EC102: Market Institutions and Efficiency

Double Auction: Experiment

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MT 2017

Notes

A Double Auction Experiment

Next we run a market experiment in which:

- participants are partitioned into buyers and sellers;
- buyers and sellers submit bids and offers in any order.

This market game is known as a **double auction** as players on both sides of the market simultaneously submit price quotes.

Learning Objectives

Understanding experimental trading data.

Understanding market predictions of classical pricing theories.

Relating trading data to predictions of classical pricing theories.

Outline for Today

1. The Double Auction framework.
2. Preparation & Experiment.

Notes

Literature & Evidence

Key References

The first laboratory experiment of double auctions appears in:

- An Experimental Study of Competitive Market Behavior, Smith (1962), Journal of Political Economy.

Laboratory double auction experiments are surveyed in:

- Experimental Economics, Davis and Holt (1993), Princeton University Press.
- Markets, Games and Strategic Behavior, Holt (2006), Addison-Wesley.

Notes

The Double Auction

Notes

Our Double Auction Specification

Rounds

- The experiment consists of **3 trading** periods or rounds.

Roles

- Please **form teams** of three people around you.
- Each team will either be a buyer or a seller in all rounds.

Actions

- Buyers submit prices to buy units of a commodity.
- Sellers submit price offers to sell such units.

Refer to:

- buyers' submissions as **bid prices**;
- sellers' offers as **ask prices**.

Notes

Roles: Sellers

Sellers can to produce **at most 3 units** at given monetary costs

$$c_1 \leq c_2 \leq c_3.$$

On each unit sold, a **seller earns the difference between** the selling **price and** the **cost** of that unit:

$$\begin{aligned} \text{Sell 1:} \quad & \pi_1^s = p_1 - c_1; \\ \text{Sell 2:} \quad & \pi_2^s = p_2 - c_2 + \pi_1^s; \\ \text{Sell 3:} \quad & \pi_3^s = p_3 - c_3 + \pi_2^s. \end{aligned}$$

So, high prices and low costs are good for sellers.

When the market opens:

- Sellers submit ask prices at which they are willing to sell units.
- The **ask price** on a unit must be **no lower than its cost**!

Notes

Roles: Buyers

Buyers value **at most 3 units** at given monetary costs

$$v_1 \geq v_2 \geq v_3.$$

On each unit bought, a **buyer earns the difference between** the monetary **value and** the buying **price** of that unit:

$$\begin{aligned} \text{Buy 1:} \quad & \pi_1^b = v_1 - p_1; \\ \text{Buy 2:} \quad & \pi_2^b = v_2 - p_2 + \pi_1^b; \\ \text{Buy 3:} \quad & \pi_3^b = v_3 - p_3 + \pi_2^b. \end{aligned}$$

So, low prices and high values are good for buyers.

When the market opens:

- Buyers submit bid prices at which they are willing to buy units.
- The **bid price** on a unit must be **no higher than its value**!

Notes

Price Revisions & Information

Buyers can revise a bid on any unit at any point (↑ or ↓).
Sellers can revise an ask on any unit at any point (↑ or ↓).

The option to revise prices in either direction permits to:

- correct an errors or;
- essentially withdraw a bid (↓) or withdraw an ask (↑).

The program will display:

- the **highest outstanding bid** to buy;
- the **lowest outstanding offer** to sell.

The lowest ask always exceeds the highest bid.

The difference between the lowest bid and the highest ask is known as to the **bid-ask spread**.

Notes

Transactions

Making a Trade: Buyers

A buyer buys a unit by entering a **bid price** $\geq$ **a seller's ask price**.

If so, the buyer:

- purchases the unit;
- **pays the lowest** outstanding **ask price**.

Making a Trade: Sellers

A seller sells a unit by entering an **ask price** $\leq$ **a buyer's bid price**.

If so, the seller:

- sells the unit;
- **is paid the highest** outstanding **bid price**.

Outstanding Bids and Offers

A transaction cancels all prior bids and offers made on **transacted units**.

Notes

Examples & Preparation

Notes

Example: First Trade

Consider the following sequence of submissions:

- Buyer A makes a bid of 1.
- Seller A makes an offer of 3.
- Buyer B first bid 1.5 and then raises to 2.
- Seller B accept by making an offer at 2.

When buyer B trades with seller B:

- Both bids of buyer B would be removed.
- If $v_1^B = 6$, then buyer B would earn 4.
- If $c_1^B = 1$, then seller B would earn 1.
- The highest bid remains buyer A's original bid of 1.
- The lowest offer remains seller A's original ask of 3.

Notes

Example: Subsequent Units

Some **participants may** be trying to **trade their first units while others** are trying to **trade their second units**.

For instance, after the first trade:

- Seller B would attempt to trade the second unit.
- Seller A would attempt to trade the first unit.
- If $c_2^B = k$, seller B's next offer would have to be at least k.
- If $c_1^A = 1$, seller A's next offer would have to be at least 1.

... and analogously for buyers.

Notes

Practice Questions

Q1: Suppose that the market period begins with buyer *A* bidding \$1 for first unit. Which is correct?

(a) The next submission must be a bid above \$1.

(b) The next submission may come from any buyer or from any seller, or it may consist of a seller accepting the buyer's bid.

Q2: Let lowest bid be \$7. A seller plans to accept this by entering an ask of \$7. Before entering the ask, however, a second buyer bids \$7.5. The seller, not knowing this, still enters the ask of \$7. The seller would, of course, prefer to sell at the higher bid price. At what will the unit sell for?

(a) \$7.5

(b) \$7.0

Notes

Trading Details: Buyers

Enter your price (dollars and cents) in the bid/ask column.

Bid and ask prices may differ for each unit traded.

But you must trade your first unit before your second...

You will see a submit box in the bid/ask column for the following unit only upon trading the previous unit.

	value	bid/ask	price	earnings
unit 1	\$11	\$8.10	\$7.50	\$3.50
unit 2	\$9			\$0.00
unit 3	\$3			\$0.00

Notes

Trading Details: Sellers

Enter your price (dollars and cents) in the bid/ask column.

Bid and ask prices may differ for each unit traded.

But you must trade your first unit before your second...

You will see a submit box in the bid/ask column for the following unit only upon trading the previous unit.

	cost	bid/ask	price	earnings
unit 1	$3	$5.10	$6.50	$3.50
unit 2	$3			$0.00
unit 3	$9			$0.00

Notes

Reminders and Final Details

Values and Costs
All values have been determined randomly, and may differ across buyers.
All costs have been determined randomly and may differ across sellers.

Bids and Asks
A bid must be no higher than the buyer's value.
An ask must be no lower than the seller's cost.

