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A demand and supply game exploring global supply chains

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ABSTRACT

In this article, the author describes a classroom experiment in which participants make decisions to achieve the lowest-cost production. Student volunteers acting as smartphone companies are provided with confidential information representing their own cost of production and are asked to make trade decisions to form a supply chain at the lowest possible cost. This interactive classroom experiment facilitates an understanding and appreciation of the basic demand and supply model. Students also explore the motivations, facilitators, and impediments of global supply chains. Suggestions are made to expand the game by incorporating more sophisticated models of the global supply chain, and also ways in which it can explore aspects of economics such as transportation costs, oligopoly and the narrowing wage gap between Eastern and Western economies.

KEYWORDS

Active learning; classroom experiment; demand; global supply chains; supply

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A22; D00; C91

Several studies have advocated the use of classroom experiments as a complement to the traditional lecture approach (Hester 1991; Bergstrom and Miller 2000). Specifically, previous research has established that classroom experiments are effective tools for teaching economics (Frank 1997; Holt 1999). Students of microeconomics also learn more effectively with an experimental approach than with a traditional lecture approach (Emerson and Taylor 2004; Ball, Eckel, and Rojas 2006; Dickie 2006). Moreover, the use of classroom experiments can significantly improve student attitudes toward the study of economics (Durham, McKinnon, and Schulman 2007).

Numerous demand and supply experiments have been used to teach this most commonly used economic model. This type of experiment was first conducted by Chamberlin (1948) in which students wandered around their classroom and negotiated in small groups. Smith (1962) later modified this experiment and demonstrated that trading results tend to produce efficient, competitive outcomes. Holt (1996) provided an excellent illustration of the discovery of equilibrium prices and quantities in a pit market trading exercise. Markwardt, Seidel, and Thum (2016) developed a computerized version of Holt's classic market game allowing the game to be used in large classes. In this classic market game, students are buyers and sellers with different willingness-to-pay levels and production costs, respectively. The participants are called to a trading area at the front of the room to begin negotiations and make mutually beneficial transactions. The game facilitates discussion among the students about the factors that would affect equilibrium price, such as the number of buyers and sellers. The present study contributes to the existing literature by incorporating global supply chain management (GSCM) features within the activity, such as the motivators of the global supply chain; the factors that can foster or repress the supply chain; and the concepts of total cost of production, efficient and responsive supply chains, and functional and innovative products.

The game introduced in this study is suitable for introductory economics courses and for class sizes of 30 to 50 students. It is best played after students have learned about both the demand

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and supply model and the global supply chain concepts. It takes about 35 to 45 minutes to introduce, play, and discuss the results.

Materials and methods

Pre-game considerations

In a normal 2-hour lecture, the instructor should spend the first hour explaining the basic demand and supply economic model to make sure the students have a basic understanding of the topics, such as the behavior of buyers and sellers, and supply and demand in equilibrium. The instructor could then introduce the basic concepts of foreign outsourcing and the definition of a global supply chain. To facilitate the adoption and implementation of the experiment later, an example is provided of how the iPhone 6 is made. Globally, 31 countries and 785 suppliers are involved in the production of the iPhone 6 (Hessman 2014). Apple established a global supply chain to produce the iPhone 6 at lowest production cost: the United States performs research and development (product design); South Korea, Taiwan, and Hong Kong produce the intermediate components; and China handles the final assembly (MHL 2014). Manufacturing the iPhone 6 in China saved Apple $4.2 billion. Apple has created nearly 600,000 jobs in the United States for full-time employees, supply chain managers, and app developers. The production has also had a huge effect on Asian economies. For example, it has boosted Japanese exports by 5 percent and increased Japanese machine tool orders by $1 billion. Currently, in 2018, Apple products are made all over the world. Apple works with 1049 suppliers in 45 countries, across a range of industries, from mining to retail to recycling (Clover 2019).

The students should be informed that they will be participating in a game (with prizes) that has been designed to reinforce their understanding of the demand and supply model, the motivators of the global supply chain, and the factors that can foster or repress the supply chain.

