USING DATA FROM CLASSROOM EXPERIMENTS TO TEACH DEADWEIGHT LOSS

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Abstract

This paper demonstrates a novel approach to teaching the concept of deadweight loss using a double oral auction experiment conducted in the classroom. After the experiment, students are given the associated data and are tasked with calculating both predicted and observed consumer and producer surplus transaction by transaction. They are then asked to differentiate between deadweight loss resulting from an inefficient allocation of production and consumption given the observed number of transactions and the deadweight loss resulting from an inefficient number of transactions. We find an improved understanding of these concepts from the participating class.

Keywords: deadweight loss, double oral auction, classroom experiments

JEL Classification: A22

Introduction

The equilibrium predictions associated with the supply and demand framework and the underlying economic logic are fundamental to any introductory course in microeconomics. As such, convincing students of these predictions' utility assures them that the model they are learning is relevant and can help them understand the world around them. One effective way of illustrating this is a classroom experiment in which students participate in a market with induced supply and demand curves. After running the experiment, the realized outcomes can be compared with predictions. Perhaps the most popular classroom experiment along these lines is the double oral auction. As first shown in Smith (1962), in this mechanism, both convergence to equilibrium and adjustment to changes in either supply and demand is rapid.

When analyzing the results of the experiment with students, the focus of the analysis typically concerns the validity of the equilibrium predictions. This paper argues that additional benefits can be wrung from this exercise. Namely, providing students with the raw data from the experiment and asking them to calculate predicted and observed consumer surplus, producer surplus, and deadweight loss deepens their understanding of these concepts.

This exercise is particularly valuable for illustrating deadweight loss. Since there is no predicted deadweight loss in market equilibrium, most textbooks initially focus their discussion of welfare on consumer and producer surplus and the prediction of perfect market efficiency. The concept of deadweight loss is given short shrift until there is a reason to *predict* an inefficient market outcome. Typically, this arises due to ad valorem taxes or subsidies, where the associated deadweight loss arises entirely due to an inefficient number of transactions. As such,

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students end up associating deadweight loss with Harberger's triangle and neglecting welfare losses related to a misallocation of resources and production for a *given* number of transactions.

Asking students to manually calculate welfare losses realized in a classroom experiment emphasizes the fact that welfare losses are also found when: 1) the marginal value of a buyer associated with a transaction is less than the marginal value of a buyer that was not associated with a transaction; 2) the marginal cost of a seller associated with a transaction is greater than another marginal cost of a seller that was not associated with a transaction.

Details of the Double Oral Auction

In the double oral auction, students are divided into buyers and sellers. Each buyer can purchase a number of units and is provided with marginal values of purchasing (consuming) each of these units. For each buyer, these marginal values decrease in the number of units purchased. Similarly, each seller can produce a number of units and is provided with marginal costs for each of these units. Further, the marginal costs are increasing in the number of units sold. Marginal values and costs are private information, and subjects do not know anything beyond their own private information before trading begins.

Students are informed that each transaction in the experiment consists of a single unit. For any transaction, the net benefit of the buyer is her marginal value of the corresponding unit less the agreed upon price. The net benefit of the seller is this price less the marginal cost of the corresponding unit. The total benefit of any student is simply the sum of the net benefit associated with all their transactions.

To begin the experiment, the instructor announces that a market period is open. During the period any buyer can submit a bid, and any seller can submit an ask. The only constraint is that any new bid or ask must improve upon the preceding bid or ask. Once the highest bid and lowest ask reveals the potential for gains from trade, a trade is conducted. The price is set at the bid or ask that was submitted first. Trades can also be initiated if a buyer (seller) decides to accept the current best ask (bid).

The market period ends after a specified amount of time, or when no additional transactions are being made. Upon the closure of the market period, the profits of the transacting individuals are calculated, and a new market period is opened with fresh supply and demand. These market periods can be conducted as many times as desired.