Resubmissions
A trade between a buyer and a seller cancels of all prior bids and asks for that unit, while all the other bids and asks still stand.

Rounds
Each trading round will last **10 minutes**.
After that, per-round earnings are calculated and a new round begins.
We will keep track of the time and announce remaining time.

Notes

The Experiment

Notes

Getting Started

There will be 3 markets:

- Downstairs right – Session Name:
- Downstairs left – Session Name:
- Upstairs – Session Name:

Next please:

- Choose a mobile device of a team member.
- **Turn-off bluetooth and mobile hotspost**, and **close apps**.
- **Connect to** the wifi via **eduroam** (LSE credentials).
- **Go to veconlab.econ.virginia.edu/login.htm**.
- Login with the correct session name and setting a password.
- Quickly run through the instructions.

Notes

Round 1

Start: **10 Minutes** to Trade

Notes

Round 1

Middle: **5 Minutes** to Trade

Notes

Round 1

End: **1 Minutes** to Trade

Notes

Round 1

Market Closed

Notes

Round 2

Start: **10 Minutes** to Trade

Notes

Round 2

Middle: **5 Minutes** to Trade

Notes

Round 2

End: **1 Minutes** to Trade

Notes

Round 2

Market Closed

Notes

Round 3

Start: **10 Minutes** to Trade

Notes

Round 3

Middle: **5 Minutes** to Trade

Notes

Round 3

End: **1 Minutes** to Trade

Notes

Round 3

Market Closed

Notes

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Double Auction: Results

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Outline for Today

- Classical Models of Centralized Markets:
  - Competitive Prices;
  - Efficient Trade.
- Classical Models of Decentralized Markets:
  - Local Prices;
  - Price Dispersion;
  - Inefficient Trade.
- Experimental Evidence:
  - Prices and Trade Volume;
  - Convergence to Competitive Equilibrium;
  - Welfare and Comparative Statics;
  - Centralized vs Decentralized Markets.

Notes

Literature & References

- An Experimental Study of Competitive Market Behavior, Smith, Journal of Political Economy 1962.
- Price Dispersion, Hopkins, New Palgrave Dictionary of Economics, 2nd Edition 2008.
- Search and Price Dispersion, Shum, Mimeo 2011 http://people.hss.caltech.edu/ mshum/ec105/matt12.pdf
- Frictional Matching Models, Smith, Annual Reviews 2012.
- The Oxford Handbook of Economics of Network, Organizations and Markets, Part VI 2016.
- The Handbook of Experimental Economics Results, Plott & Smith North Holland 2008.

Notes

Competitive Markets

Notes

Centralized Markets: Market Clearing & Invisible Hand

In our experimental setting, for any price p:

- **supply** amounts to **the number of units with cost below** p;
- **demand** amounts to **the number of units with value above** p.

As we saw in Problem Set 1, this is the case as:

- unit costs are increasing;
- unit values are decreasing.

Classical Competitive Equilibrium Models presume that:

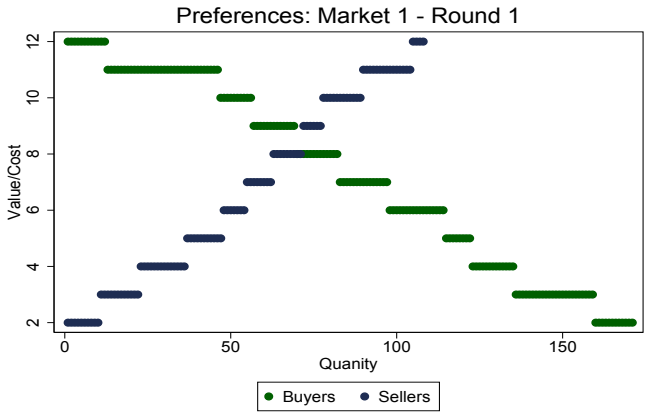
- the **market** for all commodities **is centralized**;
- traders maximize payoffs and **take prices as a given**;
- **prices** are determined so to have **demand equal supply**.

Notes

Competitive Equilibrium: Market 1 - Round 1

Both values and costs were distributed in $[2, 12]$:

- there were approximately 170 units demanded;
- there were approximately 110 units supplied.

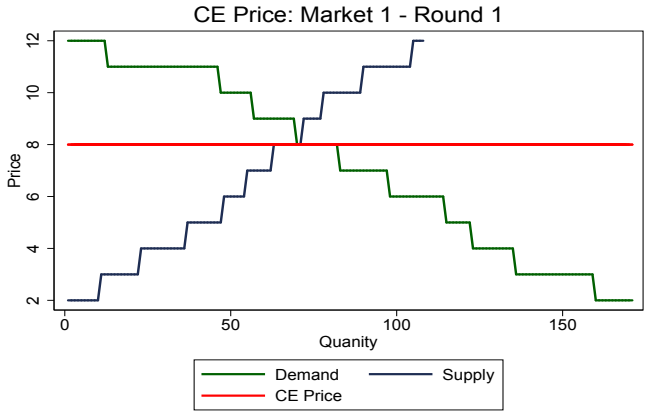


Notes

Competitive Equilibrium: Market 1 - Round 1

By setting demand equal to supply, we find:

- the competitive equilibrium price $p^{ce} = 8$;
- the competitive equilibrium trade volume $q^{ce} \approx 73$.



Notes

CE Welfare: Efficiency of Market Outcomes

Consumer surplus measures the sum of buyers' payoffs.

Producer surplus measures the sum of sellers' payoffs.

Total surplus is the sum of consumer and producer surplus.

Key features of CE in regular markets are:

- **total surplus is maximized** at CE prices;
- **cannot benefit some without hurting others** at CE outcome.

Total surplus is maximized at CE prices as

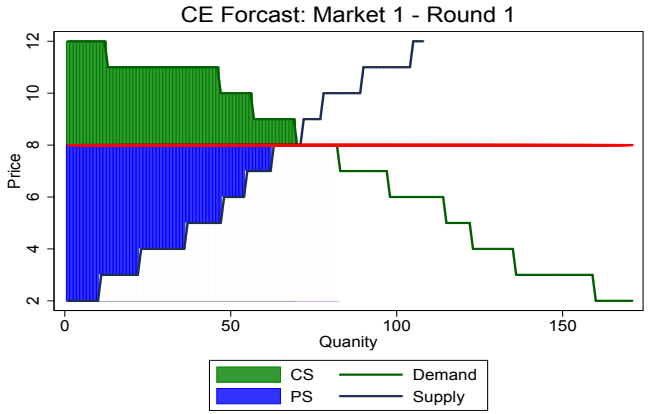
- low cost units are sold first;
- high value units are purchased first;
- trade volume depletes gains from trade.