Group assignment and game setup

The purpose of this game is to establish a production network for smartphones. The instructor should start by first asking for four student volunteers (Apple, Samsung, Huawei, and Google) to act as the smartphone companies. The four volunteers each have the objective of producing one smartphone at the lowest production cost. Students should also be informed that prizes will be given to the student with the lowest production cost. To be fair in awarding prizes, all volunteers should be given the same cost structure so that they begin at exactly the same point. The instructor should inform all students that the costs of the four volunteers are identical. Next, a simplified production process of a smartphone should be illustrated to all of the students. This production process is fragmented and should be divided into four different stages: designing the product; producing the intermediate components display and battery (two stages); and assembling the two components.

At each stage, the four student volunteers, acting as the four smartphone companies, choose either to complete that stage's task on their own or to outsource the task to a specialty firm. The four companies are then provided with confidential information about the cost of production for each stage if they choose to complete the task on their own. Appendix A represents the worksheet that contains cost information, which is distributed to the four student volunteers.

The remaining students in the class should be divided into four selling groups: smartphone design teams; producers specializing in displays; producers specializing in batteries; and assembly factories. Each of the four selling groups has only one unit of product or service to supply.

For the next step, the instructor should distribute a numbered playing card (randomized from 2 to 10 after eliminating face cards) to all students in the four selling groups, which represents

their cost of production, or bottom line for trading. The students should be reminded to conceal the numbers on their cards so that the distribution of costs for selling groups is not released to the smartphone companies. Each suit in the deck should be distributed as follows: hearts for the designers; diamonds for the assembly factories; clubs for display producers; and spades for battery producers. Each card represents one "unit" of a product or service that can be bought by a smartphone company. For example, a producer of displays with an eight of clubs would try to sell one display unit at any price above $8 (although the higher the selling price, the better for the producer). If the seller can arrange to sell the unit at a price above this cost, then the seller "earns" a profit that is equal to the difference between the price and the cost. The objective for sellers is to maximize their profits. If there is no transaction, the profit (or producer surplus) is zero. The instructor could also prepare small prizes for each of the suppliers who obtain the highest profit, although that may be somewhat unfair, as suppliers have different costs. The instructor can use as many decks of playing cards as necessary, according to the number of students in each group. For example, if there are nine students in one group, one deck of playing cards with numbers ranging from 2 through 10 is sufficient. In addition, the numbers 2 through 10 from each suit should be assigned randomly among students in the selling groups.

For a class size of about 40, it is sufficient to have only 4 smartphone companies and 9 suppliers in each of the 4 groups. It takes time for the smartphone companies to talk to the suppliers in each group, and suppliers within the same category may bid against one another to get the outsourcing jobs. Past experience indicates that it usually takes roughly 15 minutes to complete all negotiations.

The instructor can alter the number of smartphone companies for different class sizes. The appropriate ratio between the number of smartphone companies and the number of suppliers in each category is 1:2. This ratio, on one hand, provides smartphone companies more outsourcing choices (in a class of 40, 9 suppliers in each category for the 4 smartphone companies) and raises the difficulty level in finding the best match. On the other hand, it increases the competition among suppliers. Some of the high-cost suppliers, such as those given a 9 or 10, may not be able to arrange a transaction. Lastly, based on this ratio, the instructor also could ask the students to discuss the bargaining power between buyers and sellers. Ideally, this should demonstrate to the students that the numbers of buyers and sellers affect the bargaining power, which in turn affects the prices in transactions.

Before playing the game, the instructor should highlight the important guidelines with slides or a whiteboard to all students as follows.

1. A smartphone company should negotiate with different suppliers before a final transaction is made.
2. Once a smartphone company and a supplier finalize a transaction, the supplier should give the playing card to the smartphone company, and the company should write the name of the supplier as well as the agreed price on its worksheet. Once this transaction becomes final, the smartphone company cannot buy the same product or service from another supplier.
3. Once a transaction has been completed, suppliers should remove themselves from the market.

Conducting trading and listing trading outcomes

The instructor should request that the four smartphone companies and all of the sellers meet to negotiate during a 15 minutes trading period. During these negotiations, the prices must be in multiples of 50 cents. When a smartphone company finalizes its choices for all four stages of production, either by doing these tasks on its own or outsourcing to a seller, the company should report its cost structure to the instructor. The final cost structures will be announced to all

Table 1. Cost of components producers and assembly factories and winning smartphone company.

