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Abstract

There is perhaps no more important question in public finance than who ultimately bears the burden of a tax. According to tax incidence theory, the long-run incidence of a tax in competitive markets is independent of the assignment of the liability to pay tax. Moreover, the theory is silent on the possible effects of market institutions on tax incidence. We report data from an experiment designed to address two questions: (A) Is tax incidence independent of the assignment of the liability to pay tax in experimental markets? (B) Is tax incidence independent of the market institution in experimental markets? We conduct laboratory experiments with two market institutions: double auction and posted offer markets. Based on the results of Kolmogorov-Smirnov tests of experimental market prices, we conclude that the answer to both question A and question B is "no."

1. Introduction

To understand the distributional effects of a tax, it is necessary to know who ultimately bears the burden of the tax. The theory of tax incidence concerns itself with answering this very question, and there may be no more important one in public finance. According to the standard theory, the incidence of a tax in long-run competitive equilibrium has nothing to do with the statutory assignment of the liability to pay tax. Rather, it depends on the relative elasticities of supply and demand; the more inelastic of the two ultimately bears the greater burden of the tax.

The economic intuition for this conclusion is straightforward. Suppose, for example, that a firm is liable to pay tax on every unit sold. The firm can try to shift the tax forward onto the consumer through higher prices. However, the ability of the firm to do so is limited by the price elasticity of demand for the good. If demand is sufficiently inelastic relative to supply, the change in quantity demanded will be small in response to a given increase in the price. In this case, the firm will find it profitable to shift much of the tax burden onto consumers. If, however, demand is relatively elastic, increasing the price to shift the tax will lead to a large decrease in the quantity demanded, and the firm will not find it profitable to shift as much of the tax as in the inelastic case. Of course, the firm has not exhausted all of its options; it could also attempt to shift the tax backward onto the suppliers of factors of production. Again, according to the standard theory, the firm's ability to do so depends on the relative price elasticities of factor supplies and demands. From this perspective, nothing is changed if the consumer is assigned the liability to pay the tax rather than the seller.

There is a growing literature that suggests matters may not be quite so simple; that in fact, institutional, informational, and behavioral factors may influence tax incidence.[1] Furthermore, there is no accounting in the theoretical literature for the potential influence of the type of market institution on tax incidence. Markets need institutions to function, and these institutions specify how buyers and sellers interact to determine prices and quantities. Different market institutions are known to have different price formation and quantity determination properties (see below); there is no reason to believe, *a priori*, that these different properties will not affect the incidence and excess burden of a tax.

There is also a substantial empirical literature that reports evidence of tax over-shifting, which is inconsistent with the predictions of the standard theory. For example, A. Hanson and R. Sullivan (2009) use the occasion of a $1 per pack increase in the cigarette excise tax in Wisconsin to estimate the incidence of a cigarette tax. They find that this tax change increased the price per pack by $1.08 to $1.17, which they interpret to be evidence of tax over-shifting. J. Harris (1987) and T. Keeler et al. (1996) also report similar evidence of over-shifting of excise taxes on cigarettes, using state-level data for multiple states. Finally, T. Besley and H. Rosen (1999) find that sales taxes are over-shifted for more than half of the products sold at retail.[2] The

[1] See, for example, Raj Chetty, Adam Looney, and Kory Kroft (2009) for the impact of salience on tax incidence in the case of excise taxes, and Emmanuel Saez, Manos Matsaganis, and Panos Tsakloglou (2012) for the influence of the assignment of the liability to pay tax on tax salience in the case of payroll taxes. Amy Finkelstein (2009) reports evidence that salience influences the elasticity of demand for tolled roads.

[2] James Poterba (1996) reports evidence of over-shifting of sales taxes in Chicago and negative-shifting in Atlanta. D. Sumner and M. Wohlgenant (1985) report evidence of full-shifting of taxes; whereas, O. Ashenfelter and D. Sullivan (1987) contend that excise tax increases do not consistently lead to increases in retail prices. E. Saez et al. (2012) report evidence from a natural experiment created by a change in the payroll tax rate in Greece. They report evidence that the assignment of the liability to pay tax influences the incidence of a payroll tax.

standard theory of tax incidence does not predict tax over-shifting in long-run competitive equilibrium.

In the face of evidence that contradicts long-established theoretical results, a natural reaction is to find fault with the econometric strategies that result in such anomalous findings. Critics point out that taxes are used to finance government services. Unless such benefits are accounted for in the econometric specification, the estimates are inconsistent. Others contend that the estimates reported in the literature are short-run rather than long-run measures of tax incidence, and critics also point out that the transaction costs are not zero in these markets, as assumed by the theory.

The goods which are the focus of the empirical studies cited above are exchanged in posted offer markets in which the seller is assigned the liability to pay the tax. Our underlying research question therefore is whether two prominent features of a controlled experimental economy – the assignment of the liability to pay tax and the type of market institution – influence the incidence of a tax in competitive markets. The advantage of laboratory experiments is their ability to isolate the variable of interest by eliminating potential confounding effects that often plague econometric studies using observational data.

We conduct laboratory experiments, comparing two market institutions, computerized double auction (DA) and posted offer (PO) markets, to investigate whether tax incidence is independent of the assignment of the liability to pay tax and the type of market institution. The rules of the computerized DA market in our experiments are essentially the same as the rules that govern trading on the New York Stock Exchange and on many organized futures markets. An experimental DA market is open for a specified interval of time; buyers are free to announce at any instant a bid price for the commodity they wish to buy; and sellers are free to announce an

offer price for the commodity they wish to sell. In the simplified DA markets used in many experiments, including ours, each bid, offer, or contract is for a single unit. Actual trade occurs when a seller accepts the most attractive bid price or a buyer accepts the most attractive offer price among the outstanding bid and offer prices.

The rules of the computerized PO market in our experiments are similar to the rules that govern most of the consumer goods markets in developed countries. For example think of a supermarket or department store. The seller posts a sales price for a commodity and may also limit the quantity they are willing to sell at that price. Buyers may compare prices available to them from different sellers and make the decision to buy or not to buy a given commodity from a given seller at the posted price. The computerized PO market in our experiments is similar to this field institution.

