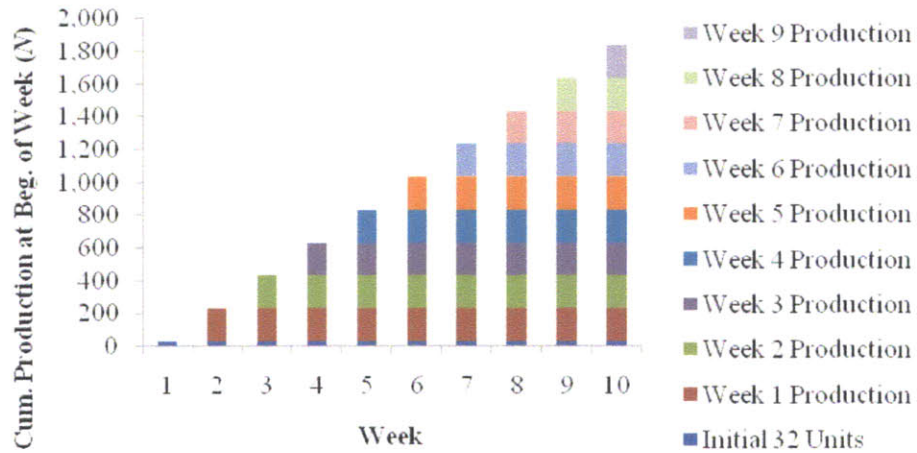
We can now use Excel to find the solutions to this equation. As shown in the graph below, the solutions for $f(N_{10})$ are 0.939 (nonsensical for this analysis) and 1,843.9. If N_{10} equals the latter, $Q_i = \frac{N_{10} - 32}{9} = 201.3$. Subbing this into the equation in line 3 above, $P = 100 - 0.15Q_i = \$69.80$. Rounding these slightly, we have the following long-run cooperative solution for each weekly play (including the learning curve but excluding shocks):

$Q_i = 200$
$P = \$70$

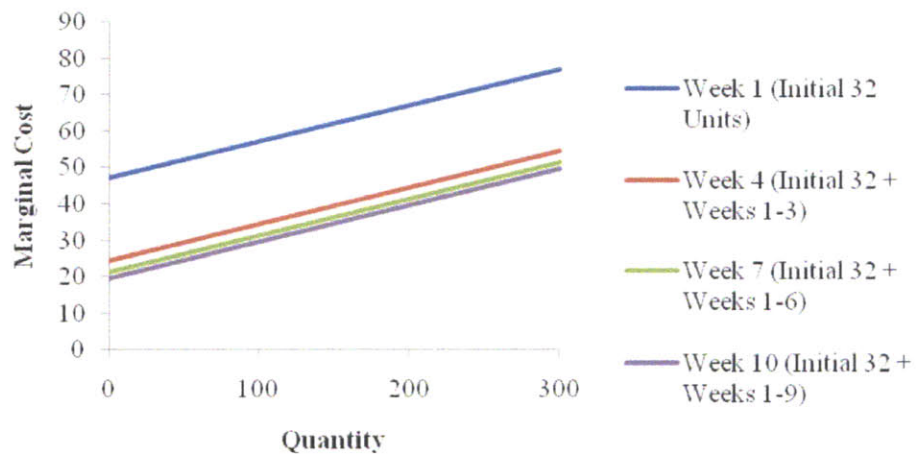


The reason that $Q_i = \frac{N_{10} - 32}{9}$ instead of $\frac{N_{10} - 32}{10}$ is that the learning curve only takes into account production that occurred up until the *beginning* of the current period. Therefore, the learning that takes place from production in week 10 does not benefit the firm at all. It theoretically pushes the firm farther down the learning curve, but since there is no week 11, that gain in efficiency is never realized. In the algebraic approach, we set marginal revenue equal to *final* marginal cost, and the final marginal cost curve in week 10 does not depend on production in week 10. Therefore, we exclude week 10 production from the calculation. See the charts below for more detail. Also, note that we subtract 32 in the numerator because the 32 units worth of “learning” at the start of the game simply capture the fact that the firm is slightly down the learning curve prior to any production. These 32 units are not actually produced by the firm, so they are subtracted from the cumulative production.