	Apple	Samsung	Huawei	Google
Design	1	1	1	1
Display	3 (2)	5.5 (4)	6	3.5 (3)
Battery	7 (5)	4 (3)	3.5 (2)	6.5 (4)
Factory assembly	4.5 (4)	5.5 (3)	7.5 (5)	6 (2)
Total cost	15.5	16	18	17

Note: The numbers in parentheses represent the exact costs for the intermediate goods producers or for the assembly factories. The numbers without parentheses are the selling prices.

students, and the class as a whole can discuss features of demand and supply in an experimental market as well as the motivators, facilitators, and impediments of the global supply chain.

Encouraging students to reflect on their learning

The instructor should provide all of the realized cost structures from the transactions of the game in a table. Table 1 illustrates a sample table that represents Apple as the winner with the lowest costs of production.

First, the instructor should ask the smartphone companies the following questions:

1. What was your cost of production with no outsourcing?
2. How did you decide between completing a stage on your own or outsourcing to a seller?
3. Why did you choose to design the product on your own while outsourcing the remaining stages to other sellers?

The answer to question 1 for all of the smartphone companies should be 26 (as demonstrated in appendix A), which is a much higher cost than what they achieved by using a supply chain (as demonstrated in table 1). Question 2 should enable students to understand that the motivation for using a global supply chain is to save on production costs. In each step of the negotiating process, smartphone companies should compare their own cost of production to the prices offered by the different sellers. If the price offered by a seller is lower, then outsourcing would result in a lower cost of production.

The instructor should then emphasize the fact that all four smartphone companies chose to design the product on their own and ask for the rationale in doing so. From their experience in the game, the four volunteers (acting as smartphone companies) should have realized that they could not negotiate a price below their production cost of 1. The instructor could then show table 1 representing the cost structure of the four smartphone companies to point out that the lowest possible cost for the design teams was higher than 1; in other words, for the seller to achieve a profit, the price offered would have been higher than 1, which is more than the cost for smartphone companies to complete the tasks on their own. This situation creates no incentives for companies to outsource the design task.

In order to reinforce this idea, the instructor should let the entire class know the number distribution on the sellers' playing cards. Given that all sellers were assigned random costs between 2 and 10, this would show that all of the smartphone companies were more effective in designing the phone on their own. For the remaining tasks, from the intermediate goods production to the assembly, all four smartphone companies had opportunities to find sellers with lower costs. In other words, for stages 2–4, there were possibilities for a price to be chosen that would be mutually beneficial to both parties. Next, the instructor should ask for the transaction details between the smartphone companies and the suppliers who were able to complete a transaction. The instructor should then list the exact cost of the intermediate goods producers and the assembly factories in parenthesis in the same table.

As table 1 indicates, all of the prices are mutually beneficial prices in that they are above the sellers' costs and generate a profit. The instructor should then ask the entire class the following questions related to table 1:

1. Why did Huawei choose to produce displays at 6 rather than outsourcing?
2. Which type of seller would most likely be successful in arranging a transaction?
3. Which party do you think has more bargaining power, the smartphone companies or the suppliers?

The instructor could first highlight the unusual situation of Huawei, which chose to produce displays on its own at the higher cost of 6 rather than outsourcing to possible low-cost suppliers. The instructor could point out that with a relatively low production cost for smartphone companies, it is more difficult to reach a mutually beneficial transaction; that is, it is only cost-saving to outsource the job to suppliers with a cost of 2, 3, 4, or 5. With fewer mutually beneficial choices and limited negotiation time, some companies may not be able to outsource the job and must do it on their own. The above discussion of Huawei is based on a hypothetical outcome. If such a situation does not occur in the game, the instructor can still make the point by asking the smartphone companies how challenging it was to find a mutually beneficial transaction.