Instructors wishing to conduct a double oral experiment in the classroom have a variety of options. In our view, Moblab.com provides an excellent implementation that is browser-based, so that students can participate from any internet-connected device. Another browser-based implementation is veconlab.econ.virginia.edu (which has the added benefit of being free). The Economic Science Institute at Chapman University provides free software for a desktop-based version of the double oral auction, which is intended to be paired with the curriculum presented in Jaworski *et al.* (2010).[3] Finally, Centro Vernon Smith de Economia Experimental at Universidad Francisco Marroquin provides an excellent implementation using z-Tree, which is a popular platform for running research experiments.[4]

[3] This software can be found at https://www.chapman.edu/research/institutes-and-centers/economic-science-institute/research/software.aspx

[4] This software can be found at https://fce.ufm.edu/centro-de-economia-experimental/fruit/

Calculating Deadweight Loss

In the experiment, quantities of the good are in discrete (integer) amounts, and marginal values and marginal costs are induced. This allows the instructor to show the class the associated supply and demand schedules after the experiment. Constructing supply and demand functions from these schedules helps students build intuition about how marginal costs and marginal benefits map into the linear functions they typically see in their textbooks.

After the experiment, we suggest that students be provided the supply and demand schedules from a single round of the experiment. To ensure a thorough understanding of deadweight loss, we suggest the instructor choose a period in which the number of transactions is not equal to the equilibrium prediction, and at least one observed transaction involves a marginal cost or marginal value that was not predicted to transact, given the observed number of transactions.[5] In the assignment itself, students are asked to answer each of the following questions:

1. What is the predicted level of consumer surplus in this market?
2. What is the predicted level of producer surplus in this market?
3. What is the predicted level of deadweight loss in this market?
4. What is the observed level of consumer surplus in this market?
5. What is the observed level of producer surplus in this market?
6. What is the observed level of deadweight loss in this market?
7. How much, if any, of the deadweight loss in this market is the result of transactions not involving the lowest available marginal cost?
8. How much, if any, of the deadweight loss in this market is the result of transactions not involving the highest available marginal value?

Moblab Example

By way of example, consider Table 1, which contains the induced supply and demand schedules from a double oral auction implemented in Moblab. Figure 1 illustrates these supply and demand schedules graphically.[6] It is straightforward to determine the equilibrium number of transactions by comparing the marginal value to the marginal cost for each quantity. Whenever the marginal value weakly exceeds the marginal cost, a transaction is predicted to take place. In this case, we arrive at a prediction of 13 transactions. Any price between the marginal value and the marginal cost of this transaction is consistent with equilibrium. For simplicity, we assume that the equilibrium price will be equal to the midpoint of this interval. In this example, this corresponds to a price of \$1.12. Having determined the equilibrium price, calculating the predicted consumer and producer surplus is straightforward. It is again worth emphasizing that these calculations assume that transactions will only involve marginal values weakly greater than \$1.12, and marginal costs weakly less than \$1.12.

To find the predicted consumer surplus, one calculates the net benefit to the buyer for each predicted transaction and then sums them. For the first transaction, the net benefit is $\$1.50 - \$1.11 = \$0.38$. These calculations are reported in column 4 of Table 1. Summing across all 13 predicted transactions yields a predicted consumer surplus of $\$2.60$.

Finding the predicted producer surplus involves a similar exercise, except that one calculates the net benefit to the seller for each predicted transaction. For the first transaction, this

[5] It is possible, although extremely unlikely that no such period emerges from the experiment. If this is the case, the instructor can simply use the example highlighted in the current paper, or construct an example of their own.

[6] We would like to thank Moblab.com for allowing us to use this figure.

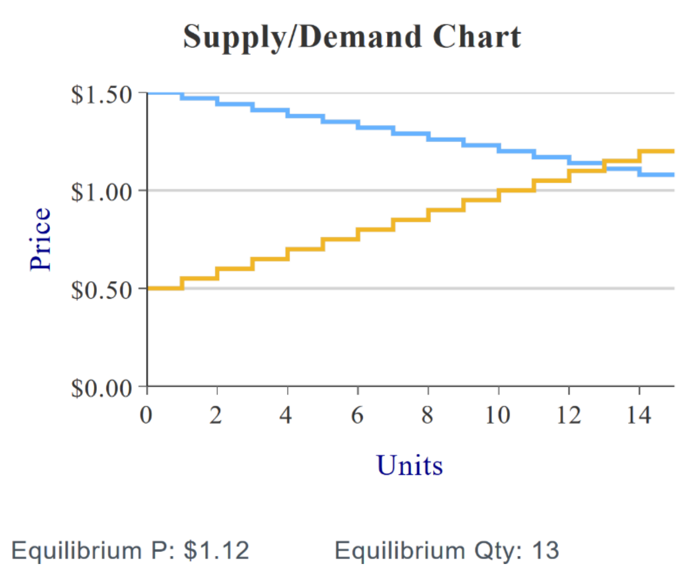
net benefit is $\$1.12 - \$0.50 = \$0.62$. These calculations are reported in column 5 of Table 1. Note that summing across all 13 predicted transactions yields a predicted producer surplus of $\$4.16$. Calculating the predicted level of deadweight loss is trivial, as equilibrium predicts that welfare will be maximized. That is, no deadweight loss is predicted.

