

An Experimental Comparison of Posted Prices with Single-Buyer and Multi-Buyer Prices

Nejat Anbarci and Nick Feltovich

Deakin University and Monash University

March 2012

The concept of **search** has been a versatile one in economic theory.

- Price dispersion in goods markets (Salop and Stiglitz, 1977 REStud; Burdett and Judd, 1983 Econometrica)
- Unemployment and job vacancies (Pissarides, 1985 AER)
- Money as a medium of exchange (Kiyotaki and Wright, 1989 JPE; 1993 AER)
- Discrimination by consumers or firms (Borjas and Bronars, 1989 JPE; Black, 1995 JLaborEcon)

The 2010 Nobel Prize in Economics was awarded to three leading search theorists, Diamond, Mortensen and Pissarides, who laid the foundations of the above applied work.

Random vs directed search

Much early work on search assumed that search is undirected or random: an agent on one side of the market is likely to meet any of the agents on the other side with a matching probability.

“In contrast to what happens in search models, exchanges in actual market economies are organized by specialist traders, who mitigate search costs by providing facilities that are easy to locate. Thus, when people wish to buy shoes they go to a shoe store; when hungry they go to a grocer; when desiring to sell their labor services they go to firms known to offer employment” (Howitt, 2005 IER, p. 405).

The solution is not to dispense with search altogether, but to look at directed instead of undirected search. (Buyers choose which seller(s) to visit, based on some relevant information.)

Bargaining was the predominant trading protocol in markets throughout the world until the early 19th century.

The use of **posted prices** is a relatively recent phenomenon. Its ascent and eventual widespread use date back to 1823 (when Alexander Stewart introduced posted prices in his NYC 'Marble Dry Goods Palace'; other famous merchants followed his lead).

Uninformed buyers: bargaining vs posted prices

Diamond (1987 *The New Palgrave*, 279) noted that in actual markets “infrequent traders are often ill-informed ... [creating an incentive for] sellers to find consumers whose beliefs make them willing to trade at high prices.”

Similarly, Stigler (1961 *JPE*, 218-19) noted the “widely held view that inexperienced buyers (tourists) pay higher prices than do experienced buyers.”

Macy’s advertisements from the 1850s stated that prior to the use of posted prices (by Macy’s), “there was no regular price for anything and the most ignorant were the most imposed upon,” while with posted prices “a child can trade with us as cheap as the shrewdest buyer in the country” (Scull, 1967)

Burdett, Shi and Wright (2001 JPE) considered a market with **posted prices** and **directed search** (recall that bargaining with random search was the main paradigm in many earlier search papers).

In the simple version of their model:

- One homogeneous indivisible good.
- Two identical firms; each can produce up to one unit of the good at 0 cost.
- Two identical buyers, each valuing the first unit of the good at 1; no benefit from additional units.
- Sellers simultaneously post prices; these are observed by buyers, who simultaneously choose which seller to visit.
- Random buyer chosen to buy, from all visiting the same seller; for the empty-handed buyer, visiting the empty-handed seller is prohibitively costly.

BSW show that a large number of subgame-perfect equilibria exists.

They impose additional **symmetry** and robustness criteria, and find a **unique equilibrium**: both sellers choose $p = 0.5$ and are visited with equal probability by a given buyer.

Frictions are possible, even though there is complete information about firms' prices, capacities and locations. (Taking limits doesn't help with infinite replicas of buyers and sellers.)

There are (coordinated) pure-strategy equilibria as well: "Buyer 1 visiting Seller 1 and Buyer 2 visiting Seller 2", "Buyer 1 visiting Seller 2 and Buyer 2 visiting Seller 1", which are efficient. There is a large range of asymmetric seller prices supporting these pure-strategy equilibria.

The CE setup and result

Coles and Eeckhout (2003 JET) note that posted-price models such as BSW's ignore the **market power** sellers have when visited by more buyers than their capacity.

They argue that these models should allow posting of prices that are contingent on demand to benefit sellers. Their simple model is like BSW's, except sellers simultaneously post "schedules" of prices: a one-buyer price and a multi- buyer price.

CE show that under some assumptions, equilibria are very similar to those in BSW's model. Both sellers still choose $p_1 = 0.5$ and are visited with equal probability by a given buyer, but p_2 is indeterminate in $[0, 1]$ (though equal for the two sellers).

Some misgivings about BSW and CE setups

CE remark that while setting high multi-buyer prices ought to be profit enhancing, “in many [field] environments such opportunistic behavior is not observed” (p. 266), due possibly to repeated-game effects.

BSW's and CE's results depend on selection criteria - such as on **symmetry** - that may or may not be reasonable (some buyers may visit the seller with the higher price to make sure that they receive the good for sure). Without such criteria, there is a large number of equilibria.

The additional flexibility of demand-contingent multi-buyer pricing of CE may not unambiguously benefit sellers contrary to CE's claim (e.g., sellers may post lower multi-buyer prices to lure all buyers).

Theoretical predictions of BSW and CE setups

To shed some light on how these posted pricing institutions affect market outcomes, we conduct an experiment that implements the BSW and CE models, with minor changes.

Buyer values are 20 and seller costs are 10; seller cost is avoidable (production on demand).

Theoretical predictions (from BSW, CE arguments):

- BSW price = CE one-buyer price = 15.
- CE two-buyer price is indeterminate (but equal for both sellers in a market).
- Each buyer/seller has a 0.75 chance of trading.
- Surpluses shared equally between buyers and sellers in BSW.