It might seem to students that, on the one hand, the lower-cost sellers likely would be the most successful in forming a buyer–seller pair, because they are more efficient, productive, and flexible and can offer a lower price. Although the higher-cost sellers would have low or even no possibility of arranging a transaction, they would not be excluded from the negotiating process, because the costs of smartphone companies and sellers are confidential in negotiation. To increase the engagement of those students, the instructor could introduce a second round of the game, as mentioned in the following sections, or encourage those students to answer more questions in the discussion section. Alternatively, at least some small prizes, such as candy, could be given to those students to acknowledge their effort in the game. On the other hand, the agreed-upon prices are closer to the production costs of those sellers than they are to the production costs of the smartphone companies, meaning the profit margin for the sellers is not high. This indicates that the smartphone companies (the buyers) have more bargaining power.

The instructor also could ask the students why the buyers have more bargaining power. Ideally, students would be able to point out the difference in the number of buyers and sellers (i.e., there are four buyers in total but nine sellers in each category). This should demonstrate to students that when supply is greater than demand, prices tend to be lower.

Expanded game: GSCM courses

Pre-game considerations

In economics courses, it is sufficient to focus on the cost-efficiency of supply chains, which is equivalent to the cost minimization problem. However, this game also can be expanded for GSCM courses. In those courses, as pre-game preparation, the instructor should point out that in the basic game the only objective is to minimize cost. However, there are other incentives to outsource besides lowering cost. If reaching the lowest possible production cost is the only justification for outsourcing, negative consequences may result, such as a decrease in quality and loss of control. The instructor should devote more time to defining and comparing the differences between efficient and responsive supply chains. Students also should learn to distinguish between functional and innovative products. Also, a more comprehensive concept of the total cost of production should be introduced, which includes delivery time.

In GSCM courses, the basic tradeoff to be made is between responsiveness and cost-efficiency. Fisher (1997) suggested that the best strategy to design a supply chain depends on the nature of the demand for the product. For functional products with stable, predictable demand and a long life cycle, such as some groceries, Fisher argues that the supply chain should be designed for cost-efficiency. For innovative products with volatile demand and a short life cycle, such as electronics, he maintained that the supply chain should be designed to be fast and responsive. An example of a responsive supply chain can be seen in Apple's iPhone. In 2007, when Steve Jobs was running the business, he decided to change the screen for the new iPhone just a few weeks before launching. No American suppliers were able to meet this deadline. However, a Chinese factory was able to hire 8000 new workers and ask them to work for 12-hour days. The team finished the project in just 4 days. Apple's executives noted that one of the motivations for outsourcing to China is the superb speed and flexibility of the Chinese plant, with which no American plant can compete.

Conducting the GSCM game

While the initial game described above focuses only on designing a low-cost supply chain, the instructor could organize a more comprehensive second round in which smartphone companies need to form an optimal supply chain that matches their firm's strategy. That strategy will depend on the demand variability of the product as discussed previously.

For this round, each supplier would receive two cards, one for cost and another for time to produce and deliver products. The instructor should prepare two decks of playing cards with different backings to allow the students to distinguish between cost and time. In order to match higher cost with faster delivery time and vice versa, 10 possible combinations of cost-delivery time could be randomly assigned to suppliers (1:10, 2:9, 3:8, 4:7, 5:6, 6:5, 7:4, 8:3, 9:2, and 10:1). Smartphone companies would have to decide between two different types of suppliers, one with lower cost but slower delivery and the other with higher cost but faster delivery.

The game is simplified in this round with only three stages. The design phase is removed to avoid duplication of the previous round. If an instructor has run the basic game, all students belonging to any of the four groups of suppliers could be reassigned evenly to one of the three stages in this new round with new playing cards. New costs should be assigned to smartphone companies as well to ensure that such costs are not known by all suppliers. Table 2 illustrates a possible new cost structure for smartphone companies. In addition to the production costs, smartphone companies also have do-it-yourself time of completion. This completion time is made relatively longer to simplify the decision-making process of those smartphone companies.

The instructor should remind the students that, to put it simply, functional products require an efficient process while innovative products need a responsive process. Fisher (1997) suggested that products that are the same physically can be either functional or innovative. For example, an entry-level smartphone, a low-cost smartphone with few advanced features or a scaled-down version of a mid- or high-end phone, has relatively stable and predictable demand from consumers who have fairly basic mobile communication and computing needs, such as the elderly. On the other hand, a flagship phone with comprehensive and advanced features has volatile demand and a short life cycle because of imitators who will erode its competitive advantage. To help the students better understand the different strategies, each phone company could be given a designated type of its product to be either functional or innovative, and the need to create an optimal supply

Table 2. Cost information for smartphone companies: round 2.