The choice of DA and PO markets are particularly well suited to the research questions at hand. F. Williams (1973), V.L. Smith (1976b), V.L. Smith, F. Williams, W.K. Bratton, and M.J. Vannoni (1982), and V.L. Smith and F. Williams (1983) report the robust result that DA markets converge rapidly to competitive equilibrium, thus exhausting the potential gains from trade. In other words, DA markets achieve the Pareto efficient resource allocation of competitive market theory. Thus, it would seem that DA markets give the standard theory of tax incidence the best chance of success. In contrast, F. Williams (1973), C. Plott and V.L. Smith (1978), J.T. Hong and C. Plott (1982), V.L. Smith (1982b), and J. Ketcham, V.L. Smith, and F. Williams (1984) report evidence that PO markets produce prices that converge to the competitive equilibrium price from above and more slowly than in DA markets. PO markets also yield less efficient allocations than DA markets. Consequently, the standard theory of tax incidence seems less likely to apply to PO markets. However, PO exchange is the most common retail market

institution in developed countries; thus, it is important to investigate the effect of this market institution on tax incidence.

Using induced, stationary supply and demand schedules, our experimental design consists of four treatments: (1) a double auction market with a unit tax on the buyer (DATB); (2) a double auction market with a unit tax on the seller (DATS); (3) a posted offer market with a unit tax on the buyer (POTB); and (4) a posted offer market with a unit tax on the seller (POTS). Tax incidence theory is silent about the role market institutions play in determining who ultimately bears the burden of a tax. The theory does predict that the incidence and excess burden of a tax is independent of the assignment of liability to pay tax to buyers or sellers.

To test the hypothesis that incidence is independent of the assignment of the liability to pay tax, we conduct Kolmogorov-Smirnov (K-S) two-sample tests using pairwise comparisons of distributions of average buyer prices from the four experimental treatments. In contrast to the predictions of tax incidence theory, the K-S tests reject the hypothesis at conventional levels of significance that changing the assignment of the liability to pay tax from sellers to buyers has no effect on the distribution of average buyer prices. The K-S tests also reject the hypothesis at conventional levels of significance that the type of market institution has no effect on the distribution of average buyer prices. In short, we report evidence that the assignment of the liability to pay tax and the type of market institution each has a statistically and economically significant effect on tax incidence in competitive markets.

The remainder of this paper is organized as follows. The next section describes our experimental design in greater detail, and the subsequent section explains the results. We conclude in the final section.

2. Experimental Design

Our experimental design tests the ability of a widely accepted economic theory to predict the influence of changes in the type of market institution and in the assignment of the liability to pay tax on the incidence of a unit tax. Following V. Smith (1976a, 1982a), we induce stationary demand and supply functions for a fictitious commodity. We use a balanced design in which tax incidence theory predicts that the economic burden of a unit tax on a homogeneous good will be equally shared between buyers and sellers, independently of the assignment of the liability to pay tax.

As previously noted, the theory makes no prediction regarding the influence of a change in the type of market institution on the incidence of a tax. To gauge the impact of the market institution, we change the market institution from a DA market to a PO market, keeping the assignment of the liability to pay tax the same. Similarly, we change the assignment of the liability to pay tax from the seller to the buyer, keeping the market institution the same, in order to gauge the impact of this change on the incidence of a tax. This illustrates the advantage of laboratory experiments. They are performed in well-defined, controlled environments, where one variable at a time is changed to measure its impact on the outcome of interest. Table 1 summarizes the four treatments of our 2×2 design.

Basic design

We conduct a total of four sessions, with each session devoted to a particular treatment. The subject's role is randomly assigned by a computer at the beginning of each session and remains the same throughout the entire session. In each session, four independent markets, consisting of five buyers and five sellers in each market, are simultaneously trading. Each buyer and seller is given five (no-tax) infra-marginal units to sell or buy at the beginning of each trading period, and there are 30 trading periods in each of the four markets in a given session. In

short, the experiment uses a between subjects design, with 40 subjects randomly assigned to the role of buyer or seller in equal numbers in each of the four treatments, resulting in a total of 160 subjects.

Table 2 below shows an individual seller's marginal costs and an individual buyer's marginal values per unit. The table shows only the no-tax, infra-marginal costs and values. Each buyer in all four treatments is assigned a value of 50 experimental dollars (ED) for unit 1 of the fictitious commodity, 47 ED for unit 2, 44 ED for unit 3, 41 ED for unit 4, 38 ED for unit 5, and 35 ED for unit 6. These marginal values represent the induced individual demand schedules used in the experiment. Similarly each seller in all four treatments is assigned a cost of 23 ED for unit 1, 26 ED for unit 2, 29 ED for unit 3, 32 ED for unit 4, 35 ED for unit 5, and 38 ED for unit 6. These marginal costs identify the induced individual supply schedules used in the experiment. Costs and values are private information. Throughout each session, the subjects are seated in a manner that protects the privacy of this information. The amount of the unit tax (12 ED) and the assignment of the liability to pay tax are announced to the subjects at the beginning of each session. The costs, values, and tax per unit remain the same throughout each session.

In the absence of a tax, the unique competitive equilibrium quantity is 25 units, consisting of 5 units traded by each buyer and seller. After we impose a unit tax of 12 ED, the unique equilibrium quantity predicted by the theory is 15 units, consisting of 3 units traded by each buyer and seller. The predicted excess burden of this tax is 60 ED [$= 5\times(38 - 35) + 5\times(41 - 32)$].

At the beginning of each experimental session, subjects read through detailed instructions appearing on their computer screens on how to interact with the computer to trade in the market. The instructions for buyers and sellers for all four treatments are available at the following URL: http://expecon.gsu.edu/jccox/subjects.html. After the subjects read through the instructions,

summary instructions are projected on a screen and read to the subjects to help promote understanding of the market participation process. The scripts of the oral summary instructions are available at the URL given above. Subjects are permitted to ask questions of the experimenter, either publically or privately. To ensure the subjects are comfortable with the software, there are five practice trading periods before the actual trading periods begin. These practice periods familiarize the subjects with the software and help them to understand the decision making process. The practice periods are followed by 30 actual trading periods in each session (treatment). The total number of trading periods is not announced to the subjects.