Quantities Used for Learning Curve



MC & the Units that Determine It



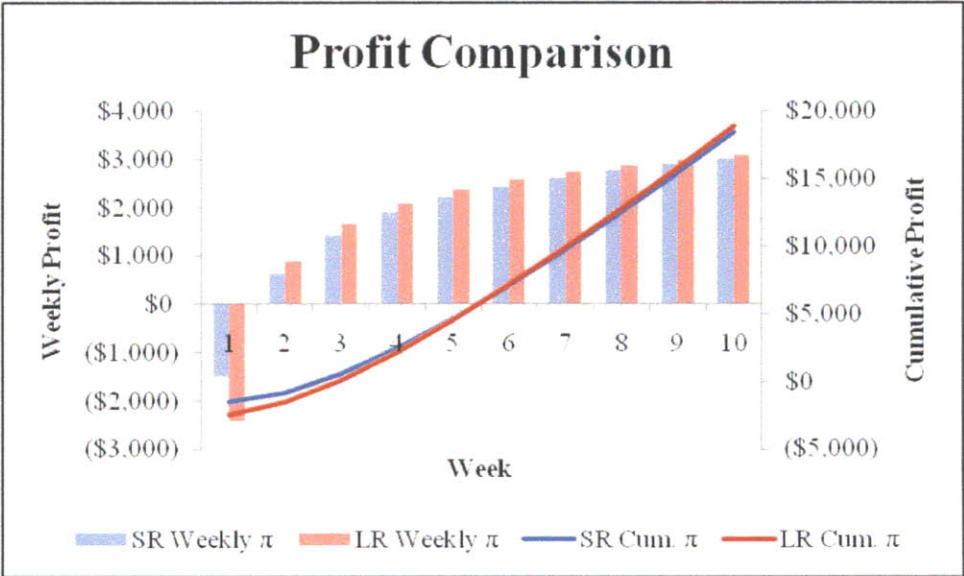
Appendix 3: Comparison of Long-Run and Short-Run Cooperative Solutions

As shown previously, accounting for the learning curve can lead to better results than simply maximizing profits period-to-period in a myopic fashion. Below, we provide a comparison of these two approaches. Note that all shocks ε are assumed to be zero and all three firms are assumed to behave identically.

As indicated in the charts, the weekly short-run price and quantity move asymptotically toward the long-run values of \$70 and 200, respectively. Therefore, the short-run solution shifts to the long-run solution after several rounds, but value is lost while this transition takes place. This fact can be clearly seen in the second chart. Although the week 1 profit for the long-run solution is significantly below that of the short-run solution, the learning that takes place during this period allows for higher profits in weeks 2 through 10 that more than compensate for the initial loss. As the chart illustrates, the long-run solution “loses” in week 1 but “wins” in each subsequent week due to the learning curve. This results in a higher cumulative profit at the end of week 10, as shown in the line graphs.

Weekly Outcomes for the Short-Run and Long-Run Cooperative Solutions (No Shocks)

	Week									
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>
<u>Short Run:</u>										
Q_i	132	168	179	186	190	193	195	197	199	200
P	\$80.14	\$74.86	\$73.10	\$72.15	\$71.52	\$71.06	\$70.70	\$70.41	\$70.17	\$69.96
π	(\$1,494)	\$620	\$1,430	\$1,893	\$2,208	\$2,443	\$2,629	\$2,782	\$2,910	\$3,021
Cum. π	(\$1,494)	(\$875)	\$556	\$2,449	\$4,657	\$7,100	\$9,730	\$12,511	\$15,422	\$18,443
<u>Long-Run:</u>										
Q_i	200	200	200	200	200	200	200	200	200	200
P	\$70.00	\$70.00	\$70.00	\$70.00	\$70.00	\$70.00	\$70.00	\$70.00	\$70.00	\$70.00
π	(\$2,409)	\$886	\$1,660	\$2,084	\$2,369	\$2,581	\$2,749	\$2,885	\$3,001	\$3,100
Cum. π	(\$2,409)	(\$1,522)	\$137	\$2,221	\$4,591	\$7,172	\$9,920	\$12,806	\$15,807	\$18,907

