How Does Firm Tax Evasion Affect Prices?*

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Abstract

How do firms' avoidance and evasion opportunities affect market prices? We investigate the causal link between tax-evasion opportunities and prices in a situation where firms remit sales taxes and have access to tax-evasion possibilities. In light of difficult causal identification with archival data, we design a controlled experiment in which buyers and sellers trade a fictitious good in competitive markets. A per-unit tax is imposed on sellers, and sellers in the treatment group are provided the opportunity to evade the tax whereas sellers in the control group are not. We find that the equilibrium market price in the treatment group is lower than in the control group, and the number of traded units is higher in treatment markets. The results further show that the after-tax incomes of sellers in the evasion treatment increases despite trading at lower prices. Our findings have implications for tax incidence. In particular, sellers with access to evasion shift a smaller share of the nominal tax rate onto buyers relative to sellers without tax evasion opportunities. Additionally, we find that sellers with evasion opportunities shift the full amount of their *effective* tax rate onto buyers. Results from additional experimental treatments show that this full shifting of the effective tax burden is due to the evasion opportunity itself rather than the evasion-induced lower effective tax rate.

Keywords: Tax Evasion, Tax Avoidance, Price Effects, Tax Incidence, Firm Behavior, Experiment

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1 Introduction

It is well documented that many firms and self-employed individuals engage in tax-avoidance and tax-evasion activities (e.g., Slemrod 2007, Hanlon et al. 2007, Dyreng et al. 2008, Hanlon and Heitzman 2010, Schneider et al. 2010, Kleven et al. 2011, Armstrong et al. 2012, Artavanis et al. 2016). Tax evasion and avoidance activities have the common effect of allowing firms to reduce their tax liability through under-reporting (legally or illegally) their tax base, and it is an important question whether this effect impacts prices and sold quantities. From a theoretical perspective, the impact of evasion/avoidance on prices and quantities is ambiguous. One prediction is that the evasion/avoidance-induced reduction of the tax burden gives firms scope for offering their goods at lower prices, and thereby increase demand for their goods. As a result, the evasion/avoidance opportunity would lead to lower prices and higher sold quantities. An alternative prediction arises in a case where firms treat their evasion/avoidance and selling decisions as separable; i.e., sellers first set a price at which to sell, and then later make their evasion/avoidance decision.[1] In this case, the opportunity to evade/avoid would not affect prices or quantities (Bayer and Cowell 2009).

The extent to which tax evasion/avoidance opportunities affect market prices and quantities is therefore an empirical question. Unfortunately, empirical evidence on this question is very scarce. The goal of this paper is to make an empirical contribution to this gap in the literature by estimating the causal effect of evasion and avoidance opportunities on market prices and sold quantities. We focus on a situation where firms remit sales taxes and have an opportunity to evade these taxes. Our precise research question is: are prices different in markets where the evasion of sales taxes is an option relative to markets where sales taxes cannot be evaded?

Data for the empirical analysis are generated in a between-subject-design laboratory experiment[2] where participants trade fictitious goods in a competitive double auction market (Smith 1962, Dufwenberg et al. 2005). Experimental participants are randomly assigned roles as sellers or buyers in treatment and control groups, and a per-unit sales tax is imposed on all sellers. Sellers in the treatment group make a tax-reporting decision and are therefore able to under-report the number of units sold, whereas sellers in the

[1]This separability result is analogous to other types of uncertainty models; for example, investment models in which the decision over how much to invest in total is separable from the decision on how much to invest in individual assets.

[2]Laboratory experiments are frequently used in taxation and accounting research; examples include: Anctil et al. (2004), Ruffle (2005), Hobson and Kachelmeier (2005), Riedl and Tyran (2005), Fortin et al. (2007), Alm et al. (2009), Tayler and Bloomfield (2011), Chen et al. (2012), Maas et al. (2012), Blumkin et al. (2012), Falsetta et al. (2013), Grosser and Reuben (2013), Doerrenberg and Duncan (2014), Balafoutas et al. (2015), Barron and Qu (2014), Elliot et al. (2015), Hales et al. (2015), Banerjee and Maier (2016), Majors (2016), Blaufus et al. (2017), Bernard et al. (2018), Brueggen et al. (2018). We discuss the external validity of our laboratory experiment in Section 5.4.

control group have their correct tax liability deducted automatically. Evasion costs, including audit probability and fine rate, are exogenous. Because the only difference between the treatment and control group is access to evasion, we attribute any occurring price differences between the two groups to the evasion opportunity.

Our decision to use a laboratory experiment is based on the fact that causal identification requires random variation in access to evasion across otherwise similar markets. This is difficult to achieve using archival data since it is always an endogenous choice of firms to operate in markets where evasion/avoidance is an option. The controlled environment of the laboratory allows us to randomly assign sellers' access to evasion opportunities and thus produce causal evidence of the effect of tax evasion on outcomes. Even if it was possible to exploit exogenous variation in evasion opportunities of firms, it would be very difficult to find an archival data set that includes information about both the evasion opportunity of the firm and the prices at which this firm sells its goods to buyers; data availability thus is a further reason for relying on the laboratory experiment.

Randomized laboratory experiments have been used extensively to study price effects of taxes. Various laboratory studies find that the theoretical results of tax incidence – without evasion – hold in competitive experimental markets such as a double auction (Kachelmeier et al. 1994; Borck et al. 2002; Ruffle 2005). This suggests that the laboratory is an appropriate setting to study the interplay between taxes and prices.[3] The tax-evasion component of our experiment also builds on established work from laboratory experiments (e.g., Ruffle 2005, Fortin et al. 2007, Doerrenberg and Duncan 2014, Balafoutas et al. 2015, Blaufus et al. 2016, Kogler et al. 2016). Our experimental design thus combines established design features from the experimental literature strands on double auctions, tax incidence and tax evasion.

The empirical results show that the equilibrium price in the treatment group with tax evasion is statistically and economically lower than in the control group. Accordingly, the number of units traded is higher in the case with evasion. These findings provide clean evidence that evasion opportunities for firms cause lower prices and higher trading quantities. This empirical result speaks to the opposing predictions that we make to rationalize the experiment (see above and in particular Section 3) and supports the prediction according to which evasion affects prices and quantities. The simple rationale for this prediction is that sellers with an evasion option are able to reduce their effective tax rate relative to those without evasion. This allows firms with evasion opportunities to offer their goods at lower prices. On the market level, evasion-induced reductions in effective tax rates imply that the tax causes the industry supply curve to shift up by a smaller amount relative to situations without access to evasion. The empirical results

[3]We employ an experimental double auction similar to Grosser and Reuben (2013). Riedl (2010) provides an overview of experimental tax incidence research.

further suggest that the evasion and pricing decisions of firms are not separable in our set-up.