The subjects are mostly undergraduate students at a large urban university in the United States. Table 3 provides information on the demographic profile of the subjects. They are nearly equally divided among class ranks, with 25 percent freshmen, 31 percent sophomores, 20 percent juniors, and 22 percent seniors. Masters students make up only 2 percent of the sample. Approximately 75 percent of the sample has previous experience in an experiment; 59 percent are female; 51 percent are African-American; 20 percent are white; 15 percent are foreign born; and the remaining 14 percent are either Asian-American, Hispanic-American, or mixed race. The average age in our sample is 20 years old; the minimum age is 18; and the maximum age is 24. Approximately 34 percent of the sample is either a business major (accounting, finance, or management) or an economics major. The modal (39 percent) grade point average (GPA) is between 3.25 and 3.74; 9 percent have a GPA between 1.25 and 2.74; 29 percent between 2.75 and 3.24, and 19 percent between 3.75 and 4.0. A small percentage of the sample (4 percent) has yet to receive a final grade in a college course. Although there is some variation in the demographic profiles among the four treatments, the percentages are similar across treatments suggesting that the randomization was successful.

2.a Computerized double auction markets

Two treatments are conducted in DA markets. In one treatment, the liability to pay tax is assigned to the seller in the market and, in the other treatment, to the buyer in the market. The assignment of the liability to pay tax is the only difference in the two DA treatments. The unit tax in both treatments is the same and equal to 12 ED. In both treatments sellers and buyers are given two and a half minutes to complete their transactions in each trading period. The time remaining in the trading period, the subject's own number of units available to buy or sell, own cumulative earnings, own profit or loss from each traded unit, outstanding bid and ask prices in the market, tax charged per unit, and the market transaction prices are displayed on the trading screens of the buyers and sellers at all times.

A seller's trading screen also shows "cost per unit" in one column and the "cost plus tax per unit" in an adjacent column.[3] If, however, the buyer is assigned the liability to pay tax, the figures in these two columns are identical, because the unit tax on the seller is equal to zero. Similarly, a buyer's trading screen shows "value per unit" in one column and the "value minus tax per unit" in an adjacent column. If, however, the seller is assigned the liability to pay tax, the figures in these two columns are identical, because the unit tax on the buyer is equal to zero. For

[3] For both the double auction and posted offer market treatments, we include separate columns for "cost per unit" and "cost plus tax per unit" in the seller's trading screen and "value per unit" and 'value minus tax per unit' in the buyer's trading screen in order to make the tax salient. R. Chetty et al. (2009) defines tax salience as the price of a good calculated at the gross-of-tax price. He reports evidence of the impact of tax salience on behavioral responses to taxes from a field experiment and regression analysis using observational data. When taxes are less salient, agents do not optimize relative to the true tax-inclusive prices, and so demand becomes less sensitive to tax. In other words, a less salient tax makes the own-price elasticity of demand more inelastic relative to a more salient tax, making consumers bear more of the tax burden. Furthermore, Amy Finkelstein (2009) shows that less salient taxes lead to higher equilibrium tax rates.

further details on the exact layout of the buyer and seller trading screens, the interested reader may see the screen shots in the subject instructions which are available at the URL given above.

2.b Computerized posted offer markets

The remaining two treatments are PO markets. In this market institution, sellers make the first move by posting an offer price and the number of units they are willing to sell at that offer price. Buyers then enter the market in a random queue, one by one, and accept the seller's offers if they find them attractive. If an offer is accepted, then trade occurs. In one posted offer treatment, the liability to pay a unit tax on each traded unit of a fictitious commodity is assigned to the seller. In the other treatment, the liability to pay a unit tax on each traded unit of the fictitious commodity is assigned to the buyer. Again, the assignment of the liability to pay tax is the only difference between these two treatments.

The amount of the unit tax in both treatments is equal to 12 ED. In both treatments, sellers have two and a half minutes to post offers to the market in each trading period. Each buyer has an equal amount of time (30 seconds) to accept the available offers in the market. The time remaining to make decisions, own number of units available to buy or sell, own cumulative earnings, own profit or loss from each traded unit, and the unit tax are displayed on the sellers' and buyers' trading screens. A seller's trading screen also shows the seller's "cost per unit" in one column and the "cost plus tax per unit" in an adjacent column. If the liability to pay tax is assigned to the buyer, the figures in these two columns are identical, because the unit tax assigned to the seller is equal to zero. A seller's screen also lists the offers posted by oneself. Sellers are not able to see the offers posted by other sellers in the market. We believe that this feature of the treatment best reflects the field institution that we are trying to replicate in the

laboratory. In the field, knowledge of the prices offered by other sellers in the market can only be obtained through costly surveillance.

A buyer's trading screen displays "value per unit" in one column and "value minus tax per unit" in an adjacent column. If, however, the liability to pay tax is assigned to the seller, then the figures in these two columns are identical, because the tax assigned to the buyer is equal to zero. A buyer's action screen lists the number of units available for sale and the offer price corresponding to each of these units as posted by the sellers. For further details on the trading screen's presentation of information and layout, please refer to the screenshots provided in the subject instructions which are available at the URL given above.

At the end of each session, the subjects are asked to complete a short survey, and then they are paid their cumulative earnings for all 30 trading periods, according to the conversion rate (1 ED = $0.07) announced at the beginning of the session. Table 4 reports the minimum, average, and maximum earnings for each of the 4 treatments. In the DATS treatment, the minimum earnings are $14.25, the average earnings $26.99, the maximum earnings $38.75. Turning to the DATB treatment, the minimum, average, and maximum earnings are $16.75, $27.66, and $35.25, respectively. In the POTS (POTB) treatment, the minimum earnings are $9.25 ($6.75), the average earnings $20.12 ($20.79), and the maximum earnings $40.75 ($38.50). A session takes approximately 2 hours to complete; thus average earnings exceed $10.00 per hour, which is a favorable hourly wage rate for student subjects.