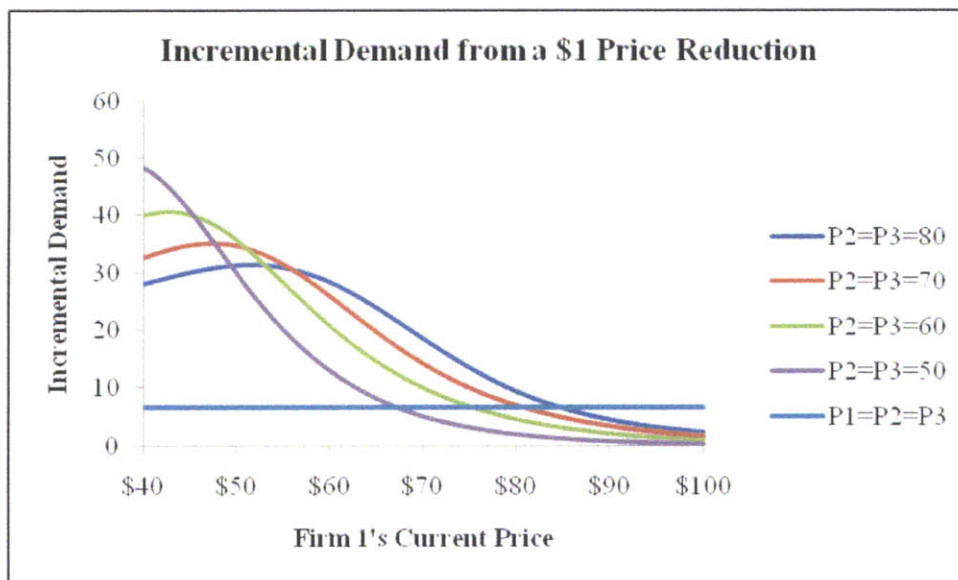


Appendix 4: Incremental Demand from Reducing Price

As discussed in the Background section, the strategy game relies on a market for a heterogeneous good. This means that a decrease in price results in an increase in demand, but the lowest price does not steal the whole market, as would be the case with a homogeneous good. In the strategy game, the amount of extra demand generated from a price reduction depends on the behavior of the other two industry competitors. If Firm 1's price is much higher than the other two industry prices, a decrease in Firm 1's price will bring about a relatively small increase in Firm 1's demand. This makes sense intuitively, since most of the price-sensitive consumers would have already chosen one of the cheaper products before the price drop.

However, if the situation were reversed, Firm 1 could achieve significant additional demand by lowering its price. This, too, makes sense, as consumers have a taste for a particular product but are also focused on price. Going back to the ink-jet printer example, you may have a strong liking for Hewlett-Packard printers, but if Epson prices a comparable printer low enough, you will likely switch. Therefore, in analyzing pricing decisions, firms should consider how much "bang for the buck" they will get from a price reduction.

The chart below aims to capture this concept. It is similar to one of the charts shown at the end of the student memo, but shows *incremental* (as opposed to total) demand brought about by a \$1 decrease in price at several different price points. As you can see, if Firm 1 prices very high (say, \$90), there is a fairly low gain in dropping the price to \$89 (depending on where the competing firms are pricing, Firm 1 would gain roughly 2 to 6 units of demand). However, if Firm 1 prices much lower (for instance, \$60), it will obtain a much higher incremental demand by dropping its price to \$59.



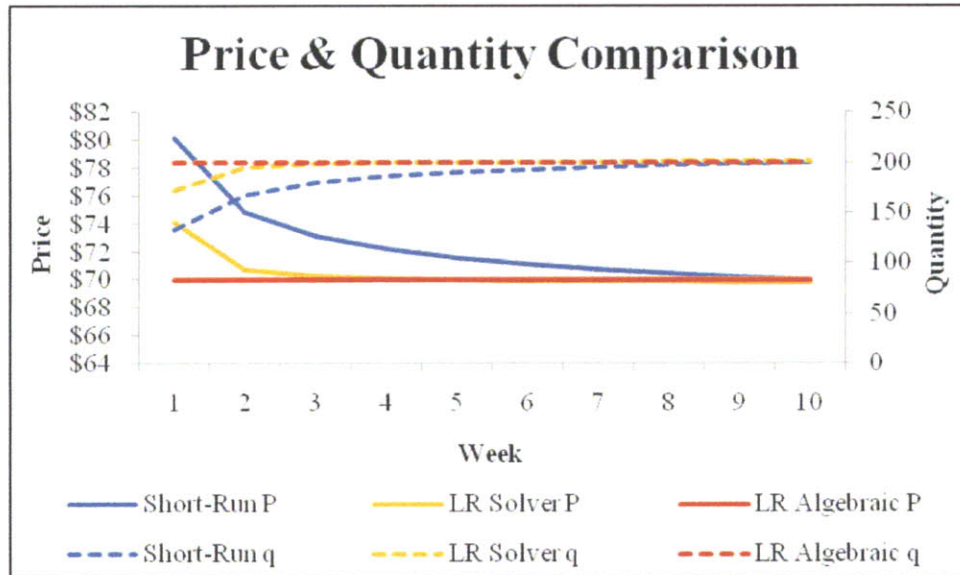
Appendix 5: Explanation of Scenarios and the Students' Optimal Solution

