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Journal Pre-proof

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PII: S0176-2680(21)00096-3
DOI: https://doi.org/10.1016/j.ejpoleco.2021.102110
Reference: POLECO 102110

To appear in: *European Journal of Political Economy*

Received Date: 27 July 2020
Revised Date: 26 July 2021
Accepted Date: 26 August 2021

Tax Liability Side Equivalence and Time Delayed Externalities[1]

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July 2021

Abstract

Past experimental research suggests that attitudes towards corrective taxes may depend on whether they are levied on the supply side or on the demand side of the market, violating the well-known Tax Liability-Side Equivalence Principle. Other experimental research has shown that consumers are more likely to oppose the introduction of corrective taxes if their benefits occur only in the future. This paper tests whether manipulating the statutory incidence of the tax interferes with the negative delay effect on public support for taxation. Data from our experiment show that the delay effect is robust regardless of the statutory incidence of the tax.

JEL codes: D03, D62, D72, H23

Keywords: tax liability side equivalence, stock externalities, support for taxation, intertemporal choice

[1] We gratefully acknowledge the Australian Research Council Discovery Project (DP160102743) for funding this research. We thank participants at the 9th Southern European Experimental Team (SEET) Workshop, Lecce (I) 23-25 February 2018 for useful comments.

1 INTRODUCTION

A major impediment to the introduction of efficiency-enhancing taxes, such as a carbon tax, is their low public support. While general distaste for taxation may explain low support for Pigouvian taxes[2], an important feature of climate change related taxes, compared to other environmental taxes[3], is that their benefits (e.g. clean air) are only experienced some time after the tax is paid. Tiezzi and Xiao (2016) provide experimental evidence that consumers are generally less willing to support a taxation policy aimed at reducing consumption externalities when the latter occur sometime after consumption (i.e. when the benefit of tax is delayed). In that study, the tax was imposed on the demand side. In practice, however taxes can be levied on both consumers and suppliers. For example, while resource production taxes in China and taxes on coal production levied in Australia are implemented upstream (Richter et al. 2018), carbon pricing schemes are often imposed midstream, on large industrial point sources of emissions as in the European Union (EU) Emission Trading System (ETS). In countries such as Finland, Denmark, Sweden, Norway, The Netherlands, Ireland, Great Britain, these taxes tend to be levied downstream under the "polluter pays principle" with exemptions and allowances for specific household types (Zhang and Wang 2017). This raises the question whether the delay effect persists when the tax is levied on the supply side.

The Liability-Side Equivalence (LSE) Principle establishes that the economic incidence of a tax, i.e. who ultimately bears the burden of the tax, is independent of the side of the market the tax is levied on, implying that public attitudes towards taxation should not be affected by the side of the market that is taxed. The violation of LSE, however, has been observed in market experiments with negative externalities (Sausgruber and Tyran 2005 and 2011). Consumers suffer from a tax-shifting bias, i.e. they more likely to support taxes levied on the supply side than taxes levied on the demand side. This experimental literature has considered only static environments without any time delay of the negative externality. It is possible that the violation of LSE as a framing effect is not sufficient to overcome the negative delay effect on support for taxation.

[2] Such as distrust in government (Rivlin 1989; Dresner et al. 2006); worldviews (Cherry, Kallbekken, and Kroll 2017); and tax aversion (Kallbekken, Kroll, and Cherry 2010; Blaufus and Möhlmann 2014).

[3] With respect to congestion charges or garbage taxes, for example, the empirical evidence shows an immediate reassessment of people's beliefs, and an increase in public support for these charges, right after implementation (Börjesson et al 2012; Eljasson and Jonsson 2011).

The delay of the negative externality is not a simple change of frame. With delayed externalities, the decision to support the tax becomes an intertemporal choice rather than a static one. Tiezzi and Xiao (2016) show that the intertemporal structure of the externalities increases the perceived complexity of decision-making in the market and leads to narrow bracketing, i.e. basing today's decisions mainly on today's payoffs with little regard for future payoffs (Rabin and Weizsäcker 2009). The reason is that in the delay condition decision-makers' current consumption choices affect each other's current and future payoffs and, as a result, the intertemporal trade-off of one's decision making is not that clear. This is in contrast with simple individual intertemporal decision-making, where one's future payoffs depend on one's own decisions only.

Indeed, while experiencing the tax leads to more consistency with LSE (Sausgruber and Tyran 2011), the delay effect remains even after individuals have experienced the tax institution (Tiezzi and Xiao 2016). Thus, the delay effect may persist when the tax is levied on the supply side of the market.

To examine whether the delay effect varies based on the side of the market the tax is levied on, we conduct an intertemporal market experiment on public support for taxes (Kallbekken, Kroll, and Cherry 2011; Sausgruber and Tyran 2005; Cherry, Kallbekken, and Kroll 2014; 2017; Tiezzi and Xiao 2016). Participants can earn money by purchasing a hypothetical consumption good in the market. Consumption, however, imposes a negative cost on everyone in the market. We manipulate the timing of the externality and introduce opportunities for buyers to vote on whether to introduce a tax on consumption. The experiment adopts a two-by-two design, which manipulates whether the externality is delayed (No Delay vs. Delay) and whether the tax is levied on the demand or on the supply side of the market (Buyer tax vs. Seller tax).

We first replicated the delay effect observed in Tiezzi and Xiao (2016) when the tax is levied on buyers in the No Delay conditions. When we examine the treatments where the tax is levied on sellers, we find that the delay effect remains significant. The difference-in-difference test shows that the size of the delay effect does not differ between the Buyer tax and the Seller tax treatments. Our findings highlight the importance of the timing of the tax benefits in attitudes towards taxation irrespective of the statutory incidence of the tax.

The rest of the paper proceeds as follows. Section 2 provides some background to the choice between demand side versus supply side environmental taxes and a review of previous experimental papers on LSE. Section 3 describes the experimental design and procedures. Section 4 reports on the presence of tax-shifting bias and delay effect. Section 5 concludes.

2 BACKGROUND

Previous research on the LSE has suggested the possibility for the policy makers to increase public support for taxation by manipulating the statutory incidence of the tax in designing a new tax institution, e.g. levying a carbon tax on the supply side of the market rather than on the demand side (Gamage and Shankske 2011).

Results from a sizable experimental work on LSE in various environments are, however, not conclusive. Kachelmeier *et al.* (1994), Borck *et al.* (2002), and Ruffle (2005) have shown that LSE holds in competitive goods markets, irrespective of the exact price formation mechanism. Riedl and Tyran (2005) and Menges and Traub (2008) also report the LSE to hold even though their setup does not involve competitive markets. Kerschbamer and Kirchsteiger (2000) observe that violations of LSE are more likely in in markets that are not perfectly competitive but rather characterized by bargaining. In the context of a modified one-stage ultimatum game, which can be thought of as a very simple bargaining situation, they find robust evidence against LSE. They argue that whether the LSE holds depends on the strength of the market forces and a violation is more likely when non-market factors such as social norms play a role in determining prices.