Table 1: Induced Supply and Demand Schedules, with Predicted Consumer and Producer Surplus

Quantity	Buyer Marginal Value	Seller Marginal Cost	Consumer Surplus	Producer Surplus
1	$1.50	$0.50	$0.38	$0.62
2	$1.47	$0.55	$0.35	$0.57
3	$1.44	$0.60	$0.32	$0.52
4	$1.41	$0.65	$0.29	$0.47
5	$1.38	$0.70	$0.26	$0.42
6	$1.35	$0.75	$0.23	$0.37
7	$1.32	$0.80	$0.20	$0.32
8	$1.29	$0.85	$0.17	$0.27
9	$1.26	$0.90	$0.14	$0.22
10	$1.23	$0.95	$0.11	$0.17
11	$1.20	$1.00	$0.08	$0.12
12	$1.17	$1.05	$0.05	$0.07
13	$1.14	$1.10	$0.02	$0.02
14	$1.11	$1.15	-	-
15	$1.08	$1.20	-	-

Notes: The predicted number of transactions is 13. There is a continuum of prices consistent with equilibrium. For simplicity, we assume the equilibrium price will be the midpoint of this interval, which is $1.12.

Figure 1: Graph of induced supply and demand



Turning attention to the observed welfare measures, Table 2 contains the observed transactions from a simulated experiment.[7] Note that there are 12 transactions, while 13 transactions are predicted, further, note that each transaction is associated with a price and that there is considerable heterogeneity in prices across transactions.

To find the observed consumer surplus, one simply calculates the net benefit of the buyer for each transaction and then sums across all (12) of the observed transactions. For example, in the first observed transaction, the buyer had a marginal value of $\$1.11$, and transacted at a price of $\$1.00$, for a net benefit of $\$1.11 - \$1.00 = \$0.11$. The relevant calculations are reported in column 5 of Table 2. Note that the total observed consumer surplus is $\$2.20$.

To find the observed producer surplus, the exercise is the same, except that for each of the observed transactions one calculates the net benefit of the seller. For example, in the first observed transaction, the seller transacted at a price of $\$1.00$, and had a marginal cost of $\$0.50$. Thus, the net benefit of the seller for this transaction is $\$1.00 - \$0.50 = \$0.50$. The associated calculation for each observed transaction is reported in column 6 of Table 2. The observed producer surplus is $\$4.02$.

Note that the predicted sum of consumer and producer surplus is \$6.76. In the data from the simulated experiment, the realized sum is \$6.22. The difference (\$0.54) is the deadweight loss in the market. While this calculation is simple to do, asking students to determine the sources of the deadweight loss is insightful.

To do so, students must first compare the set of marginal values that are predicted to be associated with transactions with the set of marginal values actually associated with transactions.[8] In our example, two marginal benefits that were predicted to be associated with transactions were not: \$1.41 and \$1.14. In addition, a marginal benefit of \$1.11 was associated with a transaction, contrary to predictions.

[7] To avoid IRB concerns about using data from an actual classroom experiment, we present a detailed example using simulated data. The outcomes described in this example are commonly found in a typical classroom experiment double oral auction.

[8] The set of marginal values predicted to be associated with a transaction is $\{1.50, 1.47, 1.44, 1.41, 1.38, 1.35, 1.32, 1.29, 1.26, 1.23, 1.20, 1.17, 1.14\}$. The set of marginal values that are actually associated with a transaction in this example is $\{1.50, 1.47, 1.44, 1.38, 1.35, 1.32, 1.29, 1.26, 1.23, 1.20, 1.17, , 1.11\}$