Indeterminate in CE - supposedly higher surplus going to sellers.

The BSW/CE 2x2 experiment

The experiment took place at SEEL (University of Aberdeen, Scotland); subjects were undergraduates and post-graduates from many programmes. Recruitment by ORSEE (Greiner, 2004).

Interaction via z-Tree (Fischbacher, 2007 ExpEcon), with partitions preventing viewing of others' screens. No identifying information about other subjects given.

Subjects played 20 rounds of the BSW game and 20 rounds of the CE game (counterbalanced – 64 subjects in each ordering), with relevant instructions read before game starts.

The BSW/CE 2x2 experiment (cont.d)

Roles fixed for entire session, but group compositions changed randomly from round to round.

Prices restricted to multiples of \$0.01, between \$10 and \$20 ($\$1 \approx \1.6).

Sellers explicitly told in CE game that p_2 could be greater than, less than or equal to p_1 .

Sellers were given “Firm 1” / “Firm 2” labels on buyers’ screens (i.i.d. across rounds).

The BSW/CE 2x2 experiment (cont.d)

- End-of-round feedback (also in history table):

Sellers: own/opponent's price, number of buyers visiting, quantity, profit.

Buyers: seller prices, buyers' visit choices, quantity, profit.

Subjects were paid (exactly) the sum of their profits from 4 randomly chosen rounds.

- Average payoffs were roughly \$20 (including a \$3 show-up fee); sessions averaged 60 minutes.

Screen shot 1

Round

2 of 2

Remaining time [sec]: 43

History of your past outcomes:

Round	Your cost of production (£)	Your price (£)	Other firm price (£)	Number of buyers visiting you	Quantity you sold	Your profit (£)
1	10.00	12.99	10.00	0	0	0.00

This is the beginning of Round 2. You are a **SELLER**.

You have been randomly grouped with another seller and two buyers.

Please choose your price for this round. Your choice can be any multiple of £0.01, between **£10.00** and **£20.00** inclusive.

MY PRICE: £

OK

Screen shot 2

Round

1 of 2

Remaining time [sec]: 43

This is the beginning of Round 1. You are a **SELLER**.

You have been randomly grouped with another seller and two buyers.

Please choose your prices for this round. Your choice can be any multiple of £0.01, between **£10.00** and **£20.00** inclusive.

MY PRICE IF **ONE** BUYER VISITS: £

MY PRICE IF **BOTH** BUYERS VISIT: £

OK

Screen shot 3

Round

1 of 2

The sellers have chosen their prices.

Firm 1's price is **£10.00** if one buyer visits it, and **£12.00** if both buyers visit it.

Firm 2's price is **£12.99** if one buyer visits it, and **£11.99** if both buyers visit it.

Please choose which of the sellers you will visit.

Remember that if you are the only buyer to visit a seller, then you will definitely be able to buy from that seller. If you and the other buyer visit the same seller, each of you has a 50% chance of being able to buy.

I CHOOSE TO VISIT

Screen shot 4

Round

1 of 2

History of your past outcomes:

Round	Your cost of production (£)	Your price if one buyer visits (£)	Your price if both buyers visit (£)	Other firm price if one buyer visits (£)	Other firm price if both buyers visit (£)	Number of buyers visiting you	Quantity you sold	Your profit (£)
1	10.00	12.99	11.99	10.00	12.00	0	0	0.00

THIS ROUND'S RESULTS:

You chose prices of **£12.99** (if one buyer visits) and **£11.99** (if two buyers visit).

The other seller chose prices of **£10.00** (if one buyer visits) and **£12.00** (if two buyers visit).

You were visited by **ZERO buyers**, so you were **UNABLE** to sell your item.

Your profit for the round is **£0.00**.

OK

Screen shot 5

Round

2 of 2

History of your past outcomes:

Round	Firm 1 price (£)	Firm 2 price (£)	Firm you visited	Firm other buyer visited	Quantity you bought	Selling price	Your profit (£)
1	10.00	12.99	1	1	0	N/A	0.00
2	16.00	15.00	1	2	1	16.00	4.00

THIS ROUND'S RESULTS:

Seller 1 chose a price of **£16.00**.
Seller 2 chose a price of **£15.00**.