Our empirical results further show that sellers increase their after-tax profits through the evasion opportunity. This implies that the revenue gains of increasing the number of units sold combined with under-reporting the tax base compensates for the revenue loss of selling at lower prices in the treatments with access to evasion. Not surprisingly, buyers also have higher net incomes in the presence of tax evasion. Overall, the increase in after-tax incomes through the evasion opportunity is higher for sellers than for buyers.

We use the price effects that we find to investigate the share of the nominal and effective tax rate firms shift onto buyers.[4] In other words, we use our main findings to determine the incidence of the sales taxes on prices. We document the following incidence results. First, the share of the *nominal* tax rate that is borne by buyers is approximately 50 percent lower in the presence of evasion. This finding suggests that access to tax evasion changes the economic incidence of the nominal tax rate. Second, we find that sellers with an evasion opportunity shift their full *effective* tax rate onto buyers. Results from an additional treatment, in which the effective tax rate is exogenously lowered to the effective rate observed in the evasion treatments, suggest that the full shifting of the effective tax rate is due to the evasion opportunity itself rather than the evasion-induced lowering of the effective tax rate. One interpretation of this finding is that sellers desire to be compensated for the risk associated with evasion.

The relevance and importance of our findings is especially evident when one considers the prevalence of tax evasion and avoidance across the world (e.g., Slemrod 2007, Hanlon et al. 2007, Dyreng et al. 2008, Hanlon and Heitzman 2010, Schneider et al. 2010, Kleven et al. 2011, Armstrong et al. 2012, Artavanis et al. 2016). Transaction taxes, which we focus on in our study, are of particular interest in this context. For example, sales tax gap estimates range from 2 percent to 41 percent for the value added tax in the European Union and 1 percent to 19.5 percent for the retail sales tax in the United States (see Mikesell 2014 for a review of sales tax evasion estimates). Additionally, it is generally accepted that 'use-tax' evasion by both businesses and individuals is much higher than retail sales tax evasion; e.g., GAO (2000) assume non-compliance rates of 20 to 50 percent among businesses and 95 to 100 percent among individuals in a study of the potential revenue losses of e-commerce.[5] Our results suggest that efforts to curb these evasion/avoidance opportunities will have a material impact on market prices and the distribution of tax burdens between buyers and sellers.

[4]Throughout the paper, we refer to the tax rate that is legally due as the *nominal* tax rate. However, some taxpayers evade part of their legal tax liability, which effectively reduces the tax rate due. The *effective* tax rate then refers to actual tax payment as a share of true taxable income, accounting for fines. See Section 3 for a more comprehensive definition.

[5]Consumers in the United States are required to pay 'use-tax' in lieu of the retail sales tax if the seller is not required – by law – to register as a tax collector in the consumers' state.

Our paper contributes to different strands of literature. First, our paper adds to the general tax evasion literature.[6] Naturally, obtaining credible causal evidence in the context of tax evasion is very difficult using observational studies (Slemrod and Weber 2012). A broad strand of literature has therefore employed randomized experiments to study evasion (see references above). However, unlike most of the tax-evasion literature, we focus on the implications of tax evasion for an outcome variable rather than on explaining tax evasion. A further difference to most of the evasion literature is that we focus on transaction taxes rather than income taxes.[7] In particular, we show that price setting is affected by the opportunity to evade a transaction tax. A related finding in this context is the study by Hoopes et al. (2016). They show that online retail firms (e-tailers) have a competitive advantage over traditional (brick and mortar) retailers because of widespread use-tax evasion among consumers. The paper does not study if e-tailers set different prices than traditional retailers. Additionally, our results support the general conjecture that economic outcomes – such as prices and quantities – are affected by tax evasion behavior (e.g., Andreoni et al. 1998) and provides empirical evidence supporting this conjecture.

Second, we relate to the literature on tax avoidance of firms.[8] Although our particular set-up studies tax evasion, rather than avoidance, the general mechanism behind our results also applies to avoidance (see above).[9] It is well documented that tax avoidance of firms is very common, especially among multinational firms (see for example Hanlon et al. 2007). However, literature on the implications and consequences of avoidance is rather scarce – presumably because of the previously discussed inherent endogeneity problem that avoidance options are not randomly assigned to firms. Exemplary exceptions are papers studying the consequences of tax avoidance in equity capital markets (Desai and Dharmapala 2009; Hanlon and Slemrod 2009; Wilson 2009; Goh et al. 2016). We relate to this stream of papers in that we study an additional dimension of potential tax-avoidance consequences, namely prices and number of sold units.

One particularly related study from the tax-avoidance literature is Dyreng et al. (2019). They study the effect of tax incidence on tax avoidance using archival data. While

[6] Andreoni et al. (1998), Alm (2012) and Slemrod (2017) provide general surveys on tax-compliance research. Recent examples of evasion research include Artavanis et al. (2016), Hallsworth et al. (2017), and Alstadsaeter et al. (2019).

[7] In an overview article on tax research, Dyreng and Maydew (2018) identify that there is little research on non-income-based taxes (such as sales taxes) in the literature. They consider this lack of research to be surprising in light of the importance and prevalence of these types of taxes around the world. Our focus on sales taxes and their effects on prices thus contributes to closing this gap in the literature.

[8] Hanlon and Heitzman (2010) present a survey. Examples of recent work on tax avoidance include Simone (2016) and Hopland et al. (2018).