Notes

CE Welfare: Market 1 - Round 1

As in Problem Set 1, we can then compute:

- CE consumer surplus which amounts to $CS = 183$;
- CE producer surplus which amounts to $PS = 231$.



Notes

CE Welfare: CE Surplus Across Markets

Theoretical surplus predictions across markets and rounds:

	Theory M1			Theory M2		
	CS	*PS*	*TS*	*CS*	*PS*	*TS*
Round 1	183	231	414	73	140	213
Round 2	187	247	434	70	151	221
Round 3	184	236	420	126	103	229

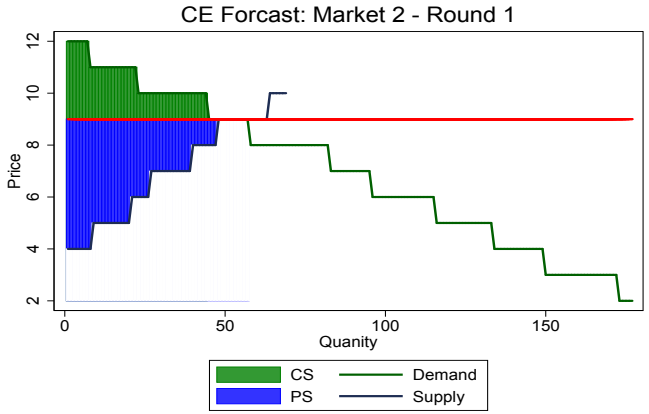
These are theoretical predictions that we will try to look for in the data!

Notes

Comparative Statics: Market 2 - Round 1

In market 2 round 1, $CS = 73$ and $PS = 140$:

- CS and PS are smaller as the market has fewer units for sale;
- PS is even smaller because the supply curve is flatter.



Notes

Experimental Evidence

Notes

Summary Statistics: DA Trading Prices

The table summarizes experimental prices across markets and rounds:

	Market 1			Market 2		
	p^{ce}	p^{da}	SD	p^{ce}	p^{da}	SD
Round 1	8	8.66	0.03	9	9.21	0.02
Round 2	8	8.43	0.03	9	8.88	0.05
Round 3	8	8.28	0.02	8	8.27	0.03

In the table in the market considered at the round considered:

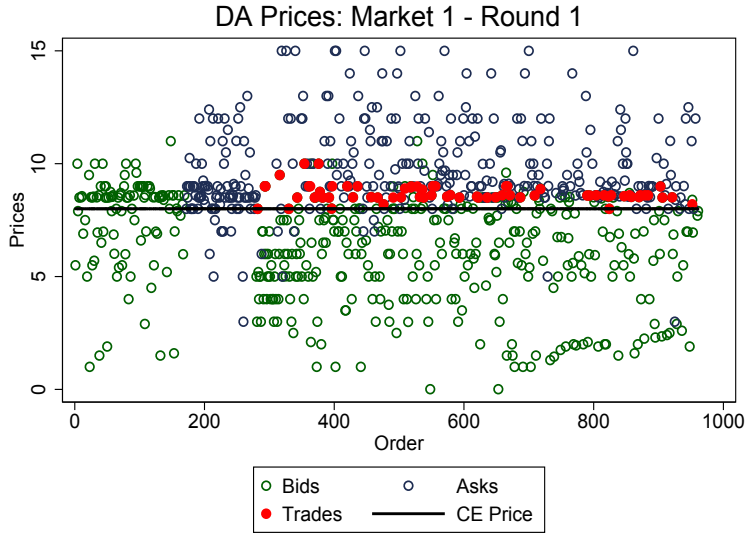
- experimental prices amount to average trading prices;
- the standard deviation captures price volatility.

Across rounds, experimental prices converge to CE.

Notes

Bids, Ask & Prices: Market 1 - Round 1

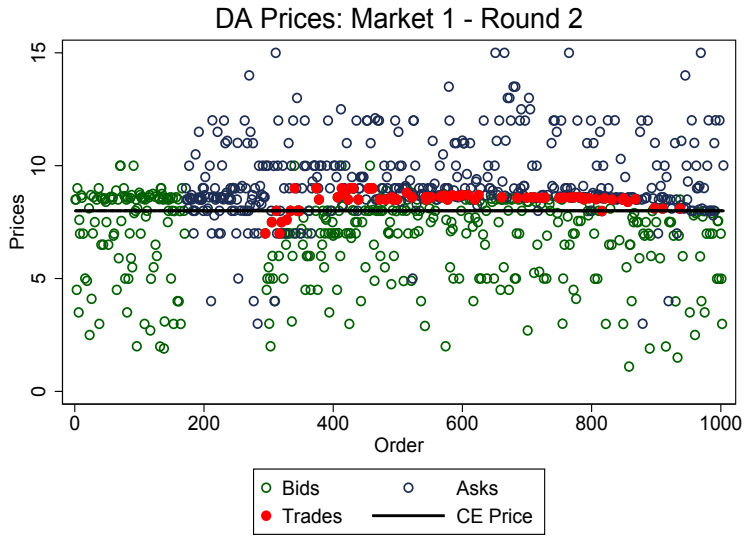
The plot below depicts the time series of prices:



Notes

Bids, Ask & Prices: Market 1 - Round 2

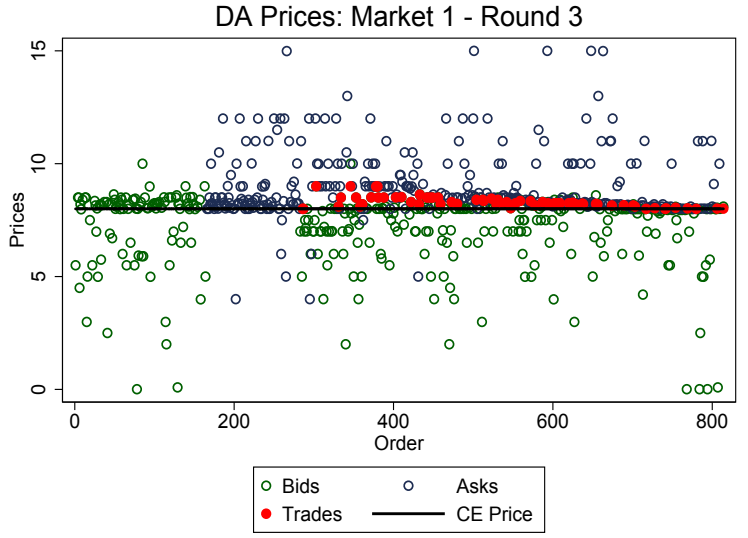
The plot below depicts the time series of prices:



Notes

Bids, Ask & Prices: Market 1 - Round 3

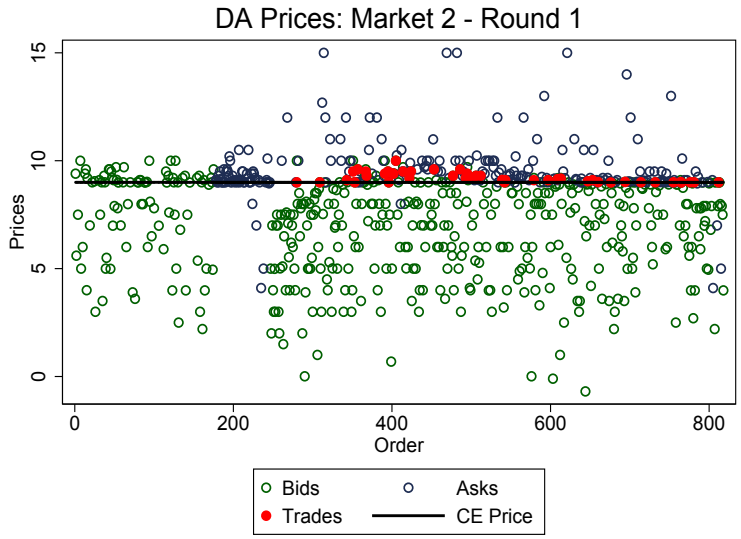
The plot below depicts the time series of prices:



Notes

Bids, Ask & Prices: Market 2 - Round 1

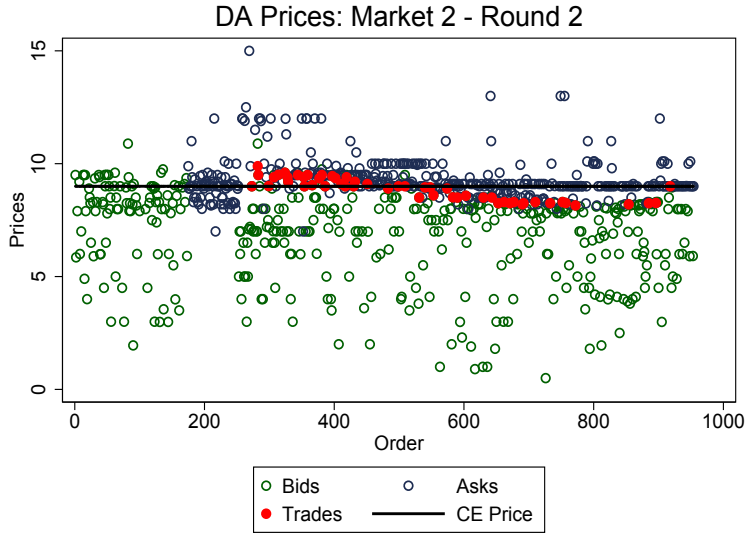
The plot below depicts the time series of prices:



Notes

Bids, Ask & Prices: Market 2 - Round 2

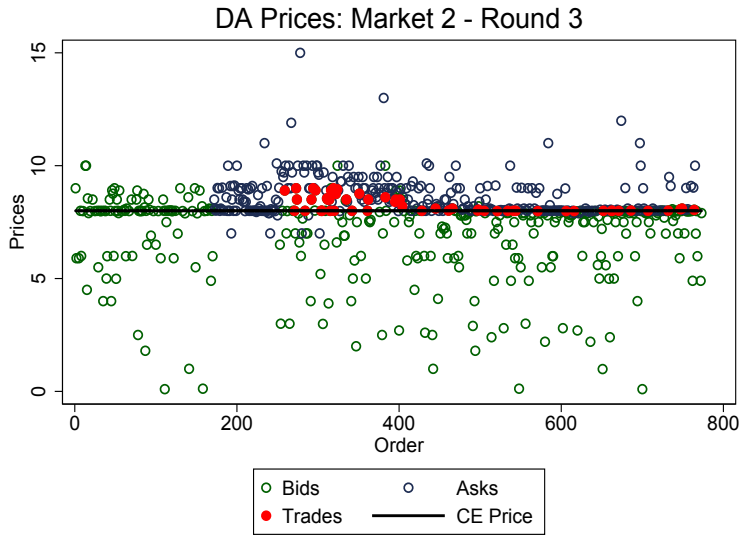
The plot below depicts the time series of prices:



Notes

Bids, Ask & Prices: Market 2 - Round 3

The plot below depicts the time series of prices:



Notes

Summary Statistics: Surplus & Welfare Market 1

The following table summarize experimental surpluses:

	Theory M1			Data M1			Percent
	CS	*PS*	*TS*	*CS*	*PS*	*TS*	*TS*
Round 1	183	231	414	133	276	409	98.8%
Round 2	187	247	434	153	280	433	99.8%
Round 3	184	236	420	158	254	412	98.1%

In the table in the market considered at the round considered:

- consumer surplus amounts to the sum of buyers' payoffs;
- producer surplus amounts to the sum of sellers' payoffs;
- empirical surpluses match theoretical predictions.

Notes

Summary Statistics: Surplus & Welfare Market 2

The following table summarize experimental surpluses:

	Theory M2			Data M2			Percent
	CS	*PS*	*TS*	*CS*	*PS*	*TS*	*TS*
Round 1	73	140	213	63	132	195	91.6%
Round 2	70	151	221	77	144	221	100.0%
Round 3	126	103	229	109	118	227	99.1%

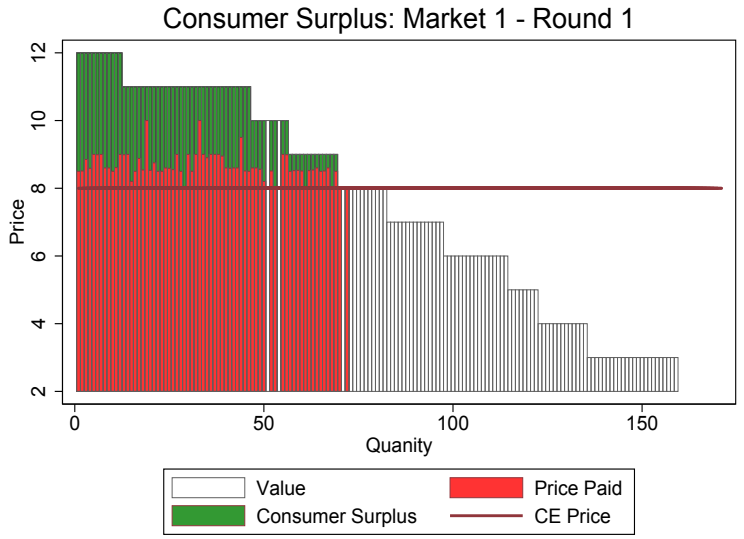
In the table in the market considered at the round considered:

- consumer surplus amounts to the sum of buyers' payoffs;
- producer surplus amounts to the sum of sellers' payoffs;
- empirical surpluses match theoretical predictions.