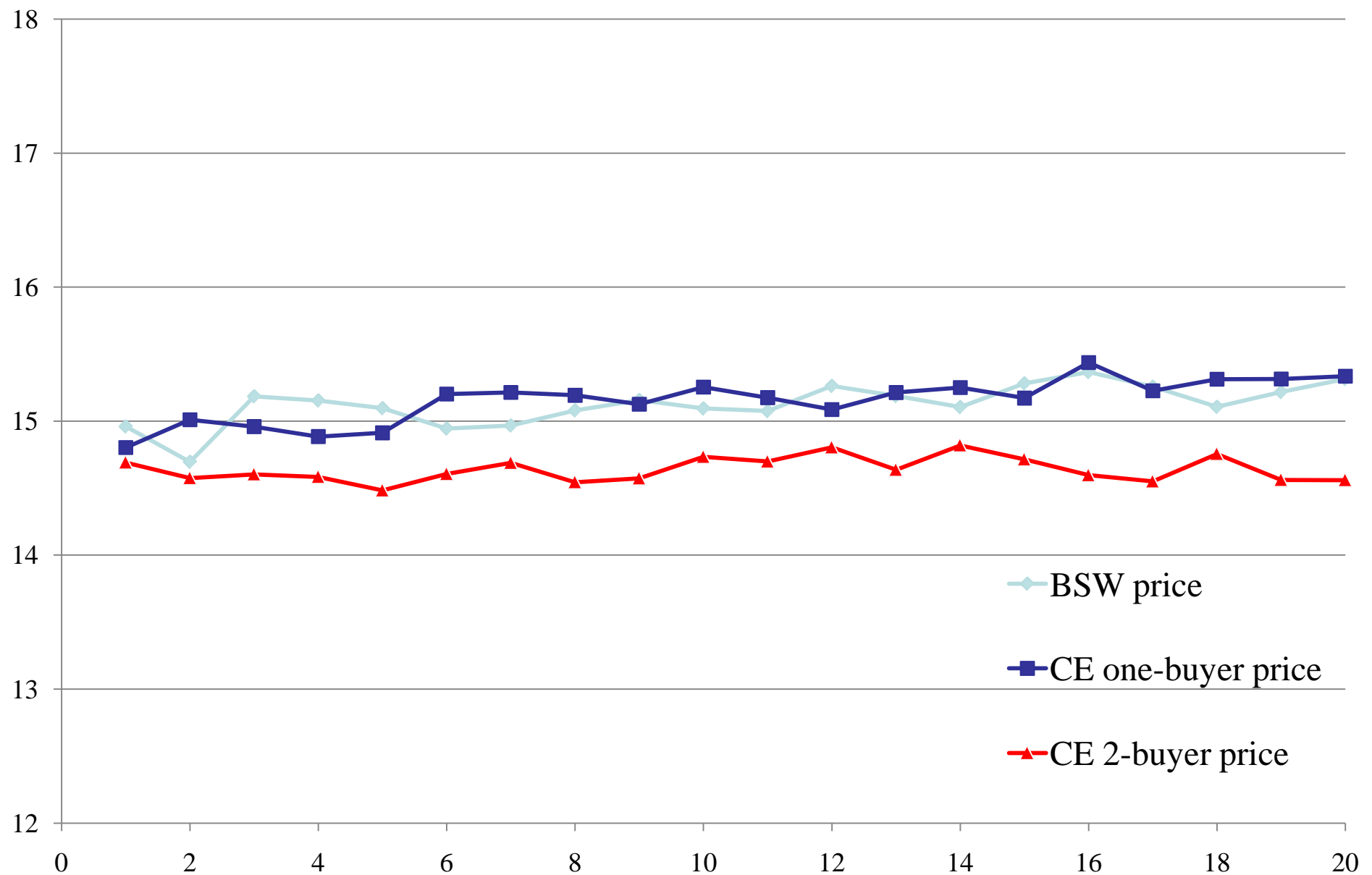
You chose to visit **Seller 1**. The other buyer chose to visit **Seller 2**.
You were **ABLE** to buy an item.

You paid a price of **£16.00**, and you resold the item for **£20.00**.

Your profit for the round is **£4.00**.

OK

Average prices in the 2x2 experiment



BSW/CE 2x2 experimental results

Aggregate behaviour:

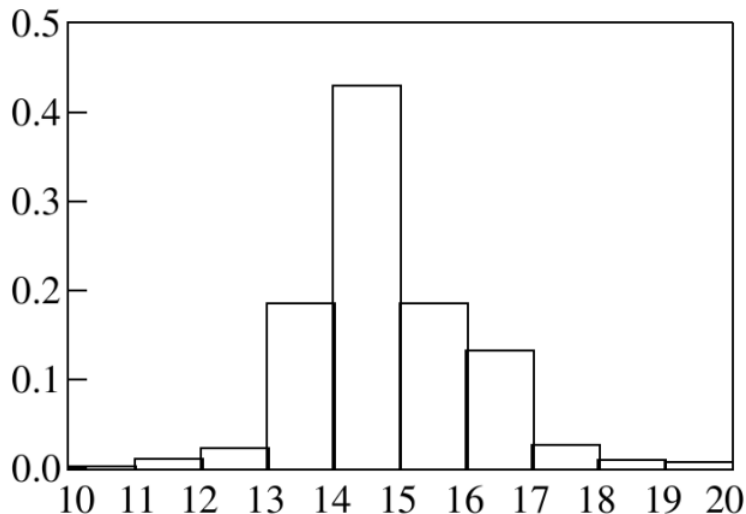
	Predicted value	BSW game	CE game	p-value, significance of differences
One-buyer price	15	15.13	15.15	n.s.
Two-buyer price	ind.	—	14.64	—
Efficiency	0.75	0.761	0.745	0.074
Seller profit	3.75	3.79	3.60	n.s.
Buyer profit	3.75	3.71	3.90	n.s.