[9] The close link between legal tax avoidance and illegal tax evasion is for example emphasized by Hanlon and Heitzman (2010) who highlight that the distinction between avoidance and evasion is very difficult. The close link between the two approaches to reducing the tax liability supports our notion that the results from our evasion context have implications for cases of tax avoidance.

the predictions of their theoretical model are ambiguous, they show empirically that firms which are not able to shift the burden of taxes to workers (because of relatively elastic labor supply of their high-skilled employees) are more engaged in tax avoidance than firms who face inelastic labor supply. In other words, the paper finds that tax incidence affects avoidance, and thus supports the presumption that there is a relationship between tax avoidance and tax incidence. We complement this paper in that we also find a relationship between avoidance/evasion and incidence, though in a set-up where causality runs in the opposite direction and using a different empirical approach.[10]

Finally, we relate to several studies that attempt to identify the incidence of taxes.[11] To overcome the challenges of identifying causal effects using observational data, several studies explore the question of economic incidence in a laboratory setting. For example, Kachelmeier et al. (1994), Quirmbach et al. (1996), Borck et al. (2002), and Ruffle (2005) find that the theoretical predictions of tax incidence hold true in a competitive laboratory market with full information.[12] We add to this strand of the literature by introducing tax evasion to a standard competitive experimental double-auction market, and show that this changes the incidence of the tax. This finding is important because it suggests that tax equivalence, which is the focus of the existing laboratory tax incidence literature, is unlikely to hold in the real world where buyers and sellers have different access to evasion.

We know of two studies that estimate tax incidence in the presence of tax evasion: Alm and Sennoga (2010) and Kopczuk et al. (2016). The latter provides evidence that the stage of production at which the tax on diesel is collected in the US affects the economic incidence of the tax. Although they suggest that this difference is driven by variation in access to evasion across production stages, reliance on observational data makes it difficult to cleanly identify whether this effect is fully due to variation in compliance behavior. Alm and Sennoga (2010) use a computable general equilibrium (CGE) model to simulate the economic incidence of tax evasion for a "typical" developing country. They find that the benefits of evasion generally do not stay with the evader if there is

[10] Evidence that the causality between avoidance/evasion and incidence can run in both directions is not a threat to causal identification in our empirical set-up because we have randomized evasion opportunities. It is, however, a further indication that avoidance and evasion opportunities are endogenous and supports our above justification of why we use a laboratory experiment. Dyreng et al. (2019) circumvent the potential identification threat of reverse causality by exploiting exogenous variation in avoidance costs that comes from the 1997 Check-the-Box regulation. In particular, they study if firms facing elastic versus inelastic labor supply responded differently to this regulation.

[11] For example, Alm et al. (2009) and Marion and Muehlegger (2011) find that the incidence of the fuel tax in the US is fully shifted to final consumers and related to supply and demand conditions, Saez et al. (2012) find that tax equivalence does not hold in the context of the Greek payroll tax, and Fuest et al. (2018) find that the burden of local business taxes in Germany partly falls on employees via lower wages. Other examples include Evans et al. (1999), Gruber and Koszegi (2004), and Rothstein (2010).

[12] Kerschbamer and Kirchsteiger (2000) and Riedl and Tyran (2005) find that the laws of tax incidence do not translate to non-competitive experimental markets.

free entry, which suggests that evasion changes the incidence of taxes. Since we rely on the controlled environment of the lab, our empirical approach provides precise control over the market institutions and allows us to randomize access to evasion and measure non-compliance accurately. As a result, we are able to offer cleaner causal identification of the impact of tax evasion on the economic incidence of the tax than these two studies. Nonetheless, we view our work as complementary to these papers. The illusive nature of tax evasion implies that consistent results across multiple techniques is required if we are to draw firm conclusions about causes and consequences of tax evasion.[13]

The remainder of the paper is structured as follows. We describe the experimental design in section 2, the theoretical predictions in section 3 and the main results in section 4. Our findings are discussed in section 5. We also present the results of an additional treatment in section 5 which helps us to rationalize our tax-incidence findings. Section 6 concludes.

2 Experimental Design

2.1 Overview

The experimental design reflects a standard competitive experimental double auction market as pioneered by Smith (1962).[14] The auction and the parameters in our experiment are based on Grosser and Reuben (2013). In each round of the double auction market, 5 buyers and 5 sellers trade two units of a homogeneous and fictious good. Sellers are assigned costs for each unit and buyers are assigned values. The roles of sellers and buyers as well as the costs and values are exogenous and randomly assigned to the lab participants. We impose a per-unit tax on sellers – which we refer to as the *nominal* tax rate – to this set-up and give sellers in the treatment group the opportunity to evade the tax whereas sellers in the control group pay the per-unit tax automatically (as with exact withholding). We employ a between-subjects design where each participant is either in the control or treatment group. Further details on the experimental design are provided in the next subsections.

[13]This is an additional reason for viewing our paper as complementary to the above discussed paper by Dyreng et al. (2019).

[14]Double auction markets mimic a perfectly competitive market. Dufwenberg et al. (2005), for example, rely on an experimental double auction to study financial markets. Holt (1995) provides an overview.

2.2 Organization

The experiment was conducted in the Cologne Laboratory for Economic Research (CLER), University of Cologne, Germany.[15] A large random sample of all subjects in the laboratory's subject pool of approximately 4000 persons was invited via email – using the recruitment software *ORSEE* (Greiner 2015) – to participate in the experiment. Participants signed up on a first-come-first-serve basis. Neither the content of the experiment nor the expected payoff was stated in the invitation email. The experiment was programmed utilizing *z-tree* software (Fischbacher 2007). We ran a total of eight sessions, and each session consisted of either a control or treatment group market and lasted about 100 minutes (including review of instructions and payment of participants).[16]

We conduct four control and four treatment sessions for a total of 80 subjects.[17] Experimental Currency Units (ECU) are used as the currency during the experiment. After the experiment, ECU are converted to Euro with an exchange of 30 ECU = 1 EUR and subjects are paid the sum of all net incomes (see below) in Euro. It was public information that all tax revenue generated in the experiment would be donated to the German Red Cross.

At the beginning of each session, subjects are randomly assigned to computer boothes by drawing an ID number out of a bingo bag upon entering the lab. The computer then randomly assigns each subject to role as buyer or seller, as well as her costs or values which stay constant during the experiment. Subjects are given a hard copy of the instructions when they enter the lab and are allowed as much time as needed to familiarize themselves with the procedure of the experiment. They are also allowed to ask any clarifying questions. The instructions are identical for the control and treatment group except for information on the reporting decision and net income of sellers. These differences in the instructions are highlighted in appendix section C.

2.3 Description of a session

Each session includes 1 market that is either a control or treatment group market. Each market has five buyers and five sellers who each have 2 units of a fictitious good to trade. Sellers and buyers are randomly assigned costs and values for both of their units. These values and costs come from a predefined distribution that was the same across treatments,

[15] The Cologne Laboratory is a well established and modern experimental laboratory that was opened in 2005; information about the lab are online at `https://ockenfels.uni-koeln.de/en/experiments/`. Recent examples of studies using experimental results from this laboratory are Bierbrauer et al. (2017), Bolton et al. (2018) and Inderst et al. (2019).