3. Data from the Experiment

We have two questions: Is tax incidence independent of the assignment of liability to pay tax? Is tax incidence independent of the type of market institution? We begin by explaining and interpreting the summary statistics from the four experimental treatments and several graphical summaries of the results generated by the experimental markets. Then, we proceed by examining

the results of K-S tests for two independent samples, using pairwise comparisons of the average buyer prices from the four treatments.[4] We conclude this section by discussing the economic significance of the results.

There is a lot of "noise" in the prices in the initial trading periods, which no doubt reflects the price discovery process. This noise fades away by the 15th trading period. Prices stabilize more rapidly in the DA markets than in the PO markets, which is consistent with previous findings reported in the literature for experimental markets without taxes. A runs test for serial randomness of the price data from the last 15 trading periods fails to reject the null hypothesis of serial independence in 14 out of the 16 cases at a 10 percent significance level.[5] This provides statistical support for our conclusion based on merely looking at the price series in each trading period that prices have converged to their post-tax equilibrium by the 15th trading period. Consequently, we feel justified in using the data from the last 15 trading periods to calculate the average buyer prices to conduct the analysis.

We make pairwise comparisons of the average buyer prices from the four treatments. According to the theory of tax incidence, there should be no difference between the average buyer prices in the two DA treatments and no difference in the two PO treatments.[6]

[4] If two samples are drawn from the same population, the two cumulative frequency distributions would be expected to be reasonably similar. The test protocol for the K-S test of two independent samples is based on the principle that if there is a significant difference at any point along the two cumulative frequency distributions, the researcher can conclude there is a high likelihood the samples come from two different populations. For further details, see W.W. Daniel (1990) and N.V. Smirnov (1939).

[5] For further details on the runs test of serial randomness, see J.H. Zarr (1999).

[6] The choice of buyer or seller prices has no bearing on the inferences drawn from the data. The buyer's price is the amount paid by a buyer for a unit of the fictitious commodity. The difference between the buyer price and the seller price is always equal to the unit tax or 12 ED. The comparisons among buyer prices across the four treatments would be the same if the analysis were conducted in terms of seller prices.

Figure 1 shows the percentage differences in pairwise comparisons of average buyer prices from the four treatments. The average buyer price from the DATS treatment is 1.46 percent greater than that from the DATB treatment. Similarly, the average buyer price in the POTS markets is 1.82 percent greater than the average buyer price in the POTB markets. A comparison of prices between market institutions reveals that the average buyer price is 5.40 percent higher in the POTS than in the DATS markets, and 5.14 percent higher in the POTB then the DATB markets. Clearly, the differences in average buyer prices are greater for the comparisons between market institutions, holding the assignment of the liability to pay tax the same, than for the comparisons between the assignments of the liability to pay tax, holding the market institution the same. These differences might appear to be rather modest; however, as discussed in greater detail below, relatively small differences in buyer prices lead to much larger differences in excess burdens.

To test the standard theory of tax incidence, we use the K-S test for two independent samples. The K-S statistic is a non-parametric test used to compare data collected in two different situations. This statistic is robust to alternative distributional properties of the data, non-normal distributions, and heteroskedasticity. Figures 2 through 5 provide pairwise comparisons of the cumulative distribution functions (CDFs) of average buyer prices from pairwise comparisons of the four treatments. Beneath each figure, we report the maximum difference between the two CDFs and the associated p-value of the K-S test statistic. The p-value is the probability of obtaining a test statistic at least as extreme as the one that is actually observed, assuming that the null hypothesis is true that the two samples are drawn from the same probability distribution.

We begin by examining whether the long-run incidence of a tax in competitive markets is independent of the assignment of the liability to pay tax. Figure 2 compares the CDFs of the average buyer prices from the DATB and DATS treatments. These two CDFs appear to be quite different. In fact, the maximum difference between the two CDFs is 0.6167 (p-value = 0.000), which is statistically different from zero. Thus, we can reject the null hypothesis that the two price series come from identical probability distributions. This finding for the DA treatments is inconsistent with the prediction of the standard theory that the incidence of a tax is independent of the assignment of the liability to pay tax.

Figure 3 makes a similar comparison for the two CDFs of the average buyer prices from the PO treatments. Again, the distributions appear to be quite different. The maximum difference between the two CDFs is 0.433 (p-value = 0.000), which is statistically significantly different from zero. Again, this leads us to reject the hypothesis that the incidence of a tax is independent of the assignment of the liability to pay tax in the PO treatments, too. It is noteworthy that the average equilibrium quantity in the POTS treatment is approximately 10 units rather than the 15 units predicted by the theory. This discrepancy in equilibrium quantities is the result of tax over-shifting, which is particularly interesting in the light of the econometric evidence of tax over-shifting described in section 1 above. In other words, the evidence of tax over-shifting in the POTS treatment in our laboratory experiments is consistent with econometric results based on observational data from the analogous field institution.

Now we turn to our second question: Is the incidence of a tax independent of the type of market institution, holding the assignment of the liability to pay tax the same. Figure 4 compares the two CDFs of the average buyer prices from the DATB and POTB treatments. Again the two distributions appear to be quite different, and, indeed, the maximum difference between the two

CDFs is 0.9833 (p-value = 0.000), which is statistically significantly different from zero. Finally, Figure 5 compares the two CDFs of the average buyer prices from the DATS and POTS treatments. The maximum difference between these two CDFs is 0.9167 (p-value = 0.000), which is also statistically significantly different from zero.

Although these differences are highly statistically significant, it is also important to ascertain whether these differences are economically significant, as well. We use two measures of economic significance, the excess burden as a share of tax revenue and as a share of participant earnings. Table 5 shows the average equilibrium quantity, average buyer price, average excess burden, average excess burden as a percentage of tax revenue, and average excess burden as a percentage of participant earnings. We also report the corresponding values predicted by the theory.