Other significance results:

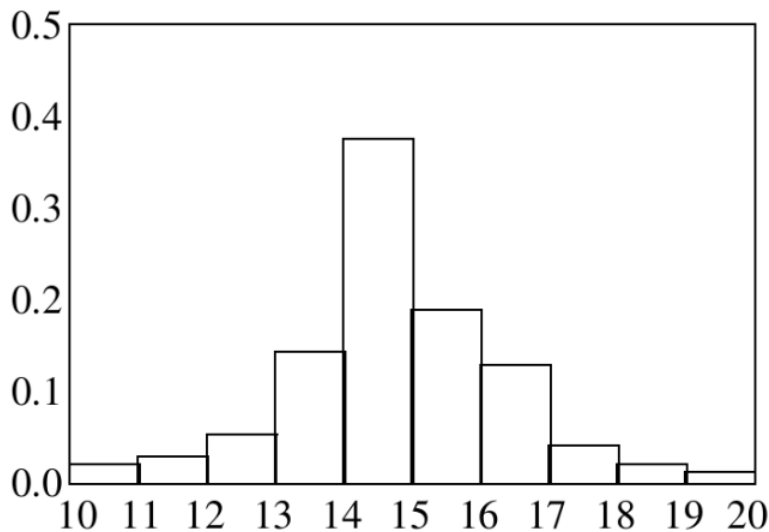
- Two-buyer prices in CE marginally significantly less than one-buyer prices in CE ($p \approx 0.055$).
- Two-buyer prices in CE significantly less than prices in BSW ($p \approx 0.007$).

BSW/CE 2x2 experimental results: BSW price dispersion

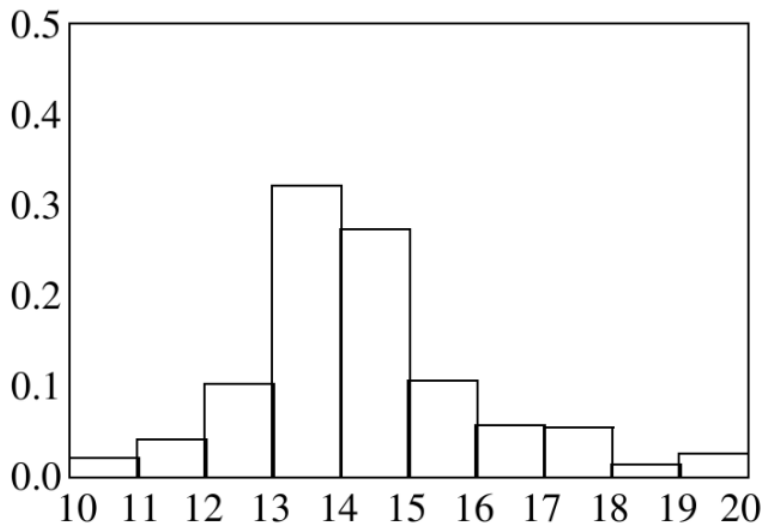
Histograms of price choices:



BSW/CE 2x2 experimental results: CE (single-buyer) price dispersion



BSW/CE 2x2 experimental results: CE (two-buyers) price dispersion



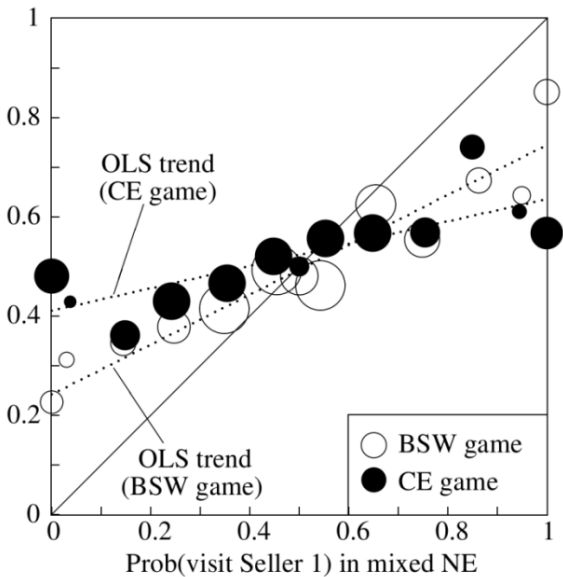
Significance results:

- Dispersion significantly less for BSW prices than for one-buyer CE prices ($p \approx 0.011$) and two-buyer CE prices ($p \approx 0.020$).
- No significant difference in dispersion between one-and two-buyer prices in CE ($p > 0.20$).

For intervals of predicted probability of visiting Seller 1, we:

1. Calculate the mean predicted probability for all possible observations in each interval (and include the endpoints, 0 and 1);
2. Calculate the actual frequency of visits to Seller 1 in each interval;
3. Plot a circle with area equal to the number of observations.

Observed freq.
of visits to
Seller 1



The BSW/CE $3 \times 2 / 2 \times 3$ follow-up experiment

The 2 (buyers) \times 2 (sellers) setup is the simplest non-trivial version of this kind of market, and is the one analysed in most detail by BSW and CE (and others).

However, the 2×2 setup is a bit mundane (if not boring)!

As a follow-up, we consider the asymmetric 3×2 and 2×3 setups.

The experiment is taking place at MonLEE (still in progress - three sessions left).

What is different in the BSW/CE 3x2/2x3 setups?

As before:

- End-of-round feedback (also in history table):

Sellers: own/opponent's price, number of buyers visiting, quantity, profit.

Buyers: seller prices, number of buyers visiting same seller, quantity, profit.

Minor changes:

Prices restricted to multiples of \$0.05, between 0 and \$20.

- Subjects were paid according to the results from 6 randomly chosen rounds.

- Average payoffs were roughly \$20 for the unfavoured side of the market, \$60 for the favoured side (incl. \$10 show-up fee).

Theoretical predictions: BSW/CE 3x2/2x3 setup

Theoretical predictions (vs core/auctions predictions - odd-man out):

3x2 game

- BSW price = CE one-buyer price ≈ 14.55 .
- CE multi-buyer price is indeterminate (but equal for both sellers in a market).
- Each buyer has a 0.583 chance of buying; each seller has a 0.875 chance of selling.