Sausgruber and Tyran (2005 and 2011) find evidence that subjects are prone to a tax-shifting bias but tax experience may lead to a correct tax perception. Cox *et al*. (2018) and Morone *et al*. (2016) examining tax incidence in posted offer markets and in double auction markets, respectively, show that LSE does not hold. Finally, Weber and Schram (2017) compare a labor market tax levied on employers and a corresponding income tax levied on employees and find that LSE does not hold when agents are boundedly rational.

To summarize, LSE seems to hold when markets work well, are simple and relatively transparent. In fact, taxation in the real world is relatively more complex, markets are usually not so simple and transparent, and prices do not freely adjust to changes in demand or supply. In real world contexts economic agents may be more sensitive to the statutory incidence of taxation than predicted by public economic theory. This hypothesis, however, has not been tested in inter-temporal environments.

In the context of climate change related taxes, whether to tax greenhouse gases upstream (on the supply side) or downstream (on the demand side) is a debated issue. For carbon emissions from fossil fuels, there is a perfect correspondence between input and output. Therefore, it makes no difference to tax the input (the fossil fuel), or the output (the emission) (Metcalf and Weisbach 2009). Thus, if LSE holds, carbon taxes could be levied upstream in the fossil fuel supply chain to minimize collection and monitoring costs, and to ensure maximum coverage. Upstream taxation might achieve these goals as there are far fewer upstream producers than downstream consumers, and because of economies of scale in tax administration (Metcalf and Weisbach 2009). In addition, supply side measures may increase moral pressure and public support for climate action, because they target a narrower set of actors compared to demand side policies (Collier and Venables, 2014). Moral pressure is essential for governments to adopt economic incentives to change behaviour, but the diffuse and very large number of actors and actions required by demand-side policies means there is very little moral pressure on decision-makers to act. On the other hand, upstream imposition could engender strong opposition from politically powerful coal, oil and gas lobbies which is one reason why supply side policies are less widespread (Lazarus *et al.* 2015). Arguments for downstream imposition of the tax tend to be based on the claim that a downstream tax is more visible or salient and will therefore have a greater effect if consumers' responses depend on tax visibility. In practice, real climate pricing policies tend to address the demand for fossil fuels, electricity, or vehicles (de Mooij *et al.* 2012) and are often levied midstream on CO_2 emissions released from major industrial smokestacks as in the EU ETS.

This paper informs this debate and offers additional insights on how to increase public support for taxation and on the presumed greater political palatability of demand measures compared to supply side ones. If the delay effect drops in the supply side tax frame, then the greater political palatability of demand measures compared to supply side ones would be called into question. On the other hand, finding no difference between the two tax frames, suggests that policy makers may instead focus on aspects other than the statutory incidence of the tax.

3 EXPERIMENTAL DESIGN

We first replicate the delay effect reported in Tiezzi and Xiao (2016) in which the tax is levied on buyers. The two Buyer tax treatments (BuyerTax_NoDelay and BuyerTax_Delay) are basically the same as the Delay and No Delay treatments in that paper (more detail on the rationale of some design specifics can be found in Tiezzi and Xiao (2016)). Then we describe the two new treatments where the tax is levied on sellers (SellerTax_NoDelay and BuyerTax_Delay).

3.1 Buyer tax treatments

The treatments are based on a simple uniform-price, multi-unit auction market with externalities. A market consists of four buyers and one automated seller. Buyers earn money by trading up to three units of a hypothetical consumption good in their market. They are informed of the resale value of each unit (160, 110 and 70 points, respectively) and told that the seller's marginal cost remains constant throughout the experiment. When an auction starts, each buyer posts a bid for each of the three units and the bid for a unit is capped at its resale value. Sellers have a per-unit production cost of 40 points (unknown to buyers). Sellers accept all bids greater than or equal to the per-unit production cost and all accepted units are sold at the market price (the lowest accepted bid). Each buyer's gross income for each purchased unit equals the difference between its resale value and the market price. Units that are not traded yield zero income.

Each traded unit generates an external cost of 60 points shared equally by all buyers in the market. That is, regardless of who gets the unit, each buyer in that market bears a cost of 15 points. We manipulate the timing of the externality. In the BuyerTax_NoDelay treatment, the costs are deducted immediately from the current earnings from trading collected at the end of the session. In the BuyerTax_Delay treatment, the external costs are deducted from the buyers' future earnings - an endowment of $18 - to be collected one week later [4]. This is the only difference between the two treatments.

This market is repeated for two practice periods and ten paying periods. At the end of each period, participants receive full history feedback including the market price, market quantity, their bids, per-capita external costs, per-period earnings and cumulative earnings for the day of the experiment and one week later. The values of the parameters are designed so that at market equilibrium (both in the Delay or No Delay treatments), all buyers purchase all three units at a price of 40 points, although the socially optimal outcome is when every buyer only purchases two units. In particular, as shown in Tiezzi and Xiao (2016), this equilibrium holds in the Delay condition unless buyers have extremely high discount rates (i.e. higher than 100%).

[4] The endowment of $18 was chosen such that the total amount of possible deductions throughout the experiment would not result in negative earnings.

Before the start of the 11th period, participants learn that they have the opportunity of introducing a Pigouvian tax through a voting mechanism. The tax is revenue neutral: a tax of 60 points (equal to the per-unit external cost) for each traded unit is imposed on either buyers or sellers; then an equal share of the total tax revenues is returned to each buyer.

In the ballot, all participants simultaneously vote yes or no on the introduction of the tax; abstentions and neutral votes are not possible. The tax is implemented in a market for the following trading periods if at least two buyers in the market vote yes. After all buyers cast their votes, acceptance or rejection of the tax is revealed, though individual votes are kept secret. The voted tax regime is effective for the next five periods (11th to 15th).

In addition to voting yes or no, we assess the degree of support by asking participants to choose one from the following eight options: Don't Know; Indifferent; Somewhat Yes (No); Moderate Yes (No); Strong Yes (No). In the 16th period, all buyers are again prompted to vote on the tax and declare their degree of support. The outcome of the second ballot is effective for the final five periods (16th to 20th).

Tiezzi and Xiao (2016) show that, comparing the payoff with and without the tax, each buyer could earn more with the tax in the BuyerTax_Nodelay treatment. The same prediction holds in the BuyerTax_Delay treatment as long as the time discounting rate is not unreasonably high[5]. Assuming that buyers seek to maximize their profit, they should support the tax in both treatments.