[16] We subsequently ran additional experimental treatment sessions (after the first set of experiments). This section provides details for the first set of experiments, the details regarding the additional treatment are in section 5.3.

[17] See section 4.2.1 for summary statistics on demographic characteristics of the participants.

and the random assignment to costs and units is without replacement. The roles as buyer or seller and the assigned values and costs are exogenously determined and stay constant for the entire experiment. All ten subjects in one session/market first trade in 3 practice rounds and then 27 payoff relevant rounds.

Trade in the Double Auction. As is common in experimental markets, subjects are given demand and supply schedules for a fictitious good at the beginning of the session (Ruffle 2005; Cox et al. 2018; Grosser and Reuben 2013). The demand schedule for buyers assigns a value to each of two items and the supply schedule for sellers assigns a cost to each of two items. The cost/value of the units vary across items and subjects as illustrated in Table 1. This allows us to induce demand and supply curves for each market, which are depicted in Figure 1. The schedules are chosen such that demand and supply elasticities are equal in equilibrium. The demand and supply schedules remain fixed across periods in a given session, and they do not differ between control and treatment markets.

Subjects trade the good in a double auction market that is opened for two minutes in each period. During this time, each seller can post an "ask" that is lower than the current ask on the market, but higher than the cost of the item to the seller. In other words, sellers cannot trade an item below its cost. Additionally, as in the literature, sellers must sell their cheaper unit before they sell their more expensive unit. Similarly, each buyer can post a "bid" that is higher than the current bid on the market, but lower than the value of the item to the buyer. Therefore, buyers cannot buy an item at a price that exceeds its value. Buyers must also buy their most valued item before their least valued item. The lowest standing ask and the highest standing bid are displayed on the computer screen of all ten market participants.[18]

An item is traded if a seller accepts the standing buyer bid or a buyer accepts the standing seller ask. Subjects are not required to trade a minimum amount of items, items that are not traded yield neither costs nor profits. Traders are not allowed to communicate with each other. This trading procedure is identical for the treatment and control groups.

Income: Control Group. Gross-income in each period consists of the sum of the profit on each unit traded. Sellers' gross profit on each unit is equal to the difference between the selling price and cost, while buyers' profit on each unit is the difference between value and price paid. All subjects (buyers and sellers) are told that sellers have to pay a per-unit tax for each unit sold, that the tax rate is fixed across all periods at $\tau = 10$ ECU per-unit and that the tax is collected at the end of every third trading

[18]Figure 9 in the appendix depicts a screenshot of the experimental market place for a seller in the treatment group with evasion opportunity.

period. In other words, subjects complete three rounds of trading then tax is collected from sellers, then three more rounds of trading then another tax collection and so on. This yields 27 trading periods and 9 tax collections; we discuss this design feature below. We define total gross profit in each trading period i ($i = 1, 2, 3, ..., 25, 26, 27$) as

$$\Pi_i^s = P_{i1}d_1 + P_{i2}d_2 - C_1d_1 - C_2d_2, \tag{1}$$

for sellers and

$$\Pi_i^b = V_1d_1 + V_2d_2 - P_{i1}d_1 - P_{i2}d_2, \tag{2}$$

for buyers. Superscripts s and b indicate seller and buyer, respectively, $d_j = 1$ if good j is traded and 0 otherwise, P_{ij} is the price of good j in period i, C_j is the cost of good j and V_j is the value of good j.

Because taxes are collected at the end of every third trading period, a seller's net income for each tax collection period k ($k = 3, 6, 9, 12, 15, 18, 21, 24, 27$) is equal to:

$$\pi_k^s = \Pi_k^s + \Pi_{k-1}^s + \Pi_{k-2}^s - \tau U, \tag{3}$$

where U is the total number of units sold in the last three rounds and $\tau = 10$ is the nominal per-unit tax rate. Because buyers do not pay a tax, their net income for each tax collection period may be written as:

$$\pi_k^b = \Pi_k^b + \Pi_{k-1}^b + \Pi_{k-2}^b \tag{4}$$

Both buyers and sellers are shown their gross income after every trading period and their net income after every tax collection period. Subjects' final payoff is the sum of their net incomes from the nine tax collection periods.

Income: Treatment Group. Since buyers do not pay the tax, the calculation of gross and net income for buyers in the treatment group is identical to that of the control group: see equations (2) and (4). Sellers, on the other hand, make a tax reporting decision at the end of every third round. In other words, subjects complete three rounds of trading then sellers make a reporting decision; then three more rounds of trading then another reporting decision and so on.

One advantage of allowing subjects to report after every third trading period is that it increases the probability that every subject has a positive amount to report and must therefore explicitly decide if they wish to under-report sales for tax purposes. Another advantage is that it yields 9 reporting decisions. This is advantageous because it means that subjects can learn the implications of tax evasion for their profits and update their beliefs about the probability of being caught. As a result, we can be assured that the market equilibrium in the evasion treatment reflects the impact of tax evasion on the behaviour of market participants. Although reporting every period would maximize the number of reporting decisions, we opted against this option because excess supply in the market implies that some subjects will sell zero units in a given trading period, which trivializes the reporting decision. Another option is to have subjects make a single reporting decision at the end of the experiment. While this approach maximizes the chance that everyone has a positive amount to report, having a single reporting decision would not allow subjects to learn or update their beliefs. We opted for every third round as a reasonable compromise between these two extremes.[19]

Sellers can report any number between 0 and the true amount sold in the previous three trading periods, and the reported amount is taxed at $\tau = 10$ ECU per-unit. Sellers face an exogenous audit probability of $\gamma = 0.1$ (10 percent) and pay a fine, which is equal to twice the evaded taxes if they underreport sales and are audited. The tax rate, audit probability, and fine rate are fixed across periods and sessions, and all subjects – buyers and sellers – in the treatment group receive this information at the beginning of the experiment.