	Display	Battery	Assembly
Cost	5	9	10
Do-it-yourself times of completion	10	10	10

Table 3. Total cost and total delivery time of smartphone companies.

	Apple	Samsung	Huawei	Google
Display	4.5 (4) [7]	3.5 (3) [8]	3 (1) [10]	4.5 (2) [9]
Battery	7.5 (7) [4]	6.5 (6) [5]	4 (2) [9]	4 (3) [8]
Factory assembly	7.5 (6) [5]	8 (7) [4]	2.5 (1) [10]	4.5 (3) [8]
Total cost	19.5	18	9.5	13
Total delivery time	16	17	29	25

Note: The numbers in parentheses represent the exact costs of the intermediate goods producers or the assembly factories. The numbers without parentheses are the prices of transactions. The numbers in square brackets represent the delivery times.

chain to match its product. For example, Apple and Samsung are considered innovative products, while the remaining are functional products.

Encouraging students to reflect on their learning

Table 3 illustrates a possible sample of the results of this round.

The results illustrate the differences in the two strategies: a tradeoff between efficiency and responsiveness. Huawei achieves the lowest-cost supply chain, and Apple designs the most responsive supply chain. If Apple and Samsung negotiate with a low-cost supplier who offers a longer lead time, but their strategy is to offer fast delivery, it is not a good match. This forces Apple and Samsung to make transactions with higher-cost suppliers but faster delivery, while Huawei and Google prefer lower-cost suppliers, albeit with slow delivery times.

Expanded game: Economics courses

Demand changes

For courses that are similar to introductory economics, the game can be extended to include a discussion about what happened to the prices when either the demand or the supply changed. The instructor could ask the students what would happen to prices if the number of smartphone companies doubled to eight with all other factors remaining the same. In that case, it would be expected that the price levels would increase simply because there would then be more market demand while the supply remained the same. The smartphone companies would then have to compete with one another to buy the cheapest possible components and services, which would result in companies paying higher prices. If time permits, the instructor could discuss the opposite situation, with the number of sellers in each group doubling from 9 to 18. The instructor could then shift to a discussion of the theoretical model by showing the effects on prices when there is a shift in either the demand or the supply curve.

Case study: Apple's global supply chain

For courses that are similar to international economics, the instructor could elaborate further on the case study of Apple's global supply chain. This game simulates the real world in the sense that the United States has a comparative advantage for the research and development stage with a relatively low cost. The U.S. comparative advantage in the research and development stage comes from its relatively high technology level, speedy innovations, and strict intellectual property law as well as its abundance of highly skilled workers. As a result, an American company would perform this task at its home base. The game reflects this situation as all four students/companies chose to design smartphones on their own. Due to an abundance of cheap labor, Asian economies have lower costs for both the production of intermediate goods and the assembly. Therefore, it costs Apple less to outsource those tasks to other countries. If time permits, the

instructor could add a discussion of the winners and losers from Apple's outsourcing to China. From the Chinese perspective, this outsourcing creates more jobs and higher income for Chinese workers, results in higher profits for Chinese firms and offers more opportunities for Chinese firms to learn and upgrade in order to participate in more stages in the production of skill-intensive goods in the future. However, this outsourcing also may increase hazardous waste disposal in China. Meanwhile, from the perspective of the United States, on one hand this supply chain reduces the cost of production for Apple and increases its competitiveness; on the other hand, some American manufacturing workers may lose their jobs or find lower wage jobs because of this foreign outsourcing.

If time permits, the instructor could illustrate to students the latest change in Apple's global supply chain. Apple is moving production of its high-end iPhones from China to India, to avoid the fallout of the U.S.–China trade war (Volodzko 2019). This resulted from U.S. President Donald Trump threatening in November 2018 to impose a 10 percent tariff on iPhones coming from China. Other incentives for the global supply chain could be discussed here, for example, minimizing tariffs, taxes, transportation costs and time by having the product produced in the country in which the product is sold.