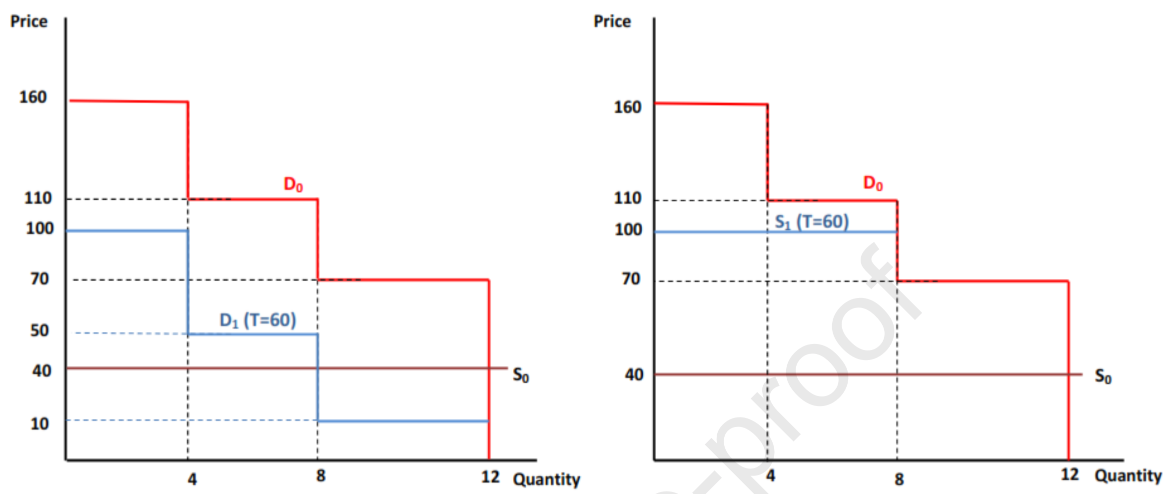
3.2 Seller tax treatments

The two Seller tax treatments differ from the Buyer tax treatments only in that buyers are told that the tax is imposed on sellers. Specifically, buyers are told that if the tax is introduced, sellers' production cost for each traded unit increases by 60 points. The right panel in Figure 1 shows the implication of buyer and seller taxes on market equilibrium. The left panel shows that the tax shifts the demand function down from D_0 to D_1. The right panel shows that the tax shifts the supply function up from S_0 to S_1. In both cases, the socially optimal outcome is reached with taxes at market equilibrium.

[5] In the experiment conducted in Tiezzi and Xiao (2016), they measured participants' one-week discount rate using a simplified version of the basic experimental design introduced by Coller and Williams (1999). Most participants displayed a one-week discount rate in the range 1%-20%, far lower than 100%.

Figure 1: Induced market demand and supply

(a) Buyer tax **(b)** Seller tax



Like the two Buyer tax treatments, the SellerTax_NoDelay treatment differs from the SellerTax_Delay treatment in that the external costs are immediately paid in the No Delay condition, while they are delayed and deducted from earnings one week later in the Delay condition.

We emphasize that both types of taxes are transaction taxes depending only on the number of units traded, not on their resale values. The tax rates are also the same, regardless of whether the tax is levied on buyers or sellers. Thus, the expected profit for buyers is the same regardless of the liability side of the market. Hence, Tax Liability Side Equivalence holds at market equilibrium.

3.3 Procedure

At the beginning of a session, participants were randomly assigned to markets and remained in the same market throughout the experiment. The first set of instructions for the two practice periods and the first ten trading periods was distributed to participants in paper form and read aloud by the experimenter. Participants were not informed about the voting stage until they reached the end of the 10th trading period, when the second set of instructions was distributed and again read aloud by the experimenter. To ensure that participants understood the instructions, they were asked to answer a comprehension quiz after reading each set of instructions. A post-experiment questionnaire was administered at the end of the 20th period.

To manipulate the timing of the externality and the benefit of the tax, we told participants at the beginning of the experiment that in addition to accumulated earnings from trading, they would receive an additional $18 cash payment minus costs incurred in the experiment exactly one week later. To receive this additional money, participants had to return to the lab exactly one week after the end of the experiment; on that occasion they did not have to perform any additional task. To minimize any credibility concerns on money collection, at the end of each session, participants each received a "payment certificate" signed by the experimenter. The certificate indicated the amount to be received, the date, time and location for collection of the payment, and the contact details of the experimenter, including office address, telephone and email address. The day before the scheduled pickup, participants received an email reminder.[6] The timeline of the experiment is illustrated in Figure A.1 of Appendix A.

Table 1: Experimental treatments

	BuyerTax_ NoDelay	BuyerTax_ Delay	SellerTax_ NoDelay	SellerTax_ Delay
# of Participants	64	60	64	60
# of Markets	16	15	16	15
Female	56%	47%	56%	48%

Sixteen computerized sessions programmed in z-Tree (Fischbacher 2007) were conducted at the Monash Laboratory for Experimental Economics (MonLEE) with a total of 248 participants (52% female). Each participant could only participate in one of the four treatments. Table 1 shows the number of participants and gender ratio by treatment. Earnings were expressed in experimental points and exchanged for cash at $1(Australian dollars) per 200 points. A typical session lasted around 2 hours with 16 or 20 participants earning on average $28 including a $5 show-up fee. All instructions are reproduced in Appendix B.

[6] To minimize any transaction costs implied by going back to the lab, participants were given the possibility of rescheduling the pickup time or pickup day. Participants could also send someone else on their behalf, to pick up their second payment.

Note that the data reported in Tiezzi and Xiao (2016) were collected in a major university in the United States. By conducting the same Buyer tax treatments in a major university in Australia, we can also have a robustness check of the previous findings of the delay effect.

4 RESULTS

We begin with a brief account of the trading behaviour. Then we turn to the voting behaviour, which is our main research interest. We first demonstrate that the delay effect is robust irrespective of the tax type. We then examine the learning effect by testing the effect of tax experience on future voting behaviour.

4.1 Trading activity

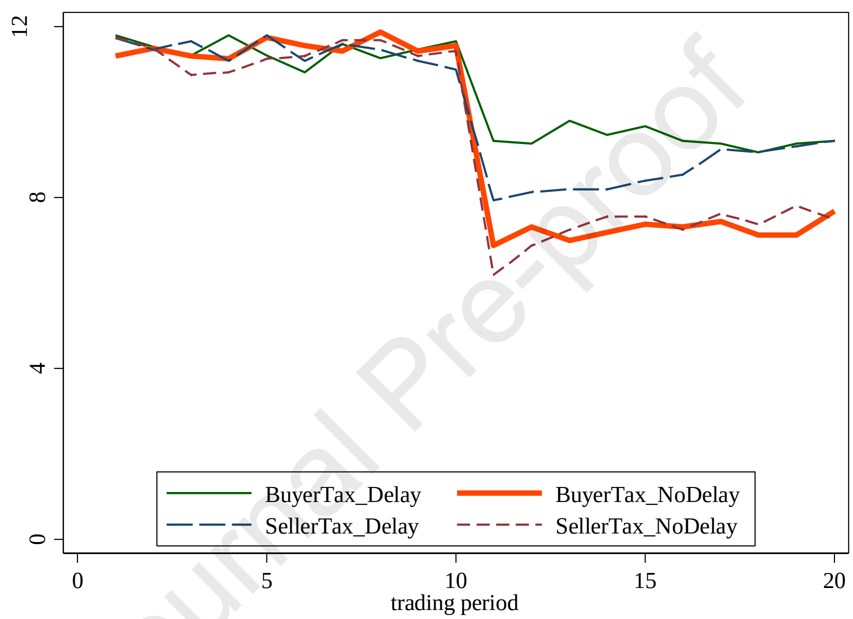
Figure 2 shows the average market quantity in the first 10 trading periods in the four treatments. The average market quantity in the first 10 trading periods was about 11 in all the four treatments. After the first ballot, the market quantity drops significantly and gets close to the efficient level of eight units in both BuyerTax_NoDelay and SellerTax_NoDelay treatments.