The values in Table 5 reveal stark differences in excess burdens in absolute terms, as a share of tax revenue, and as a share of participant earnings among the four treatments. Consider, for example, that the theoretically predicted value of the excess burden as a percentage of tax revenue is 33.33 percent, as reported in the table. The observed figures for double auction markets are close to this prediction; they are 33.44 percent for the DATB markets and 35.39 percent for the DATS markets. The observed figures are much larger for posted offer markets. The excess burden as a percentage of tax revenue is about 101 percent and 118 percent, respectively, for the POTB and POTS treatments. These differences from the theoretical prediction are very large. In the case of the DATB treatment, at least, the standard theory of tax incidence appears to be vindicated by our findings. Using the DATB treatment as a benchmark for the competitive equilibrium, we also find substantial differences in the pairwise comparisons

of the excess burdens as a share of participant earnings for each of the posted offer market treatments relative to the DATB benchmark.

4. Conclusions

We analyze data from an experiment designed to examine two important questions regarding tax incidence in competitive markets: Is tax incidence independent of the assignment of the liability to pay tax and the type of market institution? We use the K-S test for two independent samples to examine the statistical significance of differences in pairwise comparisons of the CDFs of average buyer prices generated by the four experimental treatments. In contrast to the predictions of the theory, we find that the assignment of the liability to pay tax has a statistically and economically significant effect on the long-run incidence of a tax in competitive markets. We also find that a change in the market institution has a greater impact on tax incidence than a change in the assignment of the liability to pay tax. We report evidence of greater tax shifting when the assignment of the liability to pay tax is on the seller rather than the buyer in both market institutions examined here. Interestingly, we find evidence of tax over-shifting in the case the POTS treatment which is consistent with econometric evidence using observational data from the analogous field institution. Finally, the excess burden created by the unit tax in the DATB treatment is consistent with that predicted by tax theory.

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Table 1: Summary of experimental treatments

Type of market institution	Liability to pay tax	
	on seller	on buyer
Double auction	Double auction, tax on seller	Double auction, tax on buyer
Posted offer	Posted offer, tax on seller	Posted offer, tax on buyer

Table 2: Individual marginal costs and values per unit

Quantity	Marginal cost	Marginal value
1	23	50
1	26	47
1	29	44
1	32	41
1	35	38
1	38	35

Table 3: Demographic characteristics of the full sample and by treatment

Variable	Sample				
	Full	Double Auction		Posted Offer	
		Tax on seller	Tax on buyer	Tax on seller	Tax on buyer
Percent buyers	50	50	50	50	50
Percent freshmen	25	15	30	30	25
Percent sophomore	31	30	30	30	35
Percent juniors	20	28	10	23	20
Percent seniors	22	25	30	18	15
Percent Masters students	2	3	0	0	5
Percent with experience in experiments	76	78	78	75	73
Percent female	59	55	68	63	50
Percent African-American	51	48	43	58	58
Percent Asian-American	4	3	0	5	8
Percent Hispanic-American	2	5	3	0	0
Percent mixed race	8	10	8	10	5
Percent white	20	23	25	20	13
Percent foreign born	15	13	23	8	18
Average age	20	20	20	20	20
Standard deviation of age	2	2	2	1	1
Minimum age	18	18	18	18	18
Maximum age	24	24	24	24	23
Percent business administration majors	28	25	28	43	18
Percent economics majors	6	0	5	3	15
Percent other majors	0	0	0	0	0
Percent with at least 1 economics course	55	53	58	58	53
GPA between 1.25 and 2.74 (percent)	9	8	5	13	13
GPA between 2.75 and 3.24 (percent)	29	48	28	25	18
GPA between 3.25 and 3.74 (percent)	39	30	35	45	45
GPA between 3.75 and 4.0 (percent)	19	10	30	13	23
Not taken courses with grades (percent)	4	5	3	5	3
Number of experimental subjects	160	40	40	40	40

Table 4: Earnings in U.S. dollars, by treatment

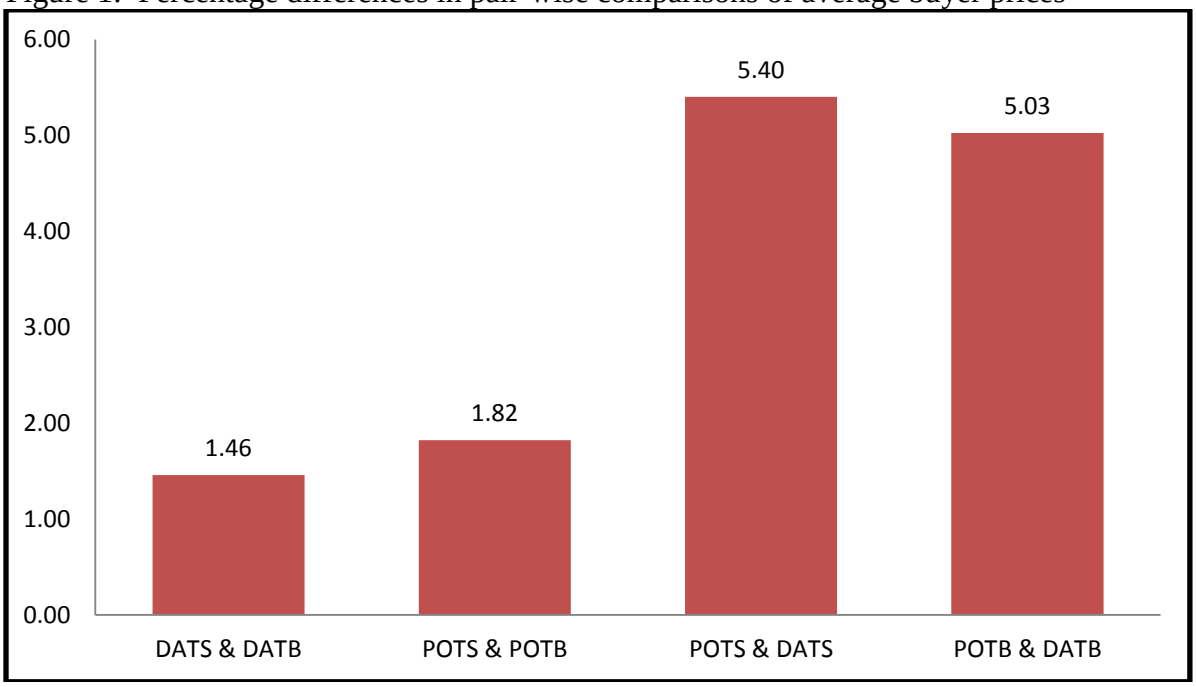
Earnings	Sample				
	Full	Double auction		Posted offer	
		tax on seller	tax on buyer	tax on seller	tax on buyer
Minimum Earnings	$6.75	$14.25	$16.75	$9.25	$6.75
Average Earnings	$23.89	$26.99	$27.66	$20.12	$20.79
Maximum Earnings	$40.75	$38.75	$35.25	$40.75	$38.50