Notes

Consumer Surplus: Market 1 - Round 1

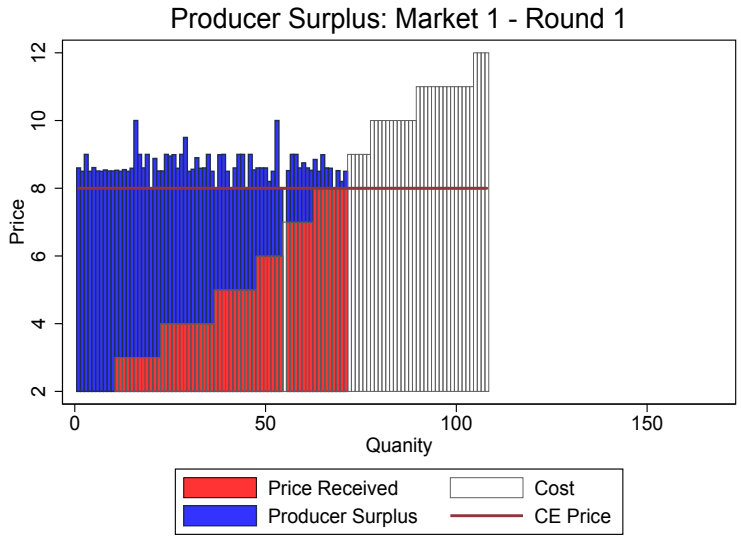
The plot below depicts experimental consumer surplus:



Notes

Producer Surplus: Market 1 - Round 1

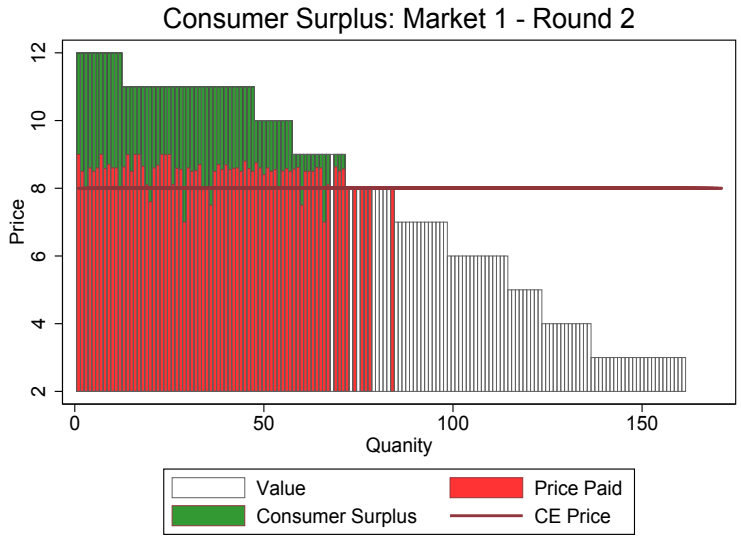
The plot below depicts experimental producer surplus:



Notes

Consumer Surplus: Market 1 - Round 2

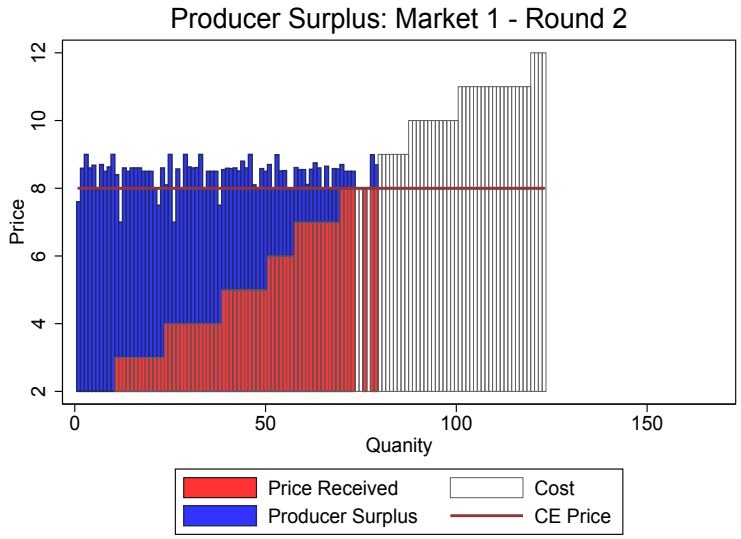
The plot below depicts experimental consumer surplus:



Notes

Producer Surplus: Market 1 - Round 2

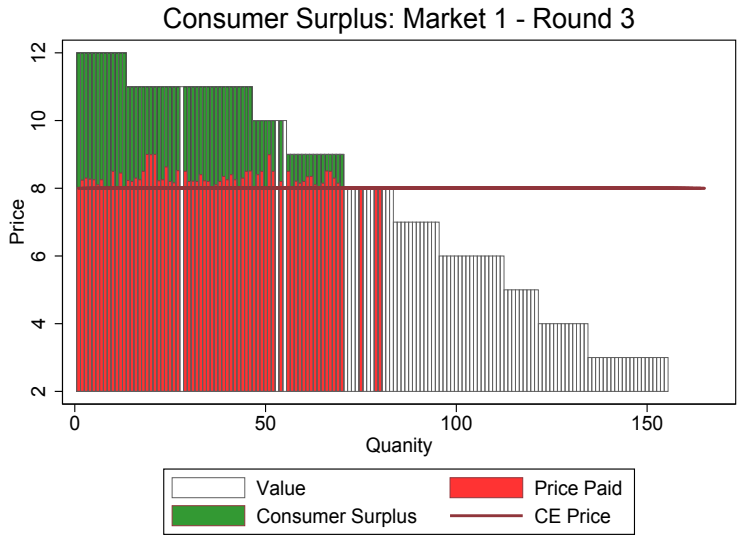
The plot below depicts experimental producer surplus:



Notes

Consumer Surplus: Market 1 - Round 3

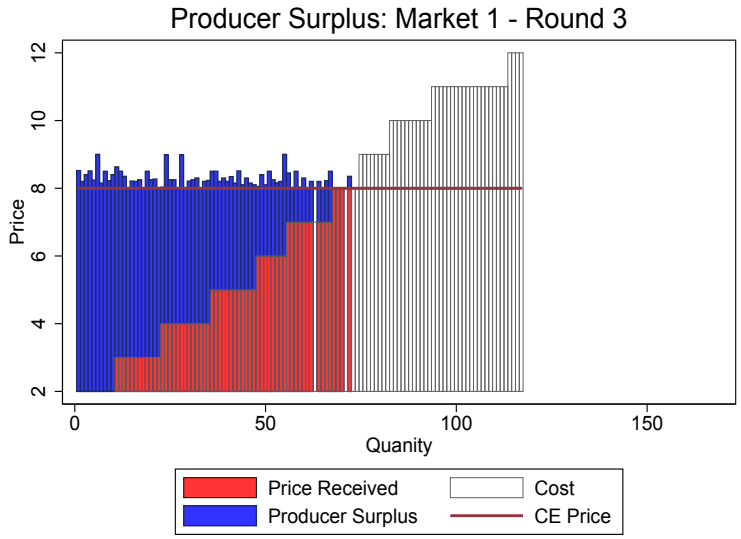
The plot below depicts experimental consumer surplus:



Notes

Producer Surplus: Market 1 - Round 3

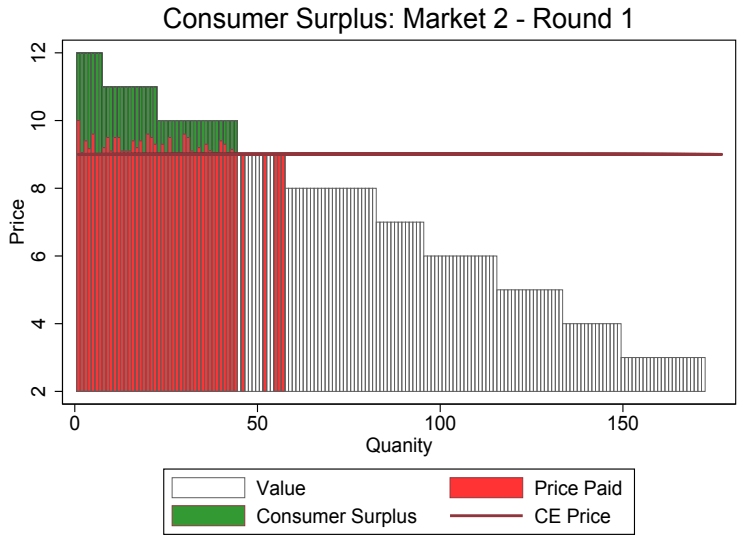
The plot below depicts experimental producer surplus:



Notes

Consumer Surplus: Market 2 - Round 1

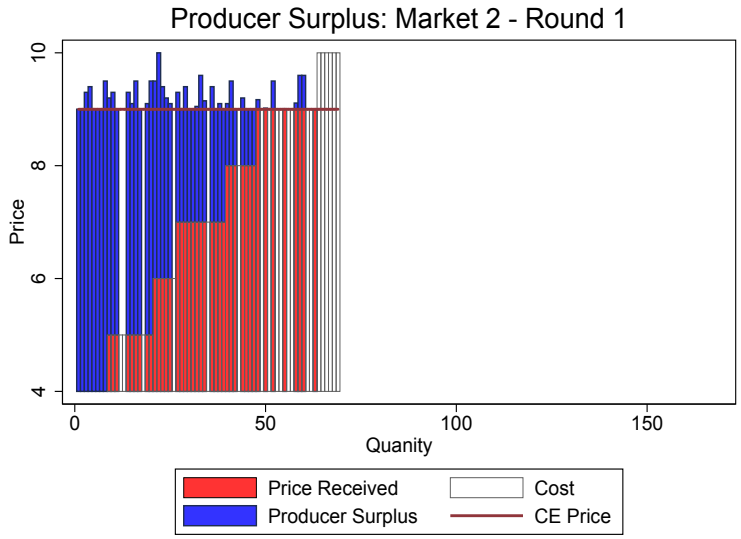
The plot below depicts experimental consumer surplus:



Notes

Producer Surplus: Market 2 - Round 1

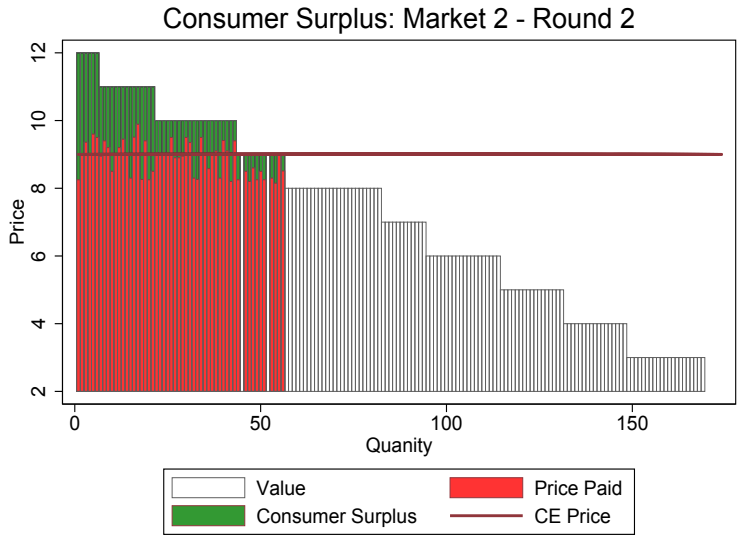
The plot below depicts experimental producer surplus:



Notes

Consumer Surplus: Market 2 - Round 2

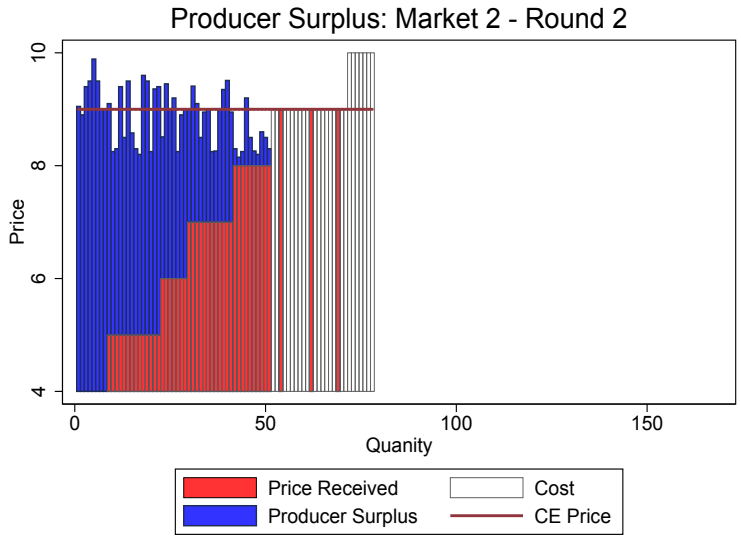
The plot below depicts experimental consumer surplus:



Notes

Producer Surplus: Market 2 - Round 2

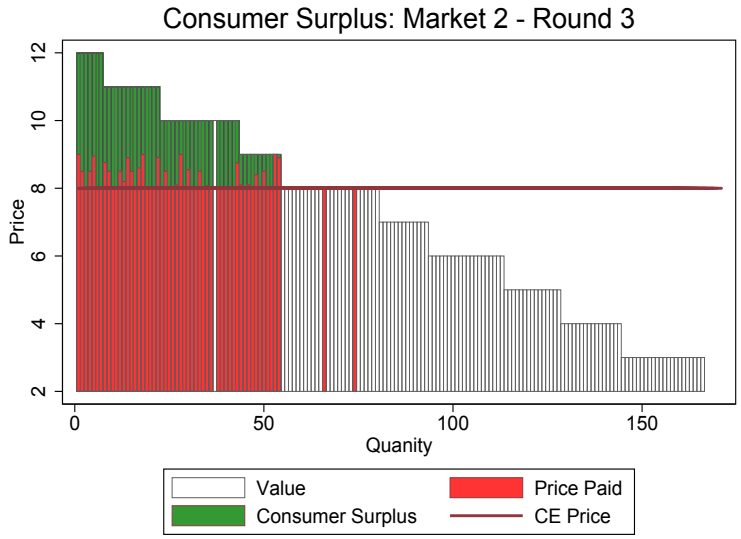
The plot below depicts experimental producer surplus:



Notes

Consumer Surplus: Market 2 - Round 3

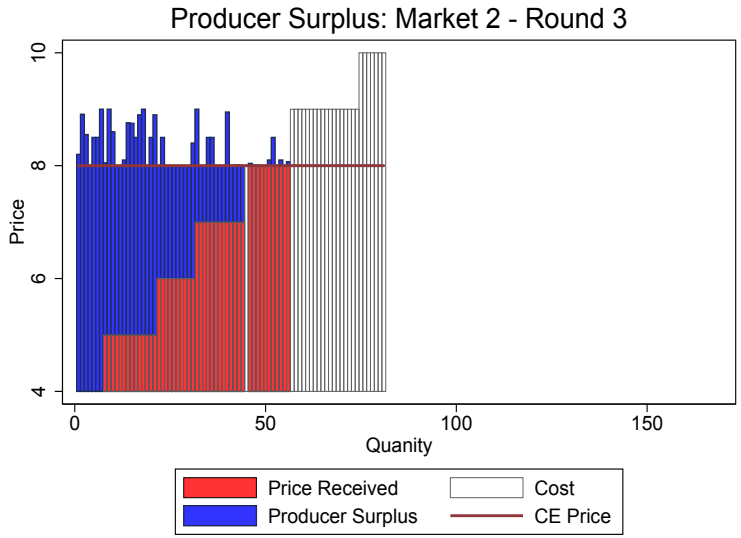
The plot below depicts experimental consumer surplus:



Notes

Producer Surplus: Market 2 - Round 3

The plot below depicts experimental producer surplus:



Notes

Evidence Summary: Convergence to Competitive Pricing

As the previous plots elucidate in the Double Auction:

- price variation is limited;
- trade is approximately efficient;
- prices converge to CE prices within rounds;
- trade volume well approximates CE trade volume;
- the market converges to a competitive market across rounds.

Notes

Decentralized Markets

Notes

Decentralized Markets

Decentralized Competition Models presume that:

- the set of **feasible transactions is constrained**;
- **prices are determined by local bargaining**;
- **trade limitations** are a key determinant of price variation.

A host of models have been developed:

- **transaction costs models**;
- **search and matching models**;
- **spatial and networked models**...

These models are built to explain price variation within markets.

Notes

Key Insights & Classical Models

Setting in which transaction costs uniformly reduce gains from trade:

- tend to limit trade relative to CE;
- tend to raise prices relative to CE.

In general though, raising transaction costs arbitrarily:

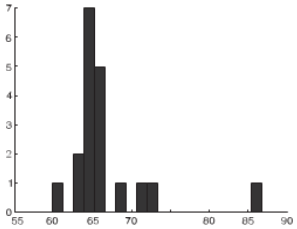
- has ambiguous local effect on trade volume relative to CE;
- has ambiguous local effect on prices relative to CE.

All of these settings deliver:

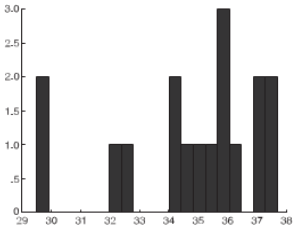
- considerable **price variation** relative to CE;
- a **smaller total surplus** relative to CE.

Notes

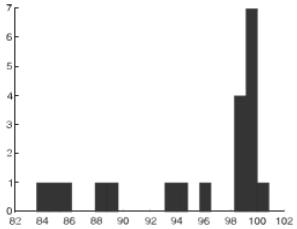
Price Variation Evidence: Hong & Shum 2006



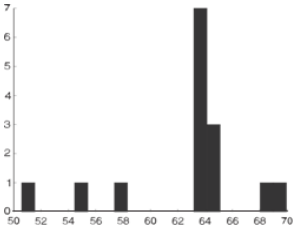
Stokey Lucas: Recursive Methods



Lazear: Personnel Economics



Billingsley: Probability & Measure



Duffie: Dynamic Asset Pricing

Notes

Effects of Centralization

Notes

Effects of Centralization: Prices

In the OTC Experiment, we found that:

	Round 1			Round 2		
	p^{ce}	p^{otc}	SD	p^{ce}	p^{otc}	SD
Market 1	5	7.51	1.10	8	6.86	1.04
Market 2	7	7.26	1.17	7	6.71	1.33
Market 3	7	6.91	0.94	7	6.50	1.09

In the Double Auction Experiment, we found that:

	Market 1			Market 2		
	p^{ce}	p^{da}	SD	p^{ce}	p^{da}	SD
Round 1	8	8.66	0.03	9	9.21	0.02
Round 2	8	8.43	0.03	9	8.88	0.05
Round 3	8	8.28	0.02	8	8.27	0.03

Notes

Effects of Centralization: Surplus

In the OTC Experiment, we found that:

	Round 1			Round 2		
	Theory	Data	Percent	Theory	Data	Percent
Market 1	41	–	–	244	165	67.6%
Market 2	368	269	73.1%	396	299	75.6%
Market 3	175	147	84.0%	187	61	32.7%

In the Double Auction Experiment, we found that:

	Market 1			Market 2		
	Theory	Data	Percent	Theory	Data	Percent
Round 1	414	409	98.8%	213	195	91.6%
Round 2	434	434	99.8%	221	221	100.0%
Round 3	420	412	98.1%	229	227	99.1%

Notes

Comparing Centralized to Decentralized Trade

Relative to the OTC game, in the DA game:

- there is **less dispersion in trade prices**;
- **prices are closer to CE** prices;
- **trade volume is closer to CE** trade volume;
- **surplus is closer to CE** surplus.