2x3 game

- BSW price = CE one-buyer price ≈ 5.45 .
- CE multi-buyer price is indeterminate (but equal for both sellers in a market).
- Each buyer has a 0.833 chance of buying; each seller has a 0.556 chance of selling.

Screen shot 1

Round

1 of 1

Firm 1 has chosen a price of **\$8.25** if one buyer visits it, and **\$9.75** if two buyers visit it.
Firm 2 has chosen a price of **\$11.00** if one buyer visits it, and **\$12.00** if two buyers visit it.
Firm 3 has chosen a price of **\$9.00** if one buyer visits it, and **\$11.50** if two buyers visit it.

Please choose which of the sellers you will visit.

Remember that if you are the only buyer to visit a seller, then you will definitely be able to buy from that seller. If the other buyer visits the same seller as you, then one of you will be randomly chosen to buy from that seller, and the other will be unable to buy.

I CHOOSE TO VISIT

FIRM 1
 FIRM 2
 FIRM 3

OK

Screen shot 2

Round

1 of 1

History of your past outcomes:

Round	Firm 1 price if one buyer visits (\$)	Firm 1 price if two buyers visit (\$)	Firm 2 price if one buyer visits (\$)	Firm 2 price if two buyers visit (\$)	Firm 3 price if one buyer visits (\$)	Firm 3 price if two buyers visit (\$)	Firm you visited	Number of buyers visiting that firm	Quantity you bought	Selling price	Your profit (\$)
1	8.25	9.75	11.00	12.00	9.00	11.50	1	1	1	8.25	11.75

THIS ROUND'S RESULTS:

Seller 1 chose prices of **\$8.25** if one buyer visits and **\$9.75** if two buyers visit.
Seller 2 chose prices of **\$11.00** if one buyer visits and **\$12.00** if two buyers visit.
Seller 3 chose prices of **\$9.00** if one buyer visits and **\$11.50** if two buyers visit.

You chose to visit **Seller 1**. A total of **1** buyer (including you) visited this seller.
You were **ABLE** to buy an item.

You paid a price of **\$8.25**, and you resold the item for **\$20.00**.

Your profit for the round is **\$11.75**.

OK

Screen shot 3

Round 1 of 1

History of your past outcomes:

Round	Your cost of production (\$)	Your price if one buyer visits (\$)	Your price if two buyers visit (\$)	One rival firm price if one buyer visits (\$)	One rival firm price if two buyers visit (\$)	Other rival firm price if one buyer visit (\$)	Other rival firm price if two buyers visit (\$)	Number of buyers visiting you	Quantity you sold	Your profit (\$)
1	0.00	8.25	9.75	11.00	12.00	9.00	11.50	1	1	8.25

THIS ROUND'S RESULTS:

You chose prices of **\$8.25** (if one buyer visits) and **\$9.75** (if two buyers visit).

One rival seller chose prices of **\$11.00** (if one buyer visits) and **\$12.00** (if two buyers visit).

The other rival seller chose prices of **\$9.00** (if one buyer visits) and **\$11.50** (if two buyers visit).

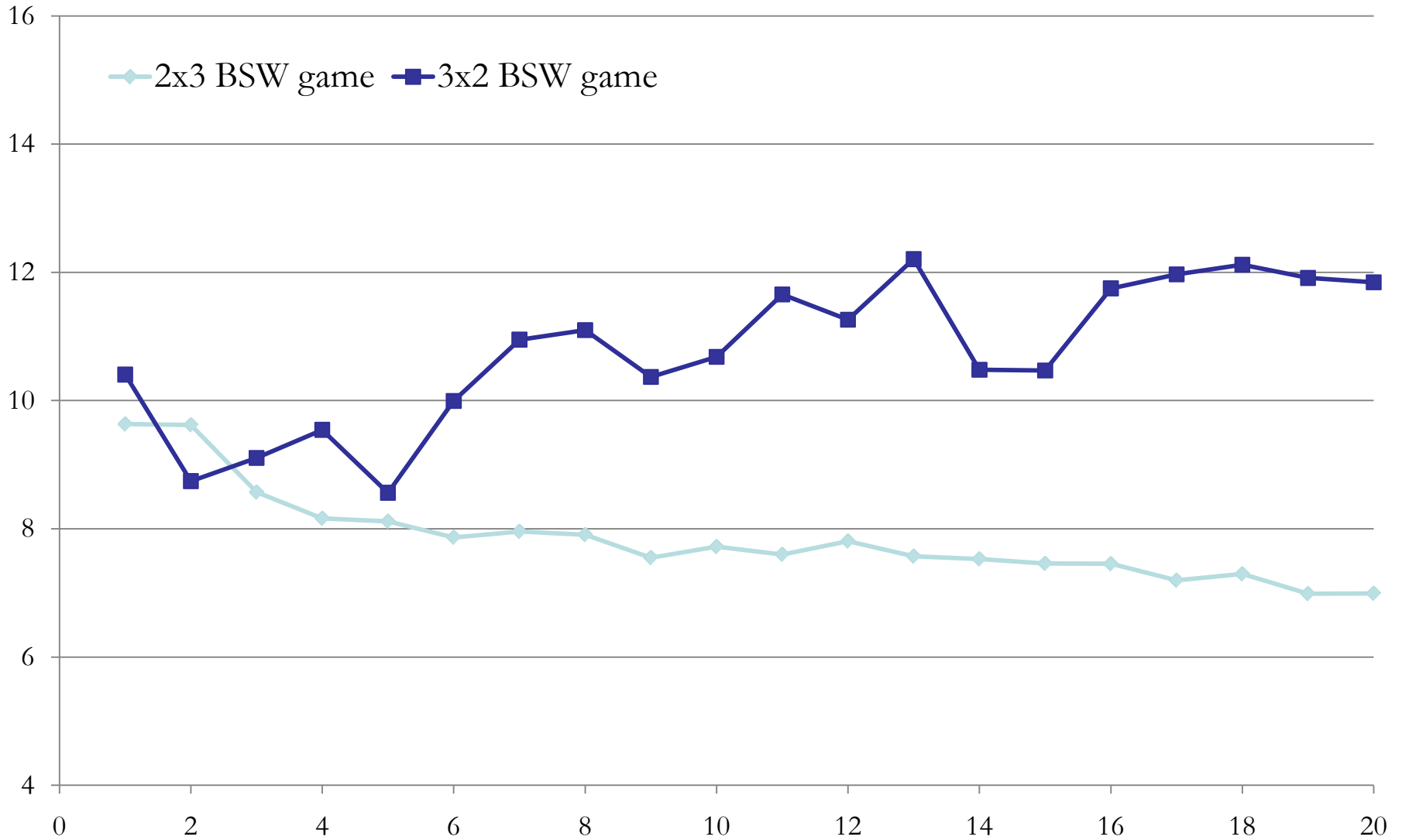
You were visited by **ONE buyer**, so you were **ABLE** to sell your item.