Table 5: Summary statistics of market outcomes, by treatment

Treatment	Equilibrium quantity	Excess burden	Excess burden as a percentage of tax revenue	Excess burden as a percentage of participant earnings
Double auction, tax on buyer	15.10	60.60	33.44	21.91
Double auction, tax on seller	15.03	63.85	35.39	23.65
Posted offer, tax on buyer	11.13	134.70	100.82	64.78
Posted offer, tax on seller	10.40	147.40	118.11	73.26
Value predicted by the theory	15.00	60.00	33.33	-

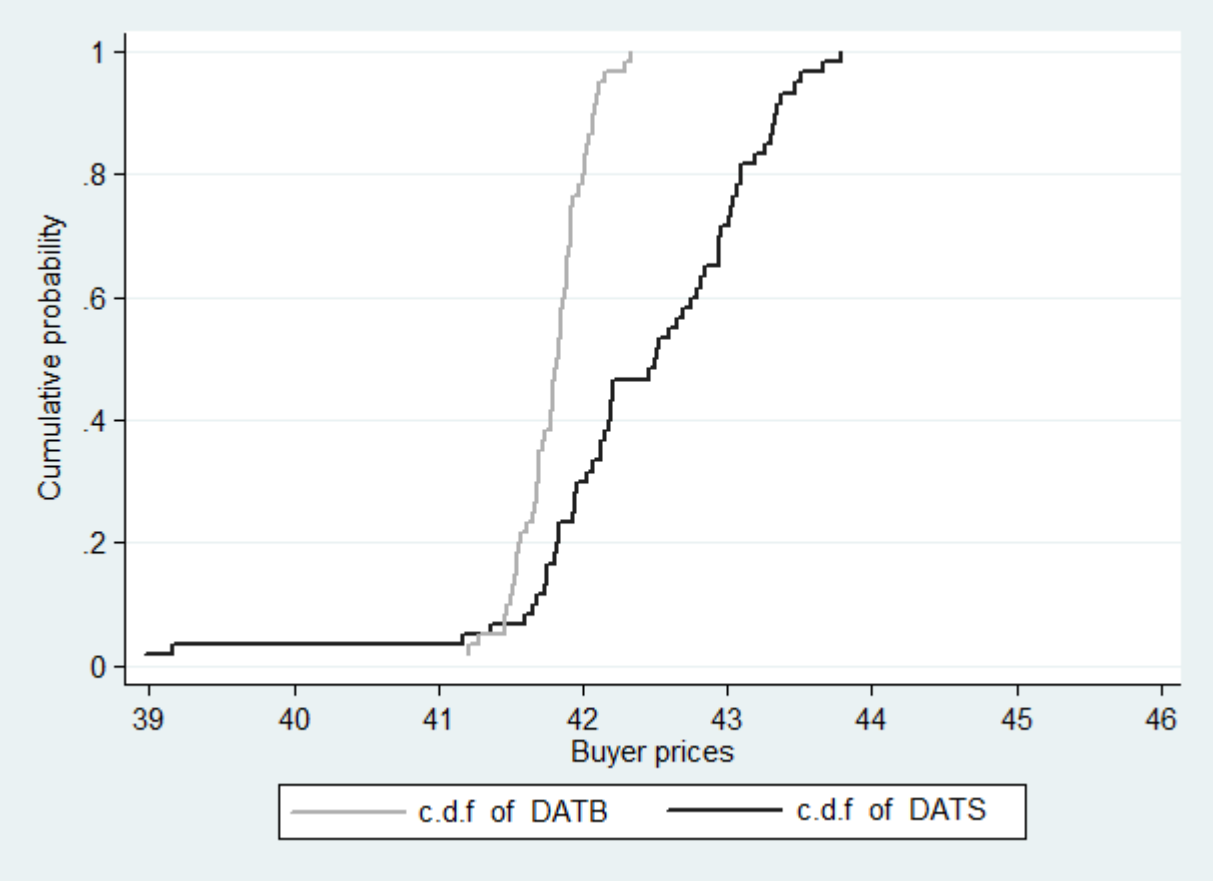
Note: All values, except for those in the last row of the table, are based on average buyer prices from the last 15 trading periods of the four markets associated with each treatment.

Figure 1: Percentage differences in pair-wise comparisons of average buyer prices



Notes: DATB = double auction market with tax on buyer;
DATS = double auction market with tax on seller;
POTB = posted offer market with tax on buyer; and
POTS = posted offer market with tax on seller.