The Scenarios worksheet in the strategy game Excel file breaks out a variety of outcomes based on different assumptions of how teams will play. Each assumes that all three industry competitors behave identically. Several of the scenarios (constant P , constant Q , monopoly, cartel, and idle) are fairly straightforward and do not factor into the model directly (they are included for comparison purposes only). However, the remaining scenarios (the long-run and short-run cooperative solutions) require a bit more explanation. Please note that concise explanations of each scenario are given in column M of the Scenarios worksheet. They are colored yellow to indicate information/instruction.

The short-run cooperative solution is derived using tools from an introductory Microeconomics course. Specifically, marginal revenue and marginal cost are determined from the given equations, they are set equal to each other, and the resulting quantity is used to back out the industry price. Please see Appendix 1 for more detail.

The long-run cooperative solutions are calculated using Solver. For the Assuming Zero Shocks case, all shocks are assumed to be zero and Solver picks the 10 industry quantities that maximize the cumulative profit at the end of the 10th week. This would be a possible outcome for students if they figured out the learning curve but did not understand how to integrate the shocks into the analysis.

Note that prices and quantities fluctuate slightly over the 10 weeks, staying fairly close to the \$70, 200 algebraic solution derived in Appendix 2. This is due to the fact that the algebraic solution yields on a constant price and constant quantity for all 10 weeks, whereas the Solver solution uses iteration to determine 10 optimal price/quantity combinations over the course of the game. Additionally, the algebraic solution assumes that learning benefits the firm immediately (learning from unit one decreases marginal cost for unit two), but this is not the case in the model. Rather, in the model, learning in a given week only lowers marginal cost in *future* weeks. This was done to simplify the calculations. The “lumpy” characteristic of learning in the model makes it advantageous to utilize a slightly higher price and lower quantity in the earlier periods, similar to the optimal short-run cooperative solution but to a lesser degree. Please see the chart below for an illustration of this (note that this is the same chart as in Appendix 3 except that the Solver solution has been added). You can also see the Scenarios worksheet for more detail.



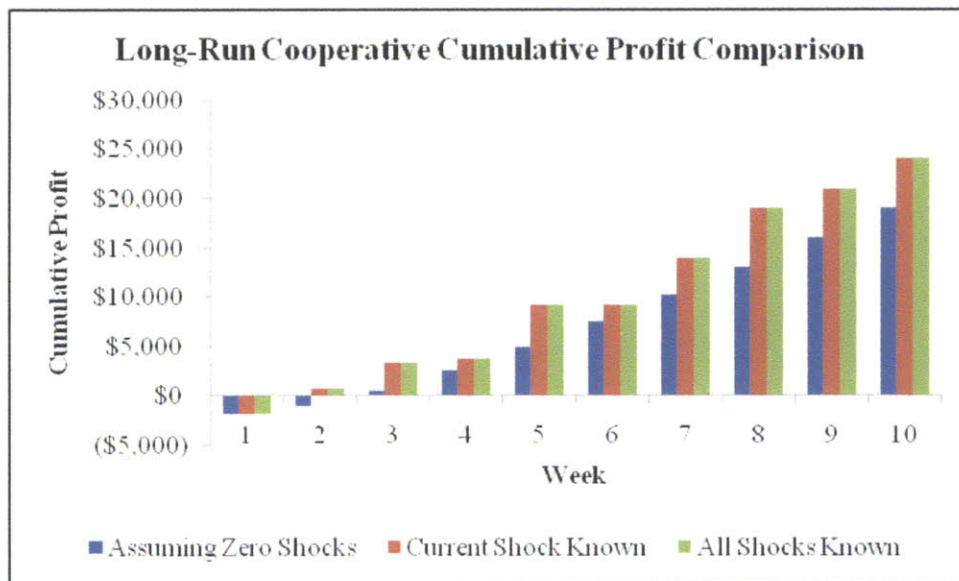
It is important to reiterate that the algebraic approach does *not* yield a precise solution, but rather a close approximation. If the model were adjusted such that gains from learning were realized immediately (instead of in the weeks to come), the yellow and red lines above would overlap. However, such a model would be much more difficult to build, and thus the “lumpy learning” simplification is a good tradeoff. Of the three scenarios plotted above, the long-run Solver solution yields the highest profit, and is therefore the true optimal solution assuming zero shocks throughout the course of the game.