Transportation cost and reshoring

It is possible to extend further the discussion of the facilitators and impediments in the global supply chain. The instructor could begin by asking students how the game results would change if transportation costs were introduced. In this way, additional costs would be involved when the intermediate components have to be shipped to the assembly factories or when the completed products are shipped from the assembly factories back to the smartphone companies. Students should be able to discern that, with transportation costs, there would be fewer incentives for outsourcing. For example, beginning in 2013, various American producers, such as the Ford Motor Company, Google, and Apple, were increasingly considering reshoring strategies to bring some production back to the United States (Hessman 2014). This was partly due to the sharp increase in the cost of shipping goods by ocean freight, and the time goods spent in transit.

Narrowing wage gap

Another factor in reshoring is the narrowing wage gap between the U.S. and Asian economies. The instructor could help students understand this by playing another round of the game. For example, the costs of the intermediate component producers and the assembly factories could be increased by distributing an additional set of cards with random numbers between 5 and 10. The instructor could then explain that this is to replicate the scenario of wage increases in Asian economies. The instructor also could accomplish this by having students in the selling groups increase their costs by 100 percent while smartphone companies' costs could be decreased in the last three stages to 4, 6, and 8, respectively. With a narrowing cost gap, it would be more difficult to form a mutually beneficial buyer–seller pair; therefore, there would be more incentives for reshoring (or, in the case of the game, completing the task on their own).

If a round is conducted incorporating transportation costs or wage increases, smartphone companies should be assigned new production costs to ensure those costs are not known by suppliers.

Oligopoly and collusion

For such courses as introductory economics, this experiment could be rerun at a later point after discussing market structure. Intermediate goods suppliers could be allowed to collude. They could

approach each other for a possible mutual agreement to avoid competition in the sense that they fix the market price of their product or service and share the profit according to a pre-agreed arrangement. A comparison between experiment outcomes with and without collusion would highlight oligopolistic market power. In general, when collusion is allowed, prices in transactions tend to be higher, which results in a higher total profit earned by intermediate goods suppliers.

Possible problems encountered by students

Various problems may be encountered by students when participating in the game. Some students may be limited by the space constraint because of difficulty in moving around and talking to people. Thus, a large classroom is more suitable for replicating this game. Another potential problem is related to identification. Specifically, it is sometimes difficult to identify the different groups of sellers during the game. To solve this issue, the instructor could divide the classroom into four different sections and have the different groups of students gather in specific areas so that they are more easily identifiable.

Conclusion

In this article, I describe a short and interactive classroom experiment designed to facilitate understanding of a key economic concept—demand and supply. Students are provided with confidential information of their own costs of production and are asked to make trade decisions with different suppliers to form a supply chain with the lowest possible cost. This article contributes to the existing literature by introducing a class experiment on how global supply chains are created as well as discussing the factors that might facilitate or repress foreign outsourcing.

The game is easy to play, whereas computerized games can be time-consuming to set up, understand, play, and monitor (Brauer 1994). Compared to computerized games, this game requires very basic equipment such as pens and paper. The instructor can prepare the necessary materials within 20 minutes of class and students would not be required to bring laptops. All of the necessary instructions can be conveyed to the participants within 5 to 10 minutes.

The game is closely tied to the learning objectives because successful completion of the game moves students closer to mastering their understanding of the demand and supply model and global supply chain concepts, such as the difference between efficient and responsive supply chains, the difference between functional and innovative products, and the concept of total cost of production. Through simple observation of the trading results, the game can effectively provide the instructor with focused feedback on the students' progress toward the related course objectives.

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Declarations of interest

None.

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Appendix A

Sample Worksheet Given to Smartphone Companies

	Design of the product	Display	Battery	Assembly
Cost	1	6	8	11

Note: These are hypothetical costs, simplified for the experiment's sake.
Please indicate the choices of your production and write down the prices of transactions
Design:Do it on your own at 1
Or
Contract it to _____at_____
Display:Produce on your own at 6
Or
Buy it from _____at_____
Battery:Produce on your own at 8
Or
Buy it from _____at_____
Assembly:Do it on your own at 11
Or
Contract it to _____at_____
Total cost: _____