Therefore, unlike sellers in the control group who must pay taxes on each unit sold, sellers in the treatment group are able to evade the sales tax by underreporting sales. Sellers' gross income in any trading period i is the same as in equation (1), but their net income in each tax collection period is rewritten as:

$$\pi_k^s = \begin{cases} \Pi_k^s + \Pi_{k-1}^s + \Pi_{k-2}^s - \tau R & \text{if not audited,} \\ \Pi_k^s + \Pi_{k-1}^s + \Pi_{k-2}^s - \tau U - \tau(U - R) & \text{if audited,} \end{cases} \tag{5}$$

where R is the reported number of units sold, U is the number of units actually sold over the last three rounds, and $\tau = 10$ is the nominal per-unit tax rate. Subjects' final payoff is the sum of their net incomes from the nine tax collection periods.

2.4 Market Equilibrium without Evasion

The demand and supply schedules described in Table 1 and displayed in Figure 1 can be used to determine the competitive equilibrium price and quantity with and without the per-unit tax. Theoretically, we expect the market to clear with 7 units traded at any price in the range 48 ECU to 52 ECU in the case without taxes. We obtain a range of prices in equilibrium because the demand schedule is stepwise linear (Ruffle 2005; Cox et al. 2018; Grosser and Reuben 2013).[20]

[19] Although subjects in the control group do not make a reporting decision, we collect taxes and report their net profits at the end of every third period to ensure comparability with the treatment group.

[20] Grosser and Reuben (2013) conducted an experiment using the same demand and supply schedule as we do and find that the "no-tax" equilibrium is equal to that predicted by the theory. Therefore,

A per-unit tax on sellers increases the cost of each unit by 10 ECU and thus shifts the supply curve to the left as shown in Figure 1. In the absence of tax evasion opportunities, this theoretically produces a new equilibrium quantity of 6 units, which is supported by an equilibrium price in the range of 53 ECU to 57 ECU. Because the linearized form of the demand and supply schedules have equal elasticity in equilibrium, the incidence of the tax should theoretically be shared equally between buyers and sellers; buyers pay an extra 5 ECU and sellers receive 5 ECU less (after paying the tax), relative to the case without a tax.[21]

The question we seek to answer is whether this equilibrium outcome is affected by the presence of tax evasion opportunities among sellers. The next section provides a theoretical discussion for why tax evasion may or may not affect prices, quantities, and the incidence of the tax.

3 Conceptual Framework

This section first describes the conceptual relationship between evasion opportunities, market prices, and traded quantities, and then explains how we measure the incidence of taxes in the context of our experiment.

3.1 Effect of Evasion Opportunity on Prices and Quantities

There are two opposing theoretical predictions for the effect of evasion opportunities on prices and quantities. We describe the rationale behind both predictions in the following.

Evasion opportunity affects prices and quantities. For simplicity, let's assume that demand and supply curves are linear. Figure 2 illustrates the effect of tax evasion on price and quantity for the cases with and without evasion. First, consider panel A, which represents the control group where evasion is not possible. As in the standard textbook case, the supply curve shifts up by the full amount of the nominal tax rate. This results in a new market equilibrium (p_c, q_c); where subscript c indicates control group.

Sellers in the treatment group have the opportunity to evade taxes by hiding a fraction of their sales. A seller who underreports sales and is not audited faces an effective tax rate that is lower than the nominal tax rate faced by sellers in the control group.

although we do not implement the "no-tax" treatment here, we expect that our "no-tax" equilibrium is in line with theoretical expectations.

[21]We are aware that the price elasticities are not properly defined in equilibrium given that the demand and supply schedules are only piece-wise linear. However, for ease of exposition, we assume the the schedules are linear in order to illustrate the likely economic incidence of the per-unit tax. Notice that the linearized form of the schedules have equal slopes and thus equal elasticities in equilibrium.

Given the deterrence parameters in our experiment – audit probability of 10% and a fine equal to twice the evaded taxes – , we expect that a large fraction of sellers will evade and thus face this lower effective tax rate.[22] As illustrated in panel B of Figure 2, this then implies that the market supply curve in the presence of evasion opportunities shifts up by less than the nominal tax rate. This results in a new market equilibrium at (p_t, q_t); subscript t indicates treatment group.

This intuition leads to a qualitative prediction: the equilibrium price in the treatment group with evasion opportunities will be lower than in the control group where evasion is not an option; i.e., $(p_t < p_c)$. Accordingly, the number of units sold will be higher in the treatment group than in the control group; i.e., $(q_t > q_c)$.

The quantitative difference between the equilibrium prices and quantities in the control and treatment group is determined by the magnitude of the shift in the treatment group's market supply curve. This shift is positively related to the effective tax rate faced by sellers in the treatment group.[23] Note that sellers have to pay the nominal per-unit (excise) tax τ for each unit they sell, but are provided a tax reporting decision. The tax reporting decision is audited with an exogenous probability γ, and because all audits lead to the full discovery of actual sales, a fine equal to twice the evaded taxes must be paid if audited. This implies that seller i has to pay an (expected) effective tax rate of:

$$t_i^e = \frac{\tau(r_i + 2\gamma(s_i - r_i))}{s_i}, \tag{6}$$

where s_i denotes the number of units a seller actually sells and r_i is the number of units she reports.[24] This simple equation shows that the effective tax rate is increasing in the nominal tax rate and decreasing in evasion (for $\gamma < 0.5$). Therefore, an increase in evasion implies a smaller shift in the market supply curve. While it is plausible to expect that the evasion rate will be larger than zero, it is difficult to predict the exact level of evasion ex-ante, and it is therefore not possible to make any predictions regarding the quantitative effects of the treatment on prices and quantities.[25]

[22] This expectation of positive tax evasion is supported by evidence from the field (e.g., Kleven et al. 2011) and the lab (e.g., Alm 2012).

[23] Note that sales taxes (which we study here) and pure profits based income taxes are likely to have very different effects on prices and quantities. In fact, a change in tax rate will not affect the equilibrium price in the case of profit-based income taxes because the price that maximizes profits X will be the same as the price that maximizes $(1 - \tau_{profits})X$.

[24] The seller's tax liability (including any fines) is (τr_i) with probability $(1-\gamma)$, and $(\tau s_i + \tau(s_i - r_i))$ with probability γ. Therefore, the expected effective tax rate can be written as $t_i^e = \frac{(1-\gamma)\tau r_i + \gamma(\tau s_i + \tau(s_i - r_i))}{s_i}$, which is equivalent to equation (6). Note that this effective tax rate reduces to the nominal tax rate τ for sellers who either do not evade or do not have an option to evade.