The All Shocks Known case is the exact same as the Assuming Zero Shocks case, except that all shocks are assumed to be known from the beginning of the game. This situation is not realistic and could not be used by students due to the fact that information on shocks is announced week to week. However, this scenario gives a sense of how well students could do if they had all of the information from the very start.

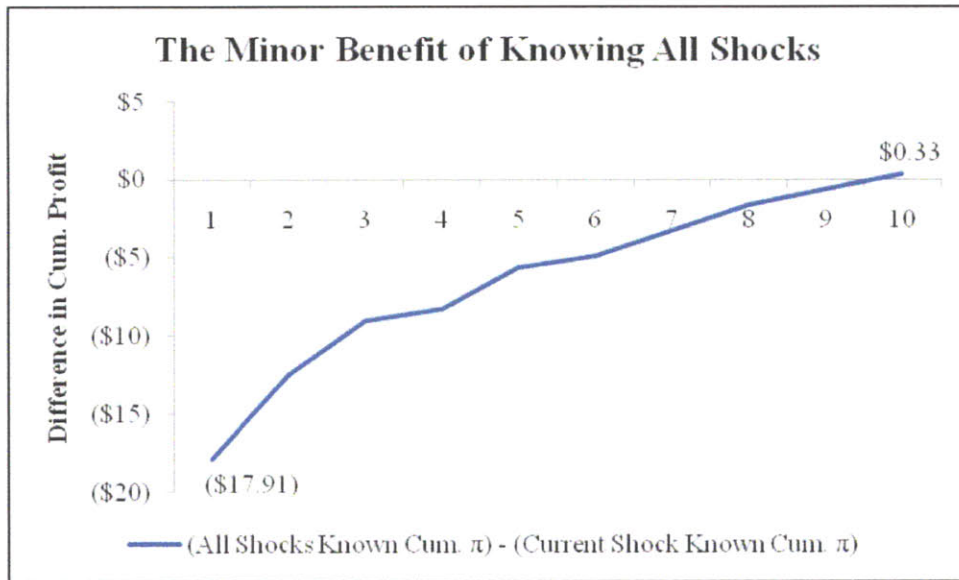
The Current Shock Known (Realistic) scenario is the best cooperative solution students can achieve. This can be considered the “correct answer” for students trying to maximize profit in a collusive fashion (but keep in mind that students can beat this outcome considerably if other firms in their industry play poorly). The optimal long-run realistic collusive scenario is similar to the two described above, except for the fact that the current shock is known and *all future shocks are assumed to be zero*. This is a reasonable assumption, as the shocks average roughly zero over the course of the game. Solver iterates to determine the final solution, taking the current shock into account and setting the remaining ones equal to zero. For instance, for week 1, Solver finds the optimal industry quantities for weeks 1 through 10 that maximize cumulative profit at the end of week 10, taking into account the shock for week 1 and assuming that the shocks for weeks 2 through 10 are all zero. For week 2, Solver finds the optimal industry

quantities for weeks 2 through 10 (since week 1 is now in the past), taking into account the shock for week 2 and assuming that the shocks for weeks 3 through 10 are all zero. This process is continued for the remaining weeks.