Consistent with Tiezzi and Xiao (2016), when the tax is levied on the buyers, the average market quantity in trading periods 11 to 15 is significantly higher when the externality is delayed 7.15 vs 9.51, $p = 0.019$, Wilcoxon rank-sum test) and such a difference remains in periods 16 to 20 (7.34 vs 9.25, $p = 0.064$).[7] When the tax is levied on the seller, the average market quantity is also higher in the Delay condition although the difference is no statistically significant in periods 11 to 15 (7.09 vs 8.17, $p = 0.524$), and is marginally significant in periods 16 to 20 (7.51 vs 9.05, $p = 0.079$). This seemingly reduced delay effect on the market quantity in the Seller Tax condition is due to more markets introducing the tax levied on sellers compared to that levied on buyers in the Delay condition (SellerTax_Delay: 10 out of 15 markets introduced the tax after the first ballot; BuyerTax_Delay: 7 out of 15 markets introduced the tax after the first ballot). Thus, the market quantity in the SellerTax_Delay treatment in periods 11 to 20 is lower than that in the BuyerTax_Delay treatment, though not a significant difference (8.61 vs 9.38, $p = 0.135$). However, as the tax is introduced as long as at least two buyers vote yes, this difference in market quantity does not necessarily mean that the seller tax frame reduces the negative delay effect on the support

[7] When comparing market quantity and degree of support data, we use the Wilcoxon rank-sum test. We use the Fisher's exact test when comparing support rate.

rate. To see this, suppose that among the larger number of markets adopting the tax in SellerTax_Delay, these markets might in fact have on average only two Yes votes, whereas the markets adopting the tax in BuyerTax_Delay, albeit fewer in total number, might have on average three Yes votes. Thus, the larger number of tax-adopting markets in SellerTax_Delay does not necessarily translate into higher overall support rate.

Figure 2: Average market quantity by treatment



4.2 Delay effect

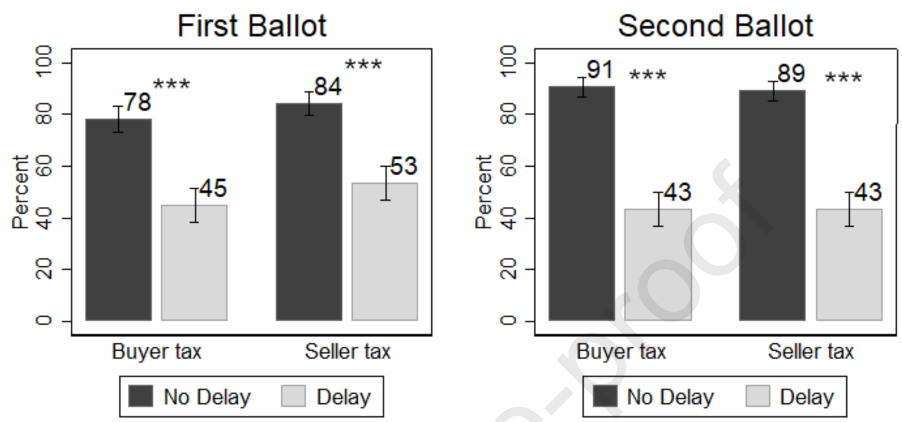
Buyers' voting decisions after 10 trading periods, which revealed their tax attitude, were the main variable of interest. We also obtained data on buyers' degrees of support. This additional data revealed finer details of changes in attitudes towards the tax. Degree of support was rated on a 7-point scale from 0 (Strong No) to 6 (Strong Yes).[8]

Our main research question is whether the delay effect on support for taxation varies based on the side of the market the tax is levied on. We first checked whether the delay effect observed previously in the experiment conducted in the US was replicated in our experiment conducted in Australia. We then examined the delay effect on support for the supply side tax. We began with the inexperienced voters in the first ballot and then examined behaviour in the second ballot to

[8] We also allowed participants to select "Don't Know". 16 buyers chose this option. We excluded these 16 buyers when analyzing degree of support.

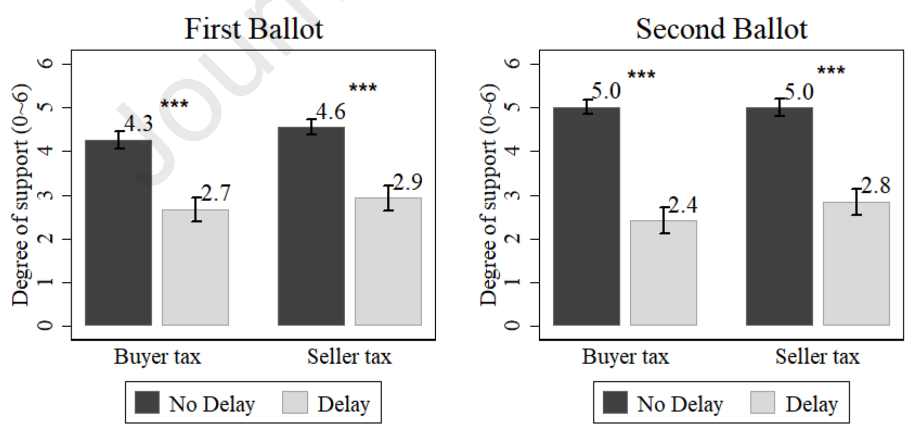
shed light on the effects of learning from experience. Figures 3 and 4 plots the average tax support rate (proportion of Yes votes) and degree of support respectively in each treatment and in each ballot. Error bars represent one standard error of the mean.

Figure 3: Tax support rate by treatment



Note: *** denotes 1% significance level for the Fisher's exact test comparing tax support between Delay and No Delay conditions for a given tax frame.

Figure 4: Degree of support by treatment



Note: *** denotes 1% significance level for the Wilcoxon rank-sum test comparing degree of support between Delay and No Delay conditions for a given tax frame.