[25] It is difficult to predict the exact level of evasion, because, as we know from the tax-evasion literature, the decision to evade is complex and depends on several factors including the nominal tax rate, deterrence parameters, the (biased) perception of audit probabilities, the degree of risk aversion, and the intrinsic motivation to pay taxes.

Evasion opportunity does *not* affect prices and quantities. An alternative finding in the theoretical literature is that firms treat their evasion and pricing decision as separable; that is, sellers first set a price at which to sell, and then later make their evasion decision (Bayer and Cowell 2009). This is analogous to other types of uncertainty models; for example, investment models in which the decision over how much to invest in total is separable from the decision on how much to invest in individual assets.

In this case, the opportunity to evade has no bearing on market prices and quantities, and the incidence of the tax is hence also unaffected by the presence of tax evasion among sellers (see Yaniv 1995 for an example of this type of model).[26] The separability result thus implies that the equilibrium price and quantity that arise in a market *with* evasion opportunities is the same as in a market *without* evasion opportunities (and thus as described above in Section 2.4). It is an empirical question whether or not sellers make the reporting and selling decisions separately (even in the absence of endogenous audits). Accordingly, it is eventually an empirical question whether or not evasion opportunities affect prices and quantities.

3.2 Estimation of Economic Incidence

We are interested in the incidence implications of our price effects. For this purpose, we estimate economic incidence in two ways: (i) economic incidence of the nominal tax rate and (ii) economic incidence of the effective tax rate. In the context of the experiment, the former refers to the share of 10 ECU, the nominal per-unit tax rate in the experiment, that sellers shift to buyers. Expressed differently, this is the difference between the equilibrium price in a no-tax scenario and the equilibrium prices that we observe in our experiment. Considering the above rationale regarding prices and quantities, we expect the economic incidence of the nominal tax rate to be larger in the control than in the treatment group.

The incidence of the effective tax rate describes the share of the effective tax rate that is shifted onto buyers. Recall from equation (6) that the effective tax rate is equal to the nominal tax rate in the control group ($r_i = s_i$), and lower than the nominal tax rate in the treatment group ($r_i < s_i$). Under the simplifying assumption that the supply and demand elasticities are equal in equilibrium (see footnote 21), we derive from textbook theory that the tax rate in the control group is shared equally between sellers and buyers. That is, the incidence of the nominal tax rate, and hence the effective tax rate, is predicted to be 50% in the control group.

Though the textbook theory would also predict a 50-50 split of the effective tax rate in the treatment group, the presence of risky evasion opportunities may imply that

[26] In a set-up with endogenous audits, the separability result breaks down and prices are affected by evasion opportunity (Marrelli 1984; Lee 1998; Bayer and Cowell 2009). However, we have an exogenous audit probability in our experimental set-up.

the incidence of the effective tax rate is different than 50% in the presence of evasion opportunities. This deviation from the theoretically expected 50%-result may be due to one of two reasons. First, because evasion is risky, it is possible that sellers shift more than their effective tax burden onto buyers as a means of receiving compensation for the evasion risk. Second, the evasion opportunity decreases the effective tax rate and sellers might perceive it to be easier to shift a lower tax rate onto buyers. Both mechanisms imply that the incidence of the effective tax rate is higher in the treatment group than in the control group. While our main experimental design, as described before, allows us to study the economic incidence of the nominal and effective tax rates in the control and treatment groups, it is not suitable to disentangle these two potential channels. We present an additional treatment in section 5.3 to be able to make this distinction.

4 Empirical Strategy and Results

Recall that we are interested in identifying the impact of tax evasion opportunities on prices and sold quantities. We describe the empirical strategy used to identify these effects in section 4.1 and our findings in section 4.2.

4.1 Empirical Strategy

Definition of prices. Given the discussion in section 3, we are particularly interested in knowing whether the market clearing price in the treatment group is different from that in the control group. Therefore, the first step in our empirical strategy is to define the market price. The experiment produced one price for each unit sold in a given market-period, which allows us to create three measures of market price. The first measure is simply the price at which each item is sold, which we denote P. We also calculate the mean and median price in a given market-period and denote them $\overline{P}$ and P_{50}, respectively. Therefore, our data set has one observation per market-period when price is measured by $\overline{P}$ or P_{50} and n observations per market-period when market price is measured by P, where n is the number of units sold in that market-period.

Non-parametric analysis. Due to random assignment to groups and markets, any (non-parametric) difference in these prices between the treatment and control groups is taken as evidence of the presence of treatment effects. Because the period-specific prices are not independent across the 27 periods within a given market, we implement our non-parametric analysis (ranksum tests; see footnote 27) using the average price for each market; that is, we use the average of P by market. This implies that our non-parametric analysis is based on eight independent observations; four in the treatment and four in the control groups.[27]

Regressions. We also test for treatment effects parametrically by regressing each measure of price, separately, on a treatment dummy. The baseline model for $\overline{P}$ is specified as follows:

$$\overline{P}_{i,m} = \beta_0 + \delta T_m + \epsilon_{i,m}, \tag{7}$$

where $\overline{P}_{i,m}$ is the mean price of the good in period i (with $i = 1, ..., 27$) of market m (with $m = 1, ..., 8$). T_m is a dummy for the treatment state, which is equal to one if treatment group and zero if control group. $\epsilon_{i,m}$ is a standard error term. Our coefficient of interest is δ, which represents the difference in market price between the two groups. More precisely, δ indicates the causal effect of evasion opportunity on the equilibrium market price. This causal interpretation follows from the fact that the groups are identical except for access to evasion and random assignment of participants to the two groups. We set up our data as a panel with 27 periods per market and run pooled ordinary least squares (OLS) regressions. To account for the dependence of prices across periods within a market, we cluster standard errors on the market level.[28] Because the treatment status of each market and hence the participants in that market is always the same, the treatment effect is identified using a between-market design.[29] We include period fixed effects in some specifications.

4.2 Results

4.2.1 Summary Statistics

After the experiment, subjects reported their age, gender, native language, level of tax morale and field of study. Tax morale is determined using a question very similar to one

[27]While the number of independent observations, eight, appears to be low, it is not unprecedented to use such few observations in empirical analysis; see for example Grosser and Reuben (2013) who apply nonparametric tests based on four independent market-level observations and have sufficient statistical power. We use the Stata routine provided by Harris and Hardin (2013), which adjusts the p-values to the low number of observations, to implement "exact" ranksum tests (these are based on Wilcoxon 1945 and Mann and Whitney 1947). We detect differences between treatment groups with significant precision, which suggests that the number of observations is sufficient in our study.