You sold your item for a price of **\$8.25**, and the cost of producing it was **\$0.00**.

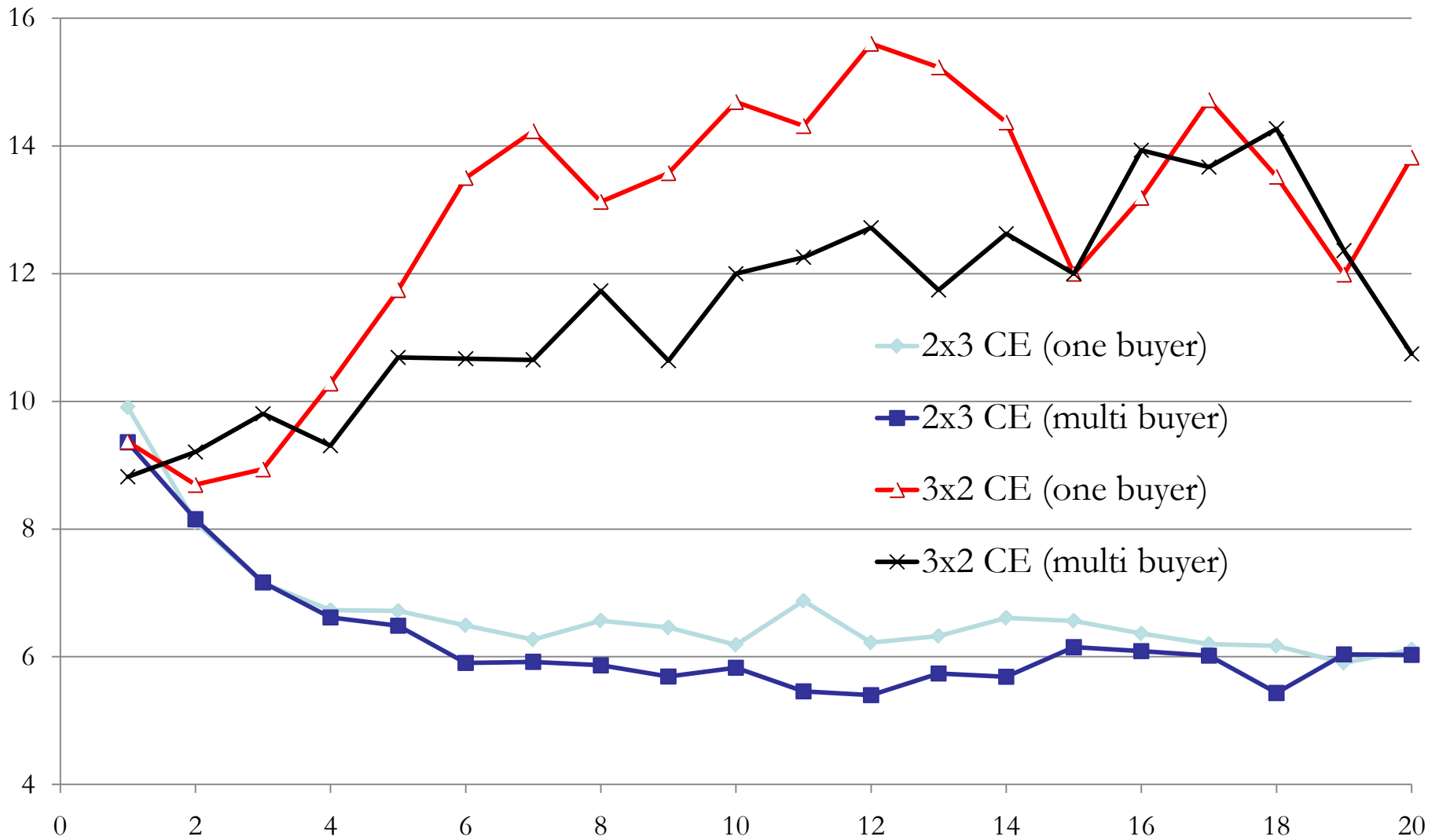
Your profit for the round is **\$8.25**.