The comparisons of the two columns on the left in each panel of Figure 3 show that we replicate the previous delay effect observed when tax is levied on the buyers in Tiezzi and Xiao (2016). In the first ballot, the support rate is significantly lower in the Delay than in the No Delay condition (78% vs. 45%, $p < 0.001$, Fisher's exact test). Although the support rate goes up in the second ballot in the No Delay condition, it remains low when the externality is delayed. As a result, the delay effect persists in the second ballot (91% vs. 43%, $p < 0.001$). Using data about the degree of support, we observe a very similar pattern of the delay effect (see Figure 4).

Data from the two Seller Tax treatments show a very similar pattern of the delay effect. The two columns on the right in the first panel of Figure 3 show that there is a significant negative delay effect on the support rate in the first ballot (84% vs. 53%, $p < 0.001$). The delay effect remains significant in the second ballot (89% vs. 43%, $p < 0.001$). Again, data about the degree of support suggest a very similar pattern of the delay effect (see Figure 4). We will examine the learning effect in more details in Section 4.3.

Another observation from Figure 3 is that the tax-shifting bias does not appear in either the Delay or the No Delay conditions, both in the first ballot and the second ballot. First, the support rate is about the same whether the tax is levied on sellers or buyers (first ballot: No Delay: 84% vs 78%, $p = 0.498$; Delay: 53% vs 45%, $p = 0.465$; second ballot: No Delay: 89% vs 91%, $p = 1.000$; Delay: 43% vs 43%, $p = 1.000$, Fisher's exact test). Likewise, Buyer Tax and Seller Tax receive about the same the degree of support in all the pairwise comparisons (first ballot: No Delay: 4.6 vs 4.3, $p = 0.329$; Delay: 2.9 vs 2.7, $p = 0.470$; second ballot: No Delay: 5.0 vs 5.0, $p = 0.448$; Delay: 2.8 vs 2.4, $p = 0.259$, Wilcoxon rank-sum test). In this regard, our data are more in line with the literature that supports the Liability-Side Equivalence Principle. The absence of the tax-shifting bias is in contrast to the robustness of the delay effect in both Buyer Tax and Seller Tax treatments. It suggests that even when people have the knowledge to act consistently with the Liability-Side Equivalence Principle, they may still not be able to understand the intertemporal trade-off underlying the choice of supporting or rejecting the tax.

As a further comparison of the delay effect between the Buyer Tax and Seller Tax conditions, we conducted a difference-in-difference regression analysis. Specifically, we ran a linear probability regression in which the probability of voting in favour of the tax was regressed on treatment dummies using BuyerTax_NoDelay as benchmark.[9] Similarly, we ran an OLS regression in which the degree of support was the dependent variable. Table 2 reports the results. Consistent with the findings above, results from the two regressions show that there is a significant

[9] Table A2 in Appendix A reports a corresponding Probit regression and the estimates are similar.

delay effect in both the Buyer Tax (β_1 is significantly negative, $p < 0.01$) and the Seller Tax conditions (H_0: $\beta_2 = \beta_3$ is rejected, $p < 0.001$). The key difference-in-difference hypothesis tests of the delay effects between the buyer and the seller tax frames are reported in the last row (H_0: $\beta_2 - \beta_3 = \beta_1$), which suggests that the delay effect did not differ between the buyer and seller taxes.

Table 2: Voting behaviour in the first ballot

	(1) Vote	(2) Degree of support
β_1: BuyerTax_Delay	-0.359***	-1.686***
	(0.100)	(0.351)
β_2: SellerTax_Delay	-0.241***	-1.324***
	(0.077)	(0.315)
β_3: SellerTax_NoDelay	0.092	0.380
	(0.074)	(0.293)
Constant	0.806***	4.271***
	(0.062)	(0.203)
N	248	232
R^2	0.160	0.201
H_0: $\beta_2 = \beta_3$	$p < 0.001$	$p < 0.001$
H_0: $\beta_2 - \beta_3 = \beta_1$	$p = 0.866$	$p = 0.971$

Note: The BuyerTax_NoDelay treatment serves as the benchmark. Both models are estimated using OLS regressions. Robust standard errors are clustered at the group/market level. Both regressions additionally control for sex, political view (liberal vs. conservative) and whether a subject is an economics major. *** $p < 0.01$

4.3. Learning

We conduct a regression analysis to further explore the role of tax experience on individual voting decisions. The dependent variable is whether the buyer voted "yes" in the second ballot. The explanatory variable is whether the tax is implemented in the buyer's market between periods 11 and 15 as a result of the first ballot. We allow different coefficients for each treatment. For example, for the BuyerTax_Delay treatment, we define a binary variable BuyerTax_Delay _TaxExper, which equals 1 if the buyer has experienced the tax between periods 11 to 15 and 0 otherwise. Results using OLS are shown in Table 3. The results from a corresponding Probit regression are shown in Table A3 in Appendix A.

Table 3 shows that in the No Delay conditions tax experience increases tax support in the second ballot, irrespective of tax frames (both β_2 and β_4 are significantly positive, $p < 0.001$). This finding is consistent with previous research showing that market experience eliminates market anomalies (Smith, Suchanek, and Williams 1988; Tyran and Sausgruber 2005). By contrast, in the Delay conditions tax experience insignificantly decreases tax support in the second ballot, irrespective of tax frames (both β_1 and β_3 are insignificantly negative). The absence of positive tax experience effect in the Delay conditions could be explained by the possibility that buyers find their *current* earnings decreasing when the tax is implemented, even though the external costs deducted from next week's earnings are smaller. If buyers are affected by narrow bracketing (Rabin and Weizsäcker 2009) and focus on current earnings, they might continue to vote "no" in the second ballot.

Thus, in both the Seller Tax and the Buyer Tax conditions, the positive effect of learning is significantly diminished when the externality is delayed. The difference-in-difference tests reported at the bottom of Table 3 (H_0: $\beta_1 - \beta_2 = \beta_3 - \beta_4$) show that there is no significant difference in the delay effect on learning between the Buyer Tax and the Seller Tax conditions.