Table 2: Observed Transactions, Consumer Surplus, and Producer Surplus

Transaction	Buyer marginal value	Seller marginal cost	Price	Consumer surplus	Producer surplus
1	$1.11	$0.50	$1.00	$0.11	$0.50
2	$1.32	$0.65	$1.08	$0.24	$0.43
3	$1.50	$1.05	$1.31	$0.19	$0.26
4	$1.26	$0.55	$0.98	$0.28	$0.43
5	$1.17	$0.75	$1.04	$0.13	$0.29
6	$1.29	$0.85	$1.16	$0.13	$0.31
7	$1.44	$0.80	$1.14	$0.30	$0.34
8	$1.23	$0.60	$0.95	$0.28	$0.35
9	$1.47	$1.15	$1.36	$0.11	$0.21
10	$1.38	$1.00	$1.28	$0.10	$0.28
11	$1.20	$0.90	$1.14	$0.06	$0.24
12	$1.35	$0.70	$1.08	$0.27	$0.38

Next, students must compare the set of marginal costs predicted to be associated with transactions with the set of marginal costs actually associated with transactions.[9] In our example, two marginal costs that were predicted to be associated with a transaction were not: $0.95 and $1.10. Further, a marginal cost of $1.15 was associated with a transaction, contrary to predictions.

One source of deadweight loss is when the "wrong" part of the supply or demand curve is involved in the observed transactions. That is, if production and consumption are not efficiently allocated *given* the observed number of transactions, this results in deadweight loss. To calculate this, exchange marginal values (costs) associated with transactions for the highest (lowest) available marginal value (cost) not associated with a transaction, whenever it is possible to do so. Keep in mind that each marginal value/cost can be associated with a single transaction. The sum of the difference between any profitable exchange is deadweight loss.

In our example, one transaction involved a marginal cost of $1.15, while a seller with a marginal cost of $0.95 did not transact. Thus, $\$1.15 - \$0.95 = \$0.20$ was lost. In addition, one transaction involved a marginal value of $1.11, while a buyer with a marginal value of $1.41 did not transact. Thus, $\$1.41 - \$1.11 \ = \$0.30$ was lost.

The second source of deadweight loss is an inefficient number of transactions, assuming that the transactions involve the highest marginal values and the lowest marginal costs. The magnitude of the difference between the marginal cost and the marginal value of each of these "missing" or "excess" transactions is lost. In our example, there is one less transaction than predicted. The marginal value associated with this missing transaction is $1.14. The associated marginal cost is $1.10. Thus, the deadweight loss from this step is $\$1.14 - \$1.10 = \$0.04$.

By separately considering the sources of deadweight loss outlined above, students learn that market inefficiencies can arise when goods are not put to their highest-value uses,

[9] The set of marginal costs predicted to be associated with a transaction is $\{0.50, 0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90\ 0.95, 1.00, 1.05, 1.10\}$. The set of marginal costs actually associated with a transaction in this example is $\{0.50, 0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 1.00, 1.05, 1.15\}$.

production is not made at the lowest marginal costs, and when the level of production is not determined by ensuring that the marginal benefit of an additional unit is weakly greater than the marginal cost. In our view, this reinforces crucial economic ideas and ensures that students learn more from welfare analysis than the formula for the area of a triangle.

Conclusion

There is significant evidence that the use of classroom experiments increases student outcomes in economics courses (Emerson and Taylor, 2004; Lin, 2020). Further, Cartwright and Stepanova (2012) find that student outcomes can be further improved if the students are subsequently asked to write a report on the experiment.

In this vein, we propose pairing a double oral auction experiment with a homework assignment in which students are asked to calculate the equilibrium and observed levels of consumer and producer surplus. In addition, students are asked to calculate the observed deadweight loss and distinguish between deadweight loss due to an inefficient number of transactions, and deadweight loss due to inefficient allocation of production and consumption conditional on the observed number of transactions. We feel this exercise connects welfare analysis directly to the underlying market transactions and leads to a more holistic understanding of deadweight loss and better classroom performance.

In the Spring of 2020, for a Principles of Microeconomics course at Utah State University, we tested this exercise. Since we did not perform a formal experiment in which some students were randomly assigned the homework assignment while others were not, our results are anecdotal. However, we strongly believe that this exercise improved student understanding and outcomes. In addition, student engagement surrounding this assignment was extremely high. There was a prolonged classroom discussion on how to solve each of the homework questions as well as a marked increase in office hour attendance. Lastly, we noted a dramatic increase in student understanding of the welfare analysis of market outcomes later in the course.

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