OK

Average prices in the 3x2 and 2x3 BSW setups



Average prices in the 3x2 and 2x3 CE setups



BSW/CE 3x2/2x3 setups: preliminary results

So far, 1 session (10 subjects) of each cell (3x2 or 2x3, BSW-CE or CE-BSW).

Aggregate behaviour:

		Predicted value	BSW game	CE game
3 buyers, 2 sellers	One-buyer price	14.55	12.86	13.32
	Multi-buyer price	ind.	—	12.95
	Efficiency	0.875	0.862	0.844
	Seller profit	12.73	10.94	11.03
	Buyer profit	3.18	4.20	3.89
2 buyers, 3 sellers	One-buyer price	5.45	7.64	7.37
	Multi-buyer price	ind.	—	7.02
	Efficiency	0.833	0.831	0.806
	Seller profit	3.03	3.96	3.57
	Buyer profit	12.12	10.68	10.77

What is the effect of allowing multi-buyer prices of CE?

- In the 2x2 setup, no evidence that it benefits sellers, and it might actually harm them.
- In the 3x2 and 2x3 setups, it benefits the side with greater market power though still less than theoretical prediction – see below for more.
- In all setups, multi-buyer prices are lower than one-buyer prices. (Is this the right way to model market power sellers have when visited by more buyers than their capacity?)

Conclusions (cont'd)

Other results:

- (all three setups) Less dispersion in BSW prices than CE one-buyer or CE multi-buyer prices.
- (3x2 and 2x3 setups) Sellers are less able to take advantage of their market power than buyers regardless of BSW and CE setups.

Overall, both parties take less advantage of their market power than implied by BSW and CE theoretical predictions.

Some gravitation towards the 50 – 50 norm in prices is evident in both BSW and CE results – subjects feeling that market power is unearned due to lack of 'real effort'? Any framing effects?

Next step?

- Add 'costly' money to this setting.

Joint project with Nick and Richard Dutu (Deakin University, Graduate School of Business).

Capture inflation by requiring buyers to borrow before visiting a seller.

How does the inflation rate influence market outcomes?

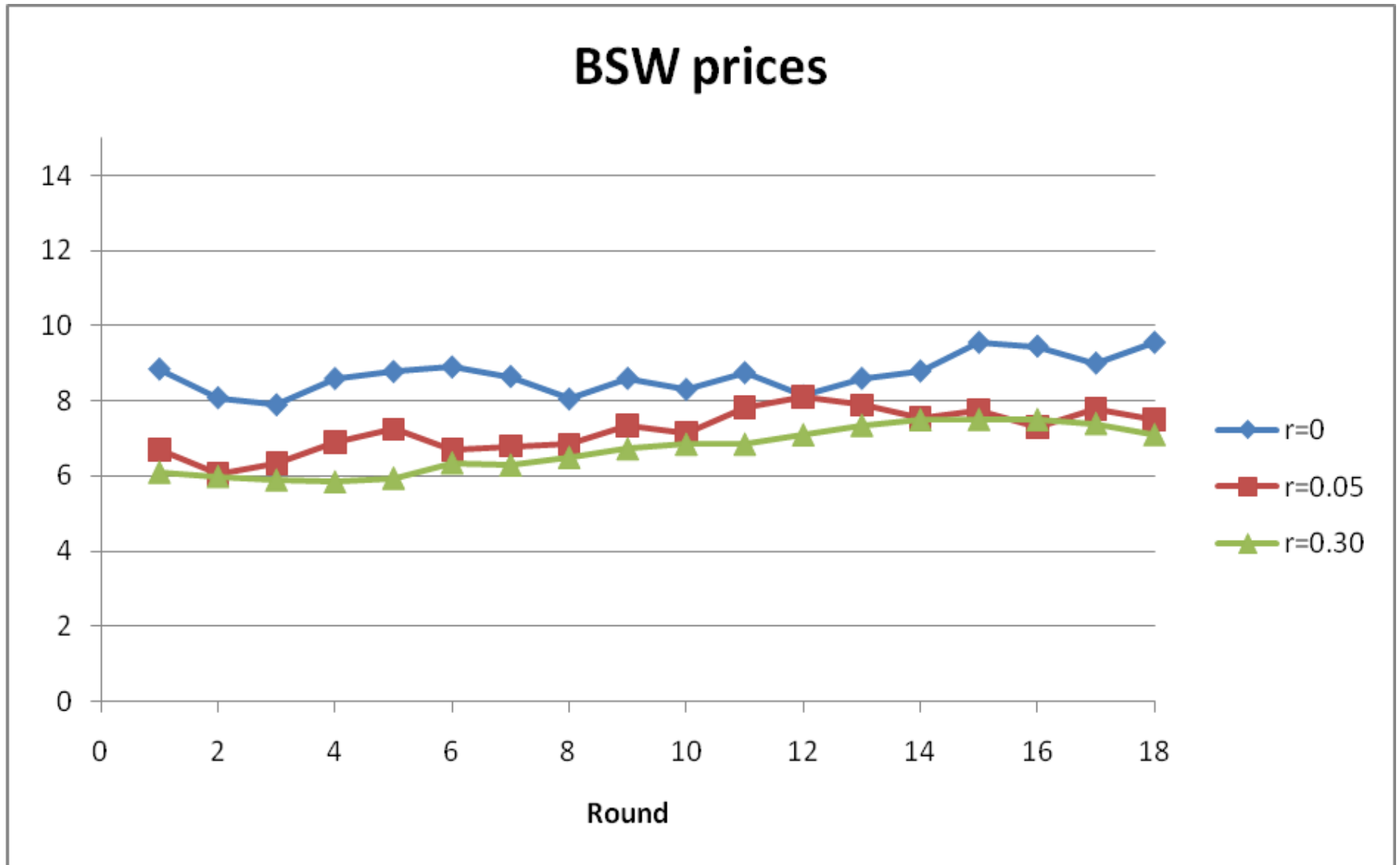
Main prediction: CE 2-buyer price indeterminacy will disappear with any positive inflation/nominal interest rate (i.e., with any level of cost of using money).