[28]Note that estimators that allow for censoring, such as Tobit models, are unnecessary since the market price is not censored. Although the market price could be no lower than 18 and no higher the 82, the distribution of market prices suggest that these prices were never binding; the lowest market price is 30 and the highest is 63.

[29]Notice that this also implies that it is not possible to estimate the treatment effect in the presence of market fixed effects. Each individual is randomly assigned to a market and everyone in the market has the same treatment status. Therefore, the treatment status of a market is the same as the treatment status of the individuals trading in that market.

used in the World Values Survey (Inglehart nd).[30] Each of these variables is summarized in Table 2. Casual observation of the data shows that randomization into the treatment states worked well. This is confirmed by non-parametric Wilcoxon rank-sum tests for differences in distributions between groups; we do not observe any statistically significant differences in gender, age, share of participants whose native language is German, tax morale or field of study across the two groups. While we do not explicitly measure other attitudinal variables such as social norms or preferences, randomization implies that these omitted variables are also balanced across groups and therefore do not have any effect on our results. Among all participants, approximately 51% were male, 77% indicated German to be their native language, and the average age was 26 years. Approximately 24% of subjects stated that cheating on taxes can never be justified and 48% indicated that economics is their major field of study.

Table 2 also reports the compliance rate in the treatment group. We find that every subject evaded some positive amount of sales at least once and 13 of the 20 sellers in the treatment group fully pursued the profit maximizing rational strategy of full evasion in every reporting period. As a result the mean compliance rate is approximately 7% among all sellers in treatment group and 61% among those who report non-zero sales.[31]

4.2.2 Prices

Non-parametric results. The non-parametric results presented in Figures 3 and 4 and Table 3 show clearly that the price in the treatment group is lower than in the control group. Figure 3 reports the mean market price by period for the treatment and control groups. The data show that the mean market price varied a lot in both groups in the first 10 to 14 trading periods. This is consistent with the existing literature, which generally finds that double auction markets take approximately 8 to 10 rounds to converge (Ruffle 2005).

Although price in both groups converged in roughly the same number of periods, the evolution of prices is different. Price increased steadily to equilibrium in the treatment group, and behave erratically in the control group. For this reason, and as is common in the literature, our primary results are based on data from trading periods 14 to 27

[30] "Please tell me for the following statement whether you think it can always be justified, never be justified, or something in between: 'Cheating on taxes if you have the chance'." This is the most frequently used question to measure tax morale in observational studies (e.g., Alm and Torgler 2006 and Halla 2012).

[31] This level of evasion is at the high end of evasion estimates in the experimental tax evasion literature (e.g., Fortin et al. 2007; Alm et al. 2009; Alm et al. 2010; Coricelli et al. 2010). However, these studies focus on income taxes and are therefore not directly comparable to our results. We do not know of any sales tax experiments in the tax evasion literature. Evidence from the real world suggest that our compliance rates are not unreasonable. For example, the compliance rate in our experiment is comparable to the compliance rate for the 'use' tax in the United States; 0 to 5 percent among individuals (GAO 2000).

(we provide results for the full sample for illustrative purposes). The mean market price in both groups stabilized after round 14: at approximately **54.36 ECU** in the control group and **51.65 ECU** in the treatment group (see panel B of Table 3). This implies that the mean market price in the treatment group is 2.71 ECU lower than in the control group.[32] As shown in Figure 4 and the second column of Table 3, median prices are also lower in the treatment group than in the control group; the median price is **51.27 ECU** in the treatment group and **54.07 ECU** in the control group, resulting in a treatment effect of 2.80 ECU.

These differences in prices between the groups are statistically significant from zero; the exact ranksum tests (two-sided) give p-values of 0.029 for differences in median prices, and 0.057 for differences in average prices.[33] In other words, we find that markets with access to tax evasion trade at significantly lower prices than markets without access to tax evasion. The experimental results are thus consistent with our qualitative prediction that the market price will be lower in the treatment than in the control group.[34]

Regression results. We extend the analysis above by estimating equation (7) for the mean market price as the dependent variable. The estimated treatment effect of -2.70 ECU reported in model 1 of Panel B of Table 4 is statistically different from zero at the 1 percent level.[35] This estimate remains significant at the 5 percent level even after correcting for the small number of clusters using the wild-bootstrap-t procedure described in Cameron et al. (2008); see Table 9 in appendix.[36] Additionally, the estimate is robust to the inclusion of period fixed effects (model 2), demographic covariates (model 3), both period fixed effects and demographic covariates (model 4), and the definition of price (Table 5). Estimating equation (7) with the median market price, P_{50}, as our dependent variable yields treatment effects of -1.60 ECU to -2.10 ECU that are statistically different from zero at the 1% level (see Panel A of Table 5). Although these estimates are approximately 0.70 to 1.00 ECU smaller than that reported in Panel B of Table 4,

[32] Note that the estimated treatment effect is larger for the full sample (panel A). Because this sample includes data before the market price converges, we prefer the estimate in panel B.

[33] Note that 0.029 is the lowest possible p-value for the exact ranksum test with 8 independent observations.

[34] Further evidence that tax evasion affects the market price is provided in Figures 7 and 8, which report the cumulative distribution of mean and median market prices, respectively, for the treatment and control groups. Both figures show clearly that the price in the control group is not drawn from the same distribution as that in the treatment group. This conclusion is supported by the Kolmogorov-Smirnov test for equality of distribution functions; in both cases we reject the null that the distributions are equal. This result also holds when we use the individual ask prices (P) instead of mean or median prices; results available upon request.

[35] Panel A of Table 4 reports the results for the full sample. These results are reported for illustrative purposes only since the market does not clear until around period 14.

[36] The correction is implemented using Stata code provided by Judson Caskey and is available here: `https://sites.google.com/site/judsoncaskey/data`.

they remain economically meaningful.[37] These results confirm our earlier non-parametric findings that the market price in the treatment group is significantly lower than in the control group.

4.2.3 Units sold

We identify the treatment effect on units sold using the same strategy as above. In particular, the non-parametric analysis is based on the mean number of units sold at the market level, while the regression analysis is based on the number of units sold in a market-period with standard errors clustered at the market-level.