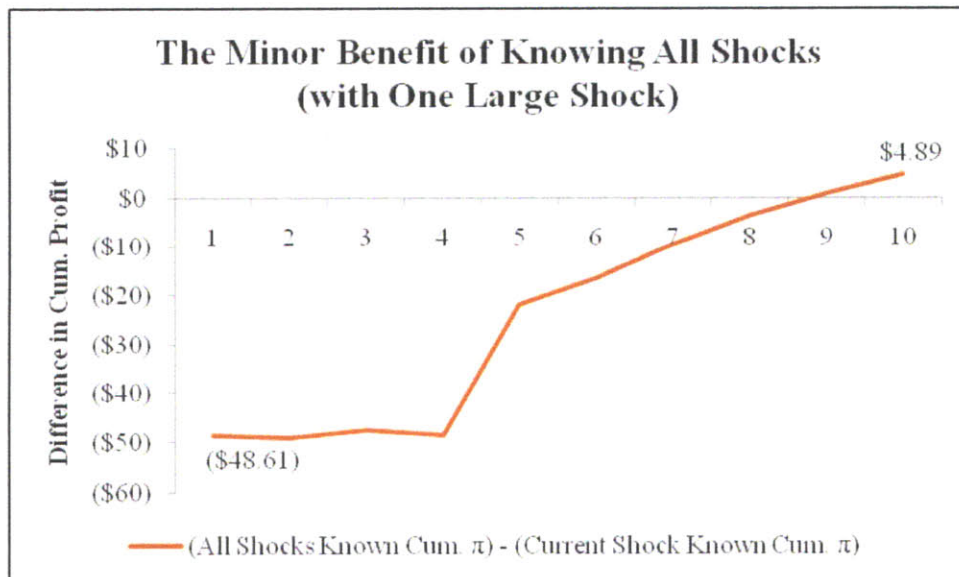
It is interesting to note that including shocks in the model has a huge positive effect on profit (look at the difference between the final cumulative profit for the Assuming Zero Shocks and Current Shock Known scenarios in the chart below), but the incremental value of knowing all shocks from the beginning versus knowing only the shock for the current week is quite small. The takeaway here is that the unknown information about the shocks in the future weeks is less of a disadvantage than one may expect. Knowing these shocks from the beginning would only provide a marginal benefit – students can achieve an extremely strong result using only the information given week to week. Please see the charts below for a visual illustration of this point (the shocks for this particular scenario are 0, 200, 100, -200, 300, -300, 200, 200, -100, 0).



The chart below shows the weekly difference between the cumulative profit for the All Shocks Known case and the Current Shock Known case. Similar to the profit comparison chart in Appendix 3, the higher-final-profit scenario (knowing all shocks from the beginning) actually has *lower* profit in the earlier weeks. This is because of the learning curve. If a firm knew all shocks from the start, it could smooth production to optimize costs and profits over the 10 weeks. With the shocks used in this example, the All Shocks Known case actually has lower cumulative profit than the Current Shock Known case until the last week. As you can see, at the end of the game, the value of knowing all shocks from the beginning versus knowing only the shock for the current week is very small (only \$0.33).



Even if we replace the fifth shock (currently 300) with a much bigger shock (for instance, 2,000), the benefit of knowing all shocks from the beginning is still very small. One might expect large gains in profit due to production smoothing (producing more earlier in preparation for the large demand increase), but this is not the case. See the graph below for a depiction of this. With the larger shock, the benefit of perfect information grows from \$0.33 to only \$4.89. This extreme example reinforces the notion that firms can perform very well despite uncertainty about future demand characteristics.



Appendix 6: Creating and Using Google Web Forms

Google web forms provide an easy and convenient way to collect information from students during the semester. They are particularly useful when compiling names for strategy game teams and collecting weekly price and production plays. To create a Google web form, please follow these steps:

1. Navigate your web browser to the Google Docs homepage by entering “docs.google.com” in the address bar.
2. If you already have a Google account (such as Gmail), log in using your user name and password. If you do not have a Google account, you will need to create one (for free) using the link on the homepage.
3. Once you are signed in, create a new spreadsheet by clicking the “Create new” link at the top left corner of the page. In the dropdown menu, click “Spreadsheet.”
4. A blank spreadsheet will appear. Save this spreadsheet by clicking the “Save” button at the top right corner of the page, or by navigating to “Save” in the File menu. Choose a name for the spreadsheet, such as “Strategy Game Teams” or “Weekly Plays.”
5. On the Form menu, click “Create a form.” This will open up a new window with a blank form template. Edit the form to include whatever information you desire. Make sure that your instructions are very clear.
6. After you have created your form, click the “Save” button at the top-right corner of the window. Note that the “Save” button turns grey, and the text on the button changes to “Saved.”
7. At the bottom of the window, there is a box that says, “You can view the published form here:” followed by a hyperlink. This is the address that you should distribute to the students so they can enter the data. Note that if you click on this link, you will be taken to a page displaying the form as students will see it. Here, they can enter their information, but cannot see anyone else’s information.
8. As students fill out the form, their data is logged in the spreadsheet you saved in step 4. If you open this spreadsheet (by navigating back to “docs.google.com” and clicking on the spreadsheet name you chose), you will see a column for each question, and a Timestamp column at the far left. The timestamps are important for the weekly plays, as they allow the model to determine if a play has been submitted late.
9. Once all data has been submitted, you can export the spreadsheet to Excel by clicking File → Download as → Excel.