Another (more mundane) prediction: Prices posted by sellers will be lower the higher the inflation/nominal interest rates.

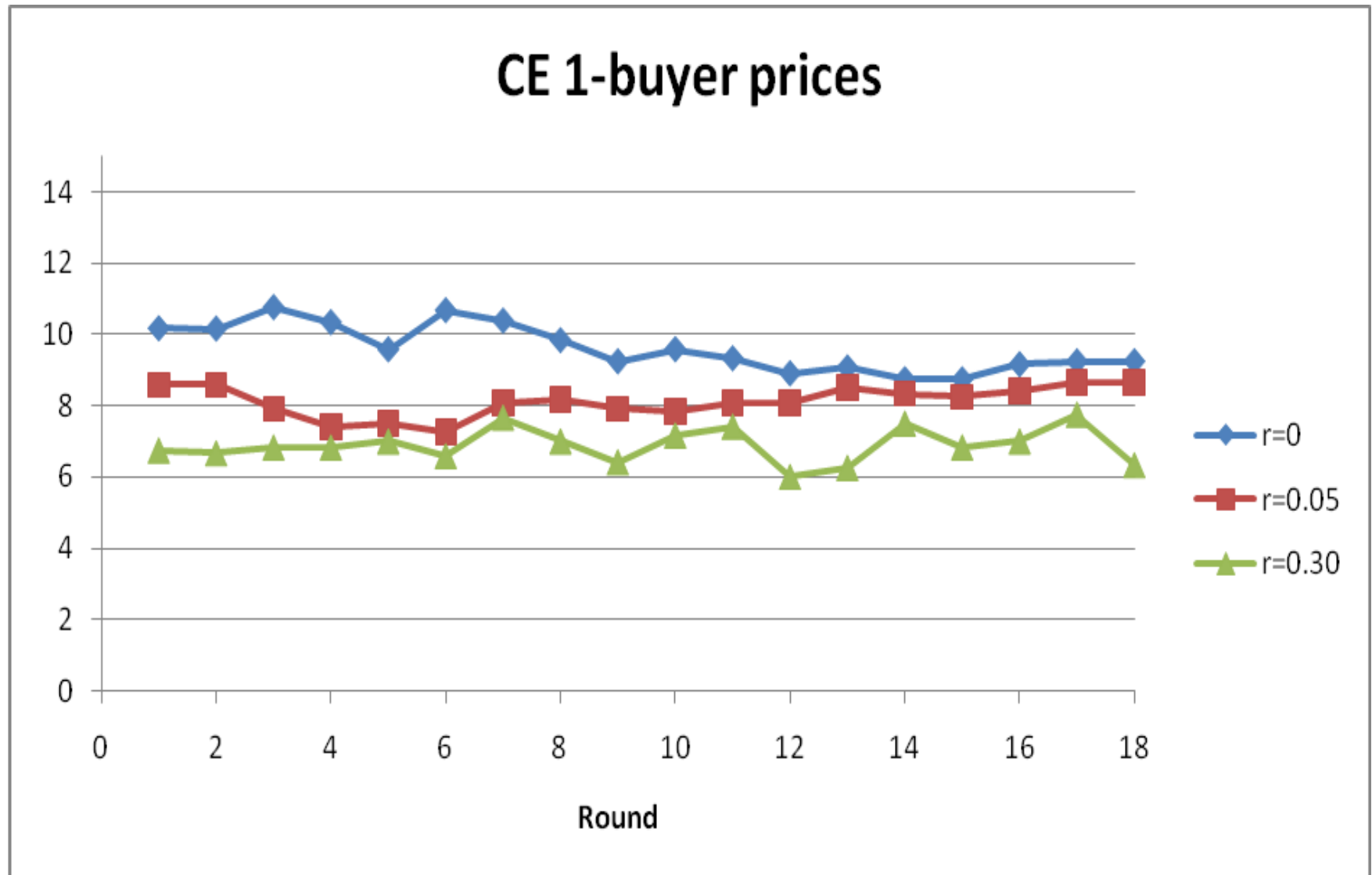
So far, some 2x2 sessions have been completed (see the preview).

Next, we will run a few more 2x2 sessions and a significant number of 3x2, 2x3 sessions.

Preview: 2x2 money experiment – BSW prices



2x2 money experiment – CE 1-buyer prices



2x2 money experiment – CE 2-buyer prices