Table 3: Impact of tax experience on the second vote

	Second vote Yes
β_1: BuyerTax_Delay_TaxExper	-0.162
	(0.102)
β_2: BuyerTax_NoDelay_TaxExper	0.422***
	(0.068)
β_3: SellerTax_Delay_TaxExper	-0.079
	(0.095)
β_4: SellerTax_NoDelay_TaxExper	0.397***
	(0.073)
Constant	0.398***
	(0.110)
N	248
R^2	0.275
H_0: $\beta_1 - \beta_2 = \beta_3 - \beta_4$	$p = 0.406$

Note: BuyerTax_NoDelay_TaxExper = 1 if buyer *i* in BuyerTax_NoDelay traded with tax between periods 11 and 15; =0, otherwise. BuyerTax_Delay_TaxExper = 1 if buyer *i* in BuyerTax_Delay traded with tax between periods 11 and 15; =0, otherwise. SellerTax_NoDelay_TaxExper = 1 if buyer *i* in SellerTax_NoDelay traded with tax between periods 11 and 15; =0, otherwise. SellerTax_Delay_TaxExper =1 if buyer i in SellerTax_Delay traded with tax between periods 11 and 15; =0 otherwise. The model is estimated using the OLS regression. Robust standard errors are clustered at the group/market level. The regression additionally controls for sex, political view (liberal vs. conservative) and whether a subject is an economics major. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5. CONCLUSION

One of the main impediments to the introduction of efficiency-enhancing policy measures in presence of negative externalities is the low public support for taxation. In a past study, we show that consumers are less willing to support corrective taxes when externalities (or tax benefits) occur with real time delay. In this study we conducted controlled laboratory experiments to investigate whether the previously observed delay effect on public support for Pigouvian taxation was phased out when the tax was levied on sellers. Our research question is inspired by recent findings in experimental public economics suggesting that public support for taxes is higher when the liability side of the tax is moved to the other side of the market. This opens up the possibility that the importance of factors shown to influence public support for taxation, such as the intertemporal delay of the tax benefit, may vary based on whether the tax is levied on the supply or on the demand side of the market.

We found that the delay effect is a robust phenomenon regardless of the side of the market the tax is levied on, and despite learning effects, which are significantly diminished when the externality is delayed. This finding suggests that levying the tax on the supply side of the market may have limited success in a dynamic setting with delayed taxation benefits. One possible explanation of our findings is that the impact of real delays in taxation benefits crowds out any framing effect due to manipulations of the side of the market the tax is levied on.

One reason for preferring demand side carbon taxes to supply side ones is their presumed higher political palatability, due to their higher visibility. Still one major impediment to the introduction of carbon taxes worldwide remains their low public support. We show that the delay of the externality plays a major role in the opposition to the tax, the impact of which cannot be reduced by simply manipulating the statutory incidence of the tax. Institutions should focus on improving the understanding of the intertemporal trade-offs implied by carbon taxes to increase their public support. In our experiment producers are automated. Whether real producers would narrow bracket less (and thus displaying a smaller delay effect) than real consumers is an interesting avenue for future research that could further inform the debate on demand side versus supply side policy measures.

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Appendix A

Figure A1: Timeline of the experiment

Timeline

First day	Period 1~10	In each period: Each buyer can trade up to three units of the good.
	At the beginning of period 11	First ballot (without knowing about the second ballot) ↓ Each buyer votes Yes or No to the tax. ↓ Each buyer indicates his/her degree of support. * ↓ Each buyer is informed whether the tax will be implemented in subsequent periods.
	Period 11-15	In each period: Each buyer trades on the market with or without tax depending on the voting outcome.
	At the beginning of period 16	Second ballot Same as first ballot.
	Period 15-20	In each period: Each buyer trades on the market with or without tax depending on the voting outcome.
One week later		Participants pick up additional earnings: • $18 under No Delay conditions • $18 minus the total external cost produced under Delay conditions.

* The timeline is identical to that of Tiezzi and Xiao (2016) except that we investigated degree of support.

Table A1: Summary Statistics on Individual Votes and Vote Strength by Treatment

	Vote Strength Index			Individual yes Votes		
	Mean	Median	s.e.	Mean	Median	s.e.
BuyerTax_NoDelay						
First vote	4.271	5	1.541	78.13%	1	0.417
Second vote	5.017	5	1.196	90.63%	1	0.294
BuyerTax_Delay						
First vote	2.673	3	2.010	45.00%	0	0.502
Second vote	2.415	2	2.205	43.33%	0	0.500
SellerTax_NoDelay						
First vote	4.557	5	1.372	84.38%	1	0.366
Second vote	5	6	1.551	89.06%	1	0.315
SellerTax_Delay						
First vote	2.930	3	2.112	53.33%	1	0.503
Second vote	2842	2	2.321	43.33%	0	0.500

Note: The mean of individual voting is the average vote (yes=1; no=0) across subjects in each treatment. The index of vote strength takes values: 0= strongly no; 1=moderately no; 2= somewhat no; 3= indifferent; 4=somewhat yes; 5=moderately yes; 6=strongly yes.

Table A2: Voting behaviour in the first ballot (Probit)

	Dependent variable: Vote "Yes"	
	Coefficients	Average marginal effects
β_1: BuyerTax_Delay	-1.051***	-0.371***
	(0.293)	(0.097)
β_2: SellerTax_Delay	-0.715***	-0.243***
	(0.240)	(0.076)
β_3: SellerTax_NoDelay	0.320	0.079
	(0.279)	(0.069)
N	248	
Pseudo R^2	0.133	
H_0: $\beta_2 = \beta_3$	$p < 0.001$	
H_0: $\beta_2 - \beta_3 = \beta_1$	$p = 0.965$	

Note: The BuyerTax_NoDelay treatment serves as the benchmark. The model is estimated using Probit regression. Robust standard errors are clustered at the group/market level and reported in parentheses. The regression additionally controls for sex, political view (liberal vs. conservative) and whether a subject is an economics major. *** $p < 0.01$

Table A3: Impact of tax experience on the second vote (Probit)

	Dependent variable: Second vote "Yes"	
	Coefficients	Average marginal effects
β_1: BuyerTax_Delay_TaxExper	-0.448	-0.122
	(0.279)	(0.075)
β_2: BuyerTax_NoDelay_TaxExper	1.420***	0.387***
	(0.269)	(0.062)
β_3: SellerTax_Delay_TaxExper	-0.220	-0.060
	(0.249)	(0.067)
β_4: SellerTax_NoDelay_TaxExper	1.284***	0.350***
	(0.271)	(0.063)
N	248	
Pseudo R^2	0.237	
H_0:$\beta_1 - \beta_2 = \beta_3 - \beta_4$	$p = 0.394$	

Note: BuyerTax_NoDelay_TaxExper = 1 if buyer *i* in BuyerTax_NoDelay traded with tax between periods 11 and 15; =0, otherwise. BuyerTax_Delay_TaxExper = 1 if buyer *i* in BuyerTax_Delay traded with tax between periods 11 and 15; =0, otherwise. SellerTax_NoDelay_TaxExper = 1 if buyer *i* in SellerTax_NoDelay traded with tax between periods 11 and 15; =0, otherwise. SellerTax_Delay_TaxExper =1 if buyer i in SellerTax_Delay traded with tax between periods 11 and 15; =0 otherwise. The model is estimated using Probit regression. Robust standard errors are clustered at the group/market level and reported in parentheses. The regression additionally controls for sex, political view (liberal vs. conservative) and whether a subject is an economics major. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Appendix B Experimental Instructions

B.1 Instructions regarding the auction

(All treatments)

- ***General***

Thank you for coming! You've earned $5 for participating, and the instructions explain how you can make decisions and earn more money which will be paid to you in cash.