Note: For simplicity, you may want to allow students to modify their plays or team selections as many times as they wish up until the deadline. This will decrease the number of emails you will receive from students asking you to change their inputs. Tell the students that they can modify their previous submission by simply submitting a new play or list of team names through the web form. If multiple entries show up in the data, simply ignore all except the most recent one.

Screenshot of Team Submission Google Web Form

15.013 Strategy Game Team Submission

Please enter the information requested below. You may change teams until the deadline by simply entering a new team on this form. The old entry will be ignored.

* Required

Which section are you in? *

Both team members must be in the same section!

First team member

Order of team members does not matter

What is the full name of the first team member? *

Type it how you would like it displayed in the weekly emails

What is the first team member's email address? *

Type the address where you want the weekly emails sent

Second team member

Order of team members does not matter

What is the full name of the second team member? *

Type it how you would like it displayed in the weekly emails

What is the second team member's email address? *

Type the address where you want the weekly emails sent

Submit

Powered by [Google Docs](#)

[Report Abuse](#) - [Terms of Service](#) - [Additional Terms](#)

Note: This Google web form only has entry boxes for two team members so that students cannot enter a team of three on their own. If necessary, the TA can make manual edits in the Teams worksheet to accommodate teams of three.

Screenshot of Weekly Play Submission Google Web Form

15.013 Strategy Game

Please fill out the survey by Monday at 5 PM.

* Required

Enter Week *

This should be a number 1 through 10, not a date (examples: "1", "2", "10")

Enter Team Number *

Team roster document available on Stellar (please enter 4-digit number only -- section not needed).

Enter Names of Students on Team *

Example: "Mike Johnson & Sally Rogers"

Enter Production Quantity (# of UNITS) *

Enter whole numbers only. Remember to check your inventory (this number will be added to your inventory).

Enter Price (\$\$\$\$\$\$\$) *

No more than two decimal places please (example: "01.50"). Make sure you enter quantity and price in the correct boxes.

Enter Comment *

Please explain your logic, frustrations, general comments, etc. Be concise - a sentence or two is fine, although you can write more if you have more to say.

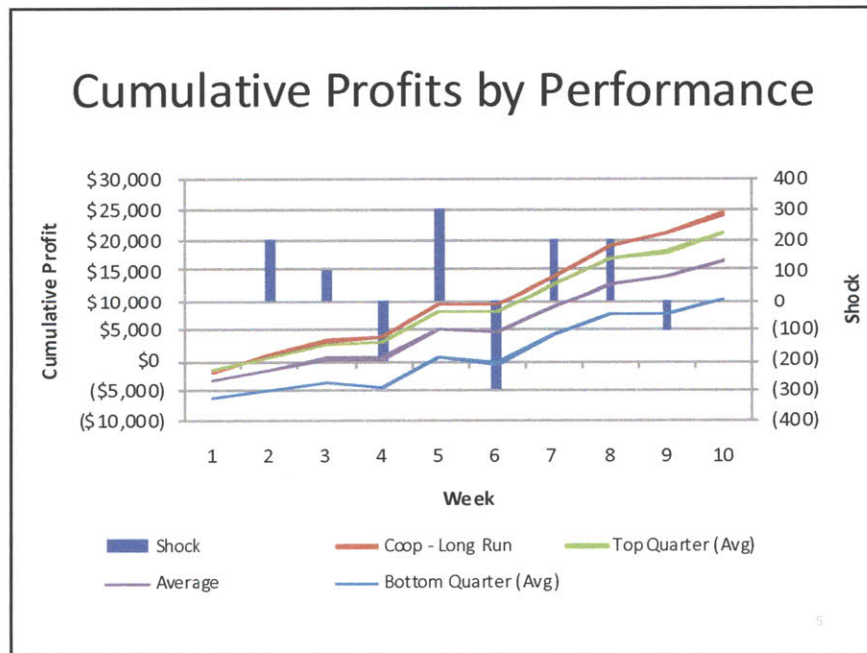
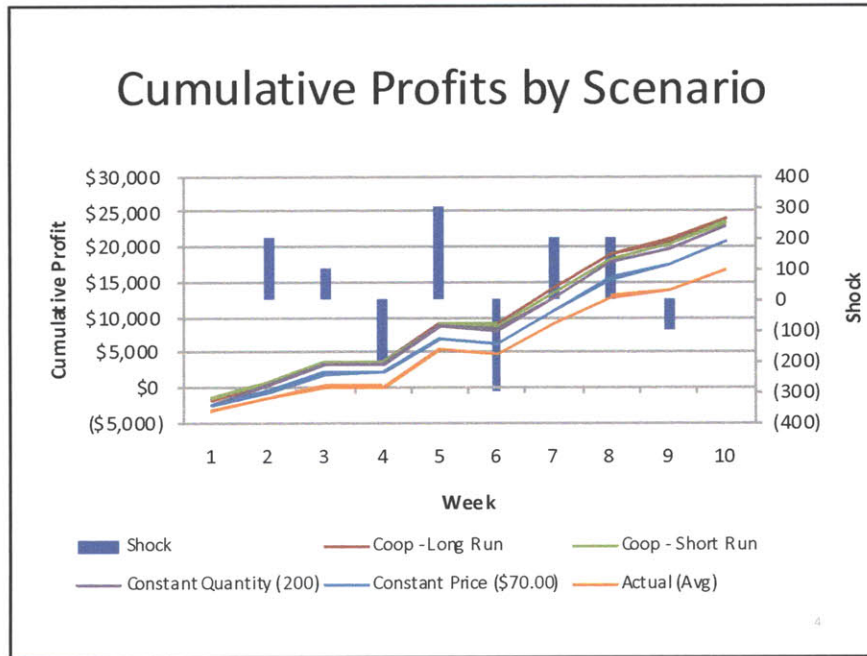
Submit