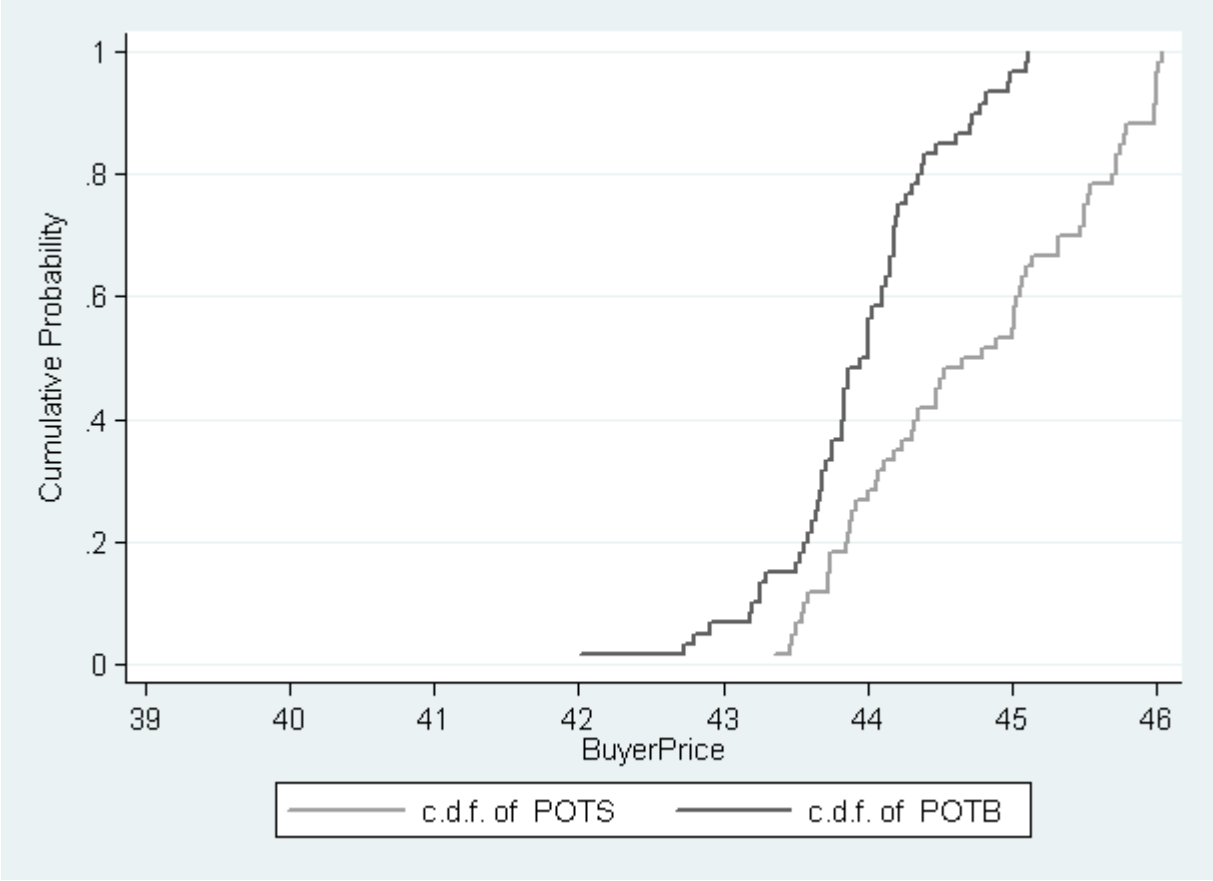
Figure 2: Cumulative distribution functions of the average buyer prices for the two double auction market treatments.



Notes: DATB = double auction market with the tax on the buyer.
DATS = double auction market with the tax on the seller.

Kolmogorov–Smirnov test of the maximum difference between the cumulative distribution functions of the buyer prices of the two double auction market treatments, using the last 15 trading periods. Maximum difference between the two cumulative distribution functions = 0.6167 (p-value = 0.000).

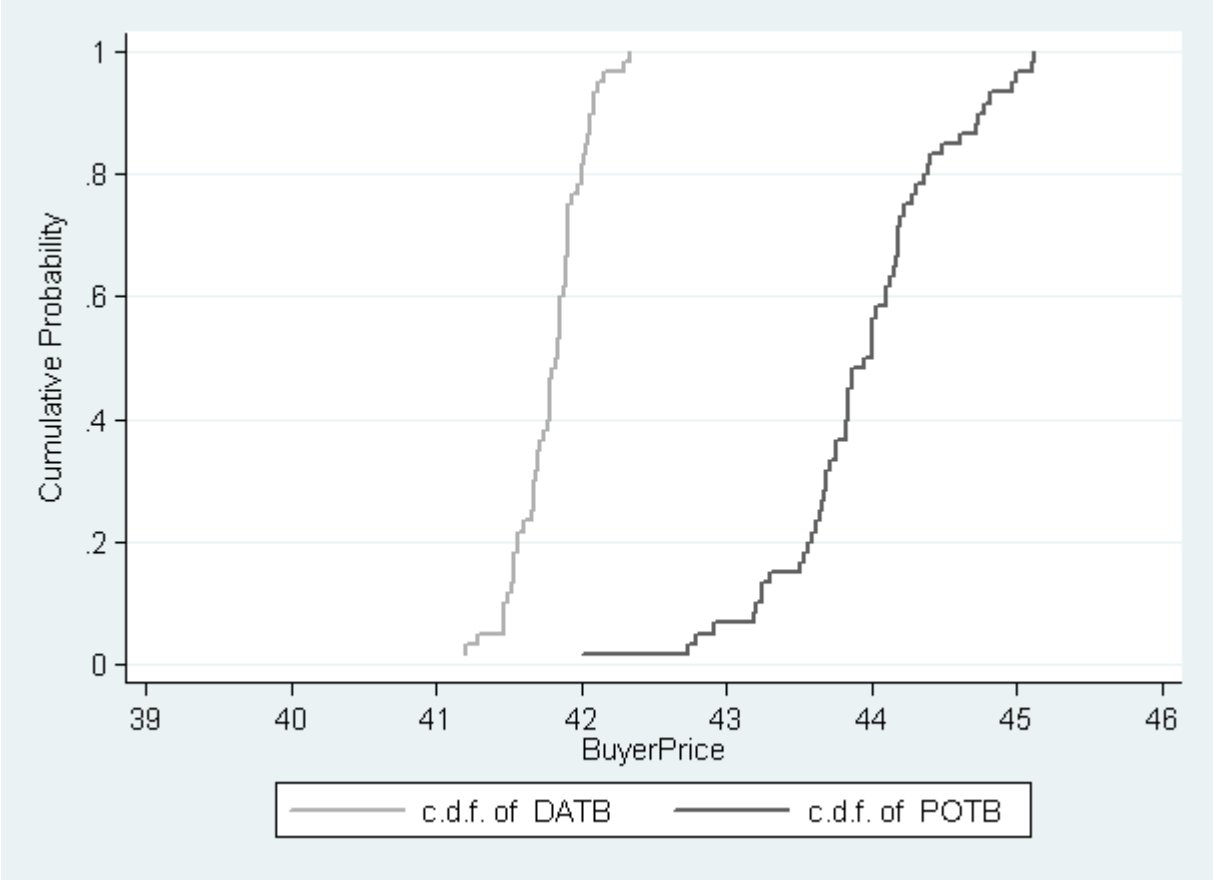
Figure 3: Cumulative distribution functions of the average buyer prices, using the last 15 trading periods of each market session, for the 2 posted offer market treatments.