This is an experiment in the economics of market decision making. In this experiment we are going to simulate a market in which each participant will be a buyer in a sequence of trading periods.

There should be no talking at any time during this experiment. If you have a question, please raise your hand, and an experimenter will assist you.

During the experiment your earnings will be calculated in experimental points. Experimental points will be converted in Dollars at the following exchange rate:

200 experimental points = 1$

At the end of today's experiment you will receive, in cash, the earnings you make today. In addition, you will receive a payment certificate to pick up your $5 participation bonus and an additional cash payment of $18 the same day next week.

For example, if today is Monday, you will receive the $5 participation bonus and the additional $18 cash payment next Monday. To pick up these amounts, you need to come back to the same lab the same day next week (if you cannot make it at the time indicated on your payment certificate please send an email to [the experimenter's email address] to schedule another time <u>on the same day</u> or you can send someone else to pick up your cash payment <u>on the same day</u>). You do not need to participate in any decision task next week to receive the additional $18 payment.

(Delay only)

However, as we describe below, you may lose some of this $18 depending on the decisions you and the other three buyers in your market make today. The final amount of the additional cash payment you pick up next week will therefore depend on the decisions you and the other three buyers in your market make in today's experiment.

(All treatments)

In today's experiment, you will first participate in two practice trading periods followed by a number of paid trading periods. In the practice trading periods you do not earn money, but you should take these periods seriously since you will gain valuable experience for the paid trading periods.

- ***Specific instructions to buyers***

  In this experiment each participant is a buyer. Each buyer is randomly assigned to a group of 4 buyers – a market – and remains in the same market with the same buyers throughout the experiment. What is happening in other markets is irrelevant for your own market and hence for your own earnings. During each trading period each buyer can buy units (up to 3 units) of a hypothetical consumption good from an automated (computerized) seller.

Resale value of a unit. At the beginning of each trading period, you will be given three separate resale values for each of the three units of the good you can purchase. These are your privately known resale values. You can think of the resale value of a unit as the potential earnings you can make out of that unit. Your resale values will remain the same in each period during the experiment.

Bid. As a buyer, you can submit a "bid" to buy a unit from the seller during a trading period. A "bid" is the amount you are willing to pay for that unit of the good. You must submit one "bid" for each of the three units. (If you do not want to purchase a unit, you may simply submit a bid "0".) Your bids have to follow the following two rules: 1) "Trade at no loss": your bid for each unit cannot be above your resale value for that unit; 2) Your bid for the third (second) unit cannot be above your bid for the second (first) unit.

- ***How the market works***

At the beginning of each trading period each buyer submits bids for each unit offered in the market. At the end of each trading period, all submitted bids are collected and ranked from high to low. If two or more bids are equal, ranks will be randomly assigned by the computer.

1. ***How the Market Price is determined***

The automated seller has a production cost unknown to all buyers. The production cost does not change during the experiment. The seller never trades at a loss, therefore it will not accept bids below its production cost. The seller will accept, among all bids from all buyers in the market, the lowest bid above or equal to the production cost. This will be the per-unit **Market Price**. Bids that are below the production cost will be rejected and buyers who have submitted those bids won't buy any units (i.e. buyers will neither pay for those units they placed a bid nor gain any resale value from those units).

The market price can be different in each period because it depends on the bids that are submitted in each period.

2. ***How the Market Quantity is determined***

Buyers will purchase a unit when their bid is greater than or equal to the market price. The **Market Quantity** is the total number of units purchased by the 4 buyers in one market in one period at the market price.

Example: Suppose, in one market and in one trading period, the automated seller's production cost is 70. And suppose the automated seller collects the following bids from the 4 buyers.

	Buyer 1	Buyer 2	Buyer 3	Buyer 4
Bid Unit 1	**135**	**135**	**140**	**145**
Bid Unit 2	**85**	**90**	**94**	**85**
Bid Unit 3	**80**	0	**80**	40

The bids are ranked from high to low as follows: 145, 140, 135, 135, 94, 90, 85, 85, 80, 80, 40, 0. In this case, the **Market Price is 80 (**the lowest bid above the production cost of 70). All 10, and only the 10 units for which the bids were equal or above the market price of 80 will be purchased by the buyers who submitted the corresponding bids. These 10 sold units are bolded in the table. Each of these 10 units will be exchanged at 80. The market quantity in this case is 10. The number of sold units is determined by the number of submitted bids above or equal to the market price. Units for which the submitted bids are below the market price will not be sold.

Please note: The information on values and production costs of a unit is private. Buyers do not know the bids of other buyers, nor do they know the per-unit production cost for the seller.

(No Delay only)

3. *Additional Costs from Trading*

Each unit traded in the market (i.e. each unit sold) causes an additional cost of 60 points that will be equally split by the 4 buyers in the market. This means that each of the 4 buyers in the market has to pay an additional cost of 60/4=15 points. **Note** that you will bear a share of the additional costs even if you do not buy any units yourself.

Using the example above where the market quantity is 10 units, in this case, each buyer incurs an additional cost of (60/4)*10=150 points=$0.75.

4. *How your earnings today in each trading period are calculated*

Your Final earnings in one trading period = Gross earnings in the trading period - **Additional Costs** per person in the trading period, where

Gross earnings in the trading period= (Resale value - Market price) of each unit purchased

In the example above Buyer 4 buys two units. Her resale value for Unit 1 is 200, her resale value for Unit 2 is 140 and her resale value for Unit 3 is 100. The market price is 80. Her Gross earnings in this period = 200 (resale value of Unit 1) + 140 (resale value of Unit 2) – 2*80 (market price) = 340 – 160 = 180

Since the market quantity is 10, the additional costs per person are (60/4)*10 = 150. Her **Final earnings** in this period =180 (Gross earnings) – 150 (Additional costs per person) = 30.

As you can see, in this case, even though Buyer 4's resale value for Unit 3 is 100, which is higher than the market price 80, Buyer 4 did not purchase the unit because her bid for Unit 3 (40) is lower than the market price (80).

Your total Final earnings for today are the sum of your Final earnings in each trading period over all the paid trading periods.

5. ***How your earnings next week are calculated***

Each participant will receive $18 next week. You do not need to participate in any decision task next week to receive the cash payment for the next week. You just need to pick it up in the lab on the same day next week.

(Delay only)

3. ***Additional Costs from Trading***

Each unit traded in the market (i.e. each unit sold) causes an additional cost of 60 points that will be equally split by the 4 buyers in the market. This means that each of the 4 buyers in the market has to pay an additional cost of 60/4=15 points. **Note** <u>that you will bear a share of the additional costs even if you do not buy any units yourself.</u>

Using the example above where the market quantity is 10 units, in this case, each buyer incurs an additional cost of (60/4)*10=150 points=$0.75.