Powered by [Google Docs](#)

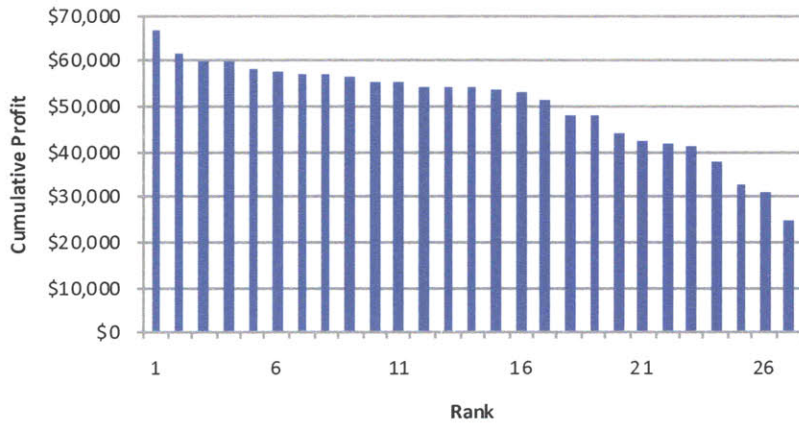
[Report Abuse](#) - [Terms of Service](#) - [Additional Terms](#)

Appendix 7: The PowerPoint Summary Slide Deck

The strategy game Excel workbook can create and export a PowerPoint file containing summary information about the game. This can be done at any point during game play. Please see the screen shots below from a sample deck created after 10 weeks of play.

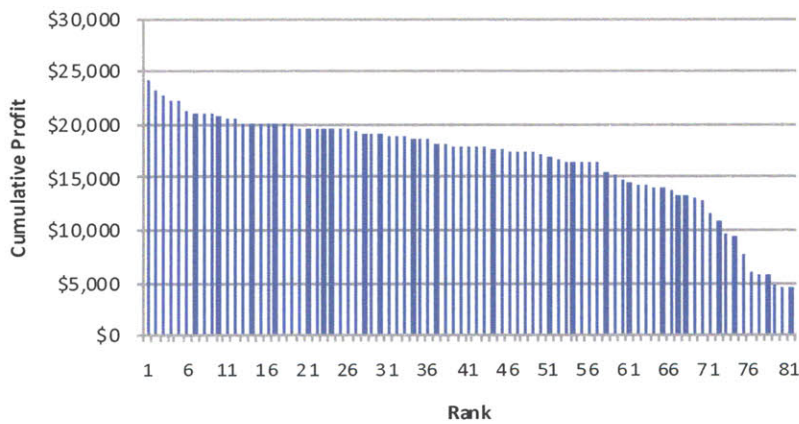


Cumulative Profits Ranking by Industry



6

Cumulative Profits Ranking by Firm



7