Notes: POTB = posted offer market with the tax on the buyer.
POTS = posted offer market with the tax on the seller.

Kolmogorov-Smirnov test of the maximum difference between the cumulative distribution functions of the average buyer prices from the two posted offer market treatments, using the last 15 trading periods. Maximum difference between the two cumulative distribution functions = 0.433 (p-value = 0.000).

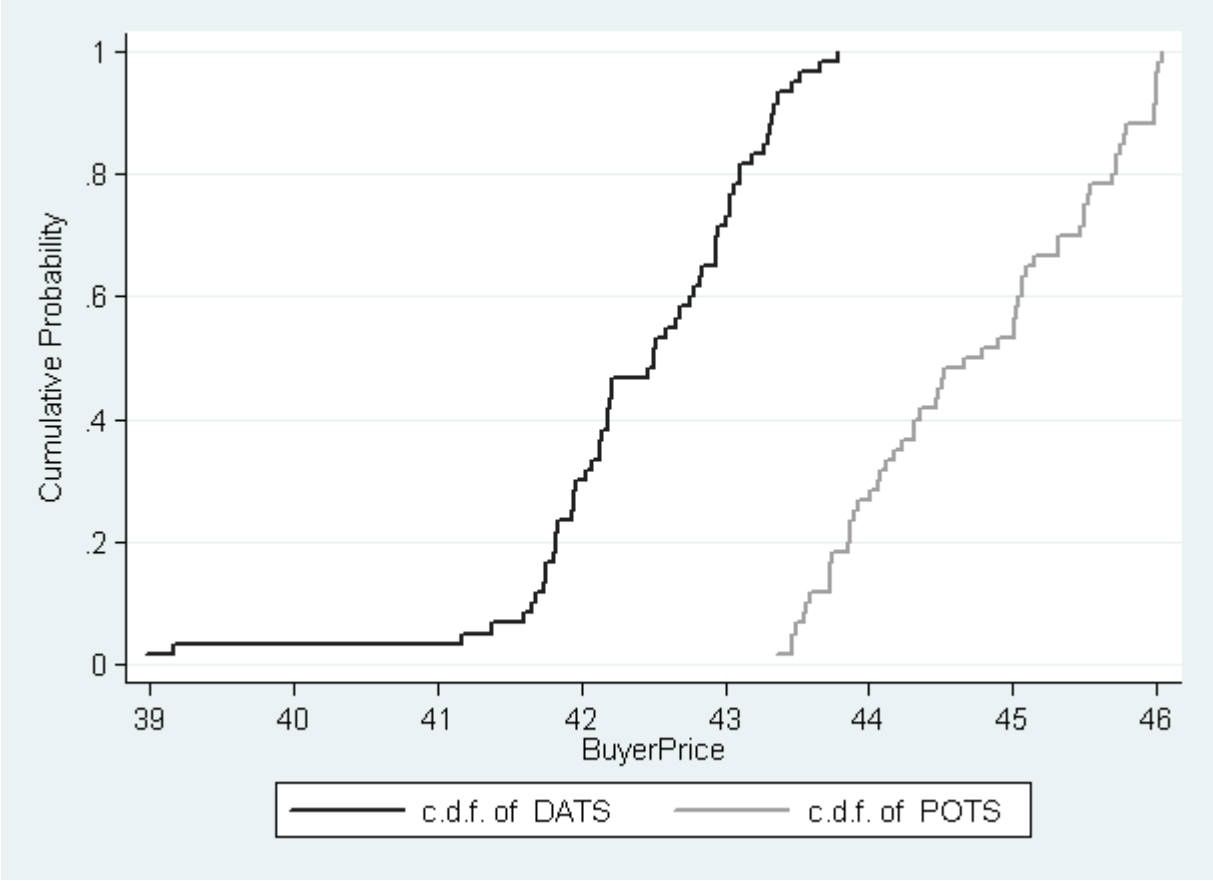
Figure 4: Cumulative distribution functions of the average buyer prices from the double auction and posted offer market treatments with the tax on the buyer.



Notes: DATB = double auction market with the tax on the buyer.
POTB = posted offer market with the tax on the buyer.

Kolmogorov-Smirnov test of the maximum difference between the cumulative distributions of the average buyer prices, using the last 15 trading periods, from the double auction and posted offer markets with the tax on the buyers. Maximum difference between the two cumulative distribution functions = 0.9833 (p-value = 0.000).

Figure 5: Cumulative distribution functions of the average buyer prices for the double auction and posted offer market treatments with the tax on the sellers.



Notes: DATS = double auction market with tax on seller.
POTS = posted offer market with tax on seller.

Kolmogorov-Smirnov test of the maximum difference between the cumulative distribution functions of the buyer prices from double auction and posted offer markets with tax on the sellers, using the last 15 trading periods. Maximum difference between the two cumulative distribution functions = 0.9167 (p-value = 0.000).