This concludes the fist section of the course.

We now leave you with Erik who will talk about tax incidence.

Have a good first year at LSE!!

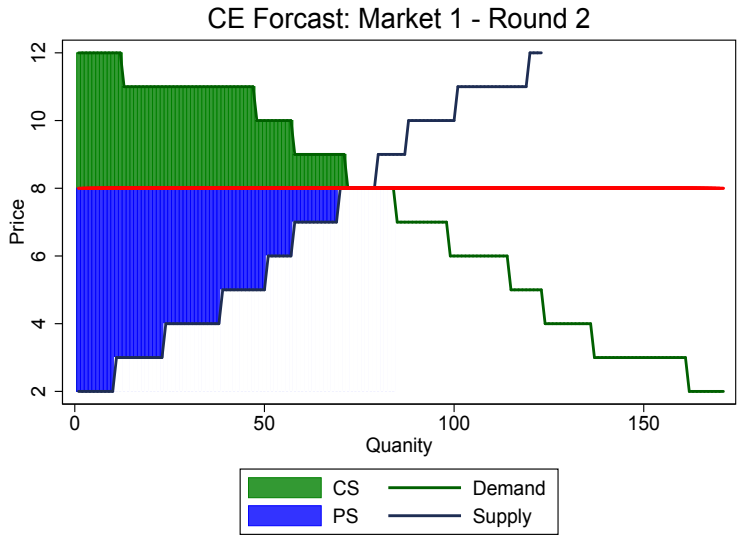
Notes

Omitted Plots

Notes

CE Outcome: Market 1 - Round 2

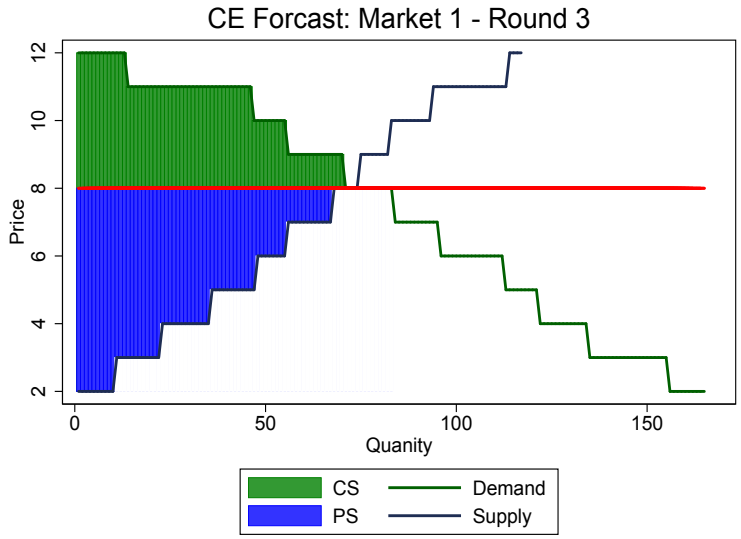
The plot below depicts the CE outcome:



Notes

CE Outcome: Market 1 - Round 3

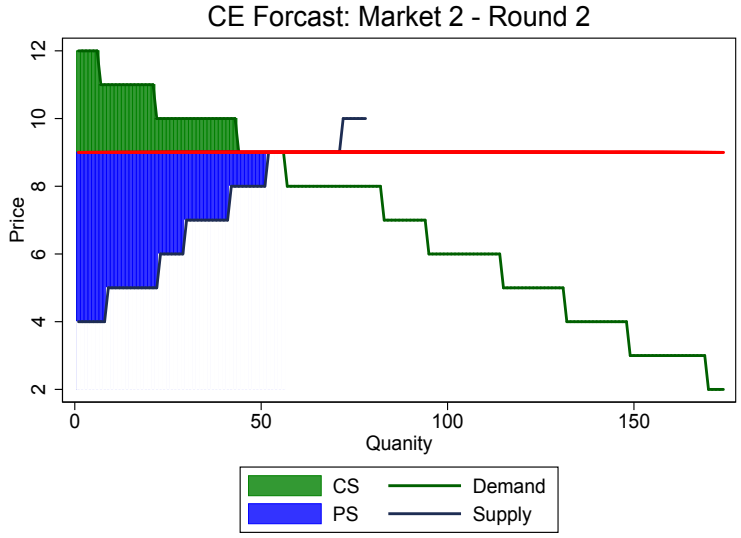
The plot below depicts the CE outcome:



Notes

CE Outcome: Market 2 - Round 2

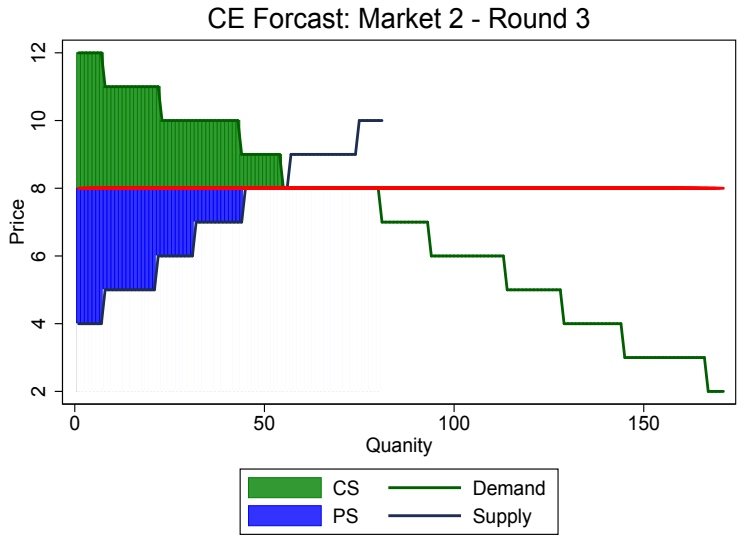
The plot below depicts the CE outcome:



Notes

CE Outcome: Market 2 - Round 3

The plot below depicts the CE outcome:



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