<u>These additional costs will not affect your earnings today but will be deducted from the $18 cash payment you will receive next week.</u>

4. ***How your earnings today in each trading period are calculated***

Your Final earnings in one trading period = (Resale value - Market price) of each unit purchased

In the example above Buyer 4 buys two units. Her resale value for Unit 1 is 200, her resale value for Unit 2 is 140 and her resale value for Unit 3 is 100. The market price is 80. Her **Final earnings** in this period are = 200 (resale value of Unit 1) + 140 (resale value of Unit 2) – 2*80 (market price) = 340 – 160 = 180

As you can see, in this case, even though Buyer 4's resale value for Unit 3 is 100, which is higher than the market price 80, Buyer 4 did not purchase the unit because her bid for Unit 3 (40) is lower than the market price (80).

Your total Final earnings for today are the sum of your Final earnings in each trading period over all the paid trading periods.

5. How your earnings next week are calculated

Each participant will receive $18 next week. However, the final amount of the cash payment you will pick up next week will depend on the decisions you and the other 3 buyers in your market make today.

In the example above, since the market quantity is 10, the additional costs per person are (60/4)*10 = 150 points. This additional cost will be deducted from Buyer 4's cash payment for the next week.

So, the **final payment each buyer will receive next week = $18 - the Sum of the Additional Cost per person in each period today.**

You do not need to participate in any decision task next week to receive the cash payment for the next week. You just need to pick it up in the lab on the same day next week.

B.2 Voting Instructions (Seller tax treatments)

You and the other three participants in your market will now vote whether to introduce a tax of 60 points on the seller on each sold unit of the good. If at least two out of four buyers in each market vote "Yes", the tax is accepted and the following changes are implemented for the following trading periods: 1) the seller pays a tax of 60 points for each unit she sells; 2) at the end of each period, each buyer will receive an equal share (one-fourth) of the total tax revenues collected from all units sold by the seller in your market. All the other rules described in the instructions for the first 10 trading periods remain the same. In particular, seller's production cost and each buyer's resale value of each unit remain the same as the previous 10 periods.

Example

Suppose the tax of 60 points per unit is accepted as the outcome of the voting in your market.

To illustrate how this would affect the outcome of the market and your earnings we use the same example from the instructions for the first 10 trading periods. In that example, when the automated seller sells one unit of the good, her production cost of this unit is 70 points but now she will also have to pay the tax of 60 points. The total cost of each sold unit for the seller will now be 70 +60 =130. Consider Buyer 4. Buyer 4's resale value for Unit 1 is 200, her resale value for Unit 2 is 140 and her resale value for Unit 3 is 100.

Consider again the example in which the seller collects the following bids from the 4 buyers.

	Buyer 1	Buyer 2	Buyer 3	Buyer 4
Bid Unit 1	**135**	**135**	**140**	**145**
Bid Unit 2	85	90	94	85
Bid Unit 3	80	0	80	0

(No Delay only)

To illustrate how a buyer's earnings today are calculated, again let's use the example of Buyer 4. Since the Market price is 135, Buyer 4 buys 1 unit. Buyer 4's gross earnings in this period = 200 (resale value of unit 1) – 135 (market price) = 65.

Since the Market quantity is now 4, in this period the **Additional costs per person** are (60/4)*4 = 60 points. Since 4 units are sold, the total tax revenues in this period are 4*60=240. One fourth of the total tax revenues, 240/4=60 points, will be returned to Buyer 4.

Buyer 4's **Final earnings** in this period = 65 (Gross earnings) – 60 (Additional costs per person) + 60 (returned tax revenues) = 65.

<u>Suppose the tax proposal is rejected.</u>

Trading will continue as before the vote and no changes will apply. Thus, in the above example, the seller will only accept bids above or equal to the production cost 70. The Market price is therefore 80. Buyer 4 buys two units. Her gross earnings for that period are 180.

Since the Market quantity is 10, in this period the additional costs per person are (60/4)*10=150 points. Her final earnings for that period are 180-150=30. All final earnings in the following periods will be calculated as illustrated above.

(Delay only)

To illustrate how a buyer's earnings today are calculated, again let's use the example of Buyer 4. Since the Market price is 135, Buyer 4 buys 1 unit. Since 4 units are sold, the total tax revenues in this period are 4*60=240. One fourth of the total tax revenues, 240/4=60 points, will be returned to Buyer 4.

Buyer 4's **Final earnings** in this period = 200 (resale value of unit 1) - 135 (market price) + 60 (returned tax revenues) = 125.

Since the Market quantity is now 4, in this period the **Additional costs per person** are (60/4)*4 = 60 points. These additional costs will not affect Buyer 4's earnings today but will be deducted from the $18 cash payment Buyer 4 will receive next week.

So, the final **cash payment each buyer will receive next week = $18 - the sum of the Additional Cost per person in each period.**

<u>Suppose the tax proposal is rejected.</u>

Trading will continue as before the vote and no changes will apply. Thus, in the above example, the seller will only accept bids above or equal to the production cost 70. The Market price is therefore 80. Buyer 4 buys two units. Her final earnings for that period are 180.

Since the Market quantity is 10, in this period the additional costs per person are (60/4)*10 = 150 points. Again, these additional costs will be deducted from the cash payment Buyer 4 will receive next week. All final earnings in the following periods will be calculated as illustrated above.

(Both treatments)

You will be informed about the outcome of the vote in your group on the screen before the trading continues. Nobody, however, will be informed about individual votes of other participants. In the ballot, all participants simultaneously vote Yes or No for the introduction of the tax. Abstentions or neutral votes are not possible. Voting is anonymous.

Before proceeding to the vote you will be asked to do an exercise to make sure you understand the instructions.

If you now have questions, please, raise your hand and wait until an experimenter will come by to answer your questions individually.

Tax Liability Side Equivalence and Time Delayed Externalities

Highlights

- We conduct laboratory market experiments with time delayed externalities.
- Past research found lower support for taxation when externalities are delayed.
- We test whether this delay effect varies with the statutory incidence of the tax.
- We find the delay effect is robust regardless of the liability side of the tax.
- Changing liability side has no success in a dynamic setting with delayed benefits.

Conflict of Interest and Authorship Conformation Conflict Form

Article reference: POLECO_EJPE-D-2000255

Article title: Tax Liability Side Equivalence and Time Delayed Externalities

The authors of the above referenced article hereby declare that:

- All authors have participated in:

(a) conception and design, analysis and interpretation of the data;

(b) drafting the article or revising it critically for important intellectual content;

(c) approval of the final version.

- This manuscript has not been submitted to, nor is under review at, another journal or other publishing venue.

- The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in the manuscript.

- None of the authors have affiliations with organizations with direct or indirect financial interest in the subject matter discussed in the manuscript.