Non-parametric results. The predictions in section 3 suggest that treatment markets will clear at a lower price and higher quantity than the control-group markets. We have already demonstrated that the market clearing price is lower in the treatment group. This section shows that the treatment group also sold more units than the control group. The results in Table 3 show that the mean number of units sold per period in the control group is **5.96**. On the other hand, the treatment group sold an average of **6.49** units per period. The difference between units sold in the treatment and control group is statistically significant with the lowest possible p-value of 0.029 (exact two-sided ranksum test based on eight independent observations). In other words, the estimated treatment effect of 0.5 units is statistically different from zero. The difference in sales between the two groups is even more obvious when we look at the total number of units sold by each group. Again, restricting attention to trading periods 15 to 27 (after the market clears), we find that the treatment group sold a total of 336 units while the control group only sold 308 units. Corresponding numbers for periods 1 to 27 are 704 and 647 in the treatment and control group, respectively. The experimental results hence confirm our prediction that markets with access to evasion trade more units than markets without evasion opportunities.

Regression results. These results are supported by results from a regression analysis that are reported in Table 6. Focussing on Panel B, which reports results for periods 15 to 27, we find a statistically significant treatment effect of 0.6 units; relative to the control group, the treatment group sold approximately 0.6 more units per period.

[37] We also estimate the model with the ask price for each unit sold as the dependent variable and report the results in Panel B of Table 5. The estimated treatment effect in this case is -2.66 ECU to -2.72 ECU, which is almost identical to that for the mean market price as reported in Panel B of Table 4.

5 Discussion

The results presented in section 4.2 show that markets with sellers who have the opportunity to evade taxes trade more units and do so at lower prices than markets where tax evasion is not possible. These main findings show that tax-evasion opportunities have a causal effect on prices and quantities.

The identified empirical effects speak to the two opposing predictions that we presented in section 3. Our findings clearly support the prediction that tax evasion opportunities do have an effect on prices and quantities. The rationale for this prediction is that tax evasion lowers the effective tax rate facing sellers, which then allows sellers to trade at lower prices in a competitive market. As a result, the industry supply curve shifts by less than in the case without access to evasion. We do not find support for the alternative prediction according to which evasion does not have an effect on prices and quantities because sellers treat their evasion and pricing decision separately from each other. Our empirical results thus suggest that this separability result does not hold in our set-up.

In the following, we discuss the implications of our price and quantity effects, in particular with respect to after-tax profits and tax incidence. We proceed as follows. Section 5.1 discusses the effects of evasion on net incomes and profits. Section 5.2 explains the incidence results in the context of the conceptual framework. Section 5.3 describes an additional treatment that sheds more light on our tax-incidence results. The external validity of our findings is discussed in section 5.4.

5.1 Treatment Effects on After-Tax Income

Our experimental design allows us to identify the effect of tax evasion on the net income of buyers and sellers. Because markets with access to evasion trade at lower prices and higher quantity, the presence of tax evasion should lead to an increase in buyers' net income relative to buyers in the control group. Additionally, sellers' net income might also increase despite the lower price because they only report a fraction of their true sales. Our findings are consistent with these predictions. In the absence of tax evasion (i.e., in the control group), total net income of buyers is $1,161.25$ ECU compared to sellers' net income of 959.25 ECU. The introduction of tax evasion opportunities increases buyers' net income to $1,375.75$ ECU and sellers' net income to $1,322.75$ ECU. This represents a treatment effect of 214.5 ECU and 363.5 ECU for buyers and sellers, respectively.

These treatment effects are consistent with the observed price changes. Buyers' net incomes increase because they pay 2.7 ECU less per unit in the evasion treatment. Although sellers in the evasion treatment receive 2.7 ECU less per unit, their effective tax rate falls by a larger margin (approximately 7.5 ECU) due to their evasion opportunity. As a result, both buyers and sellers experience an increase in net income, but sellers receive a much larger increase.

5.2 Economic Incidence

Our conceptual framework predicts that the final tax burden shifted from sellers to buyers is lower in the presence of evasion opportunities than it would otherwise be in the absence of tax evasion. This is exactly what we find; we observe a mean compliance rate of 7% among all sellers, which implies an average effective tax rate of approximately 2.56 ECU among all sellers (see equation 6 to see how we calculate the effective tax rate). Sellers facing these lower effective tax rates trade at lower prices.

So how does this response among sellers affect the incidence of the tax? In order to answer this question, we first have to determine the incidence of the tax in the control group, which requires knowing the market equilibrium in the absence of the tax. Although we did not run a "no-tax" treatment, we are able to derive this "no-tax" equilibrium by relying on theoretical predictions and the empirical evidence of Grosser and Reuben (2013). As outlined in section 2.4, we expect the no-tax market to produce an equilibrium with 7 units at a price in the range 48 ECU to 52 ECU. This prediction is supported by empirical evidence in Grosser and Reuben (2013); they find a mean market price of 49.04 ECU (standard deviation: 1.3) and 7.03 (sd: 0.36) units in the "no-tax" equilibrium. Using the "no-tax" result as a benchmark, in the following we discuss the economic incidence of the nominal tax rate (10 ECU in both groups) and the effective tax rate (10 ECU in control group, and 2.56 ECU in the treatment group due to underreporting).

Using the results from Grosser and Reuben (2013) as a baseline for our incidence analysis is supported by at least three reasons. First, we use the same double auction as they do. Most importantly, the following components are identical: the number of buyers and sellers in each market, length of a trading period, the demand and supply schedules, the number of homogeneous goods to be traded, and the visual appearance of the market place as coded using z-tree. Additionally, their experimental sessions were run in the same laboratory as ours (Cologne, Germany), implying that the subject pool is highly comparable and laboratory characteristics (e.g., composition of subjects, laboratory facilities, quality of subject pool, university characteristics, etc) are held constant. Second, the price they observe in their no-tax treatment is well within the theoretically-predicted price range. Finally, there is very little order effects on trading prices in their within-subjects design.[38]

[38]Grosser and Reuben (2013) implement a within-subject design where each subject trades in a market with a tax and a market without tax. The order of tax and no-tax treatments is randomized to control for order effects, and we rely on their no-tax results as a benchmark for our incidence analyses. The mean trading price is 48.37 ECU (sd: 0.99) among subjects who participated in the no-tax treatment before the tax treatment and 49.04 ECU (sd: 1.3) among all no-tax treatments. The small difference between 49.04 ECU and 48.37 ECU indicates that order effects are tiny. This suggests that it is reasonable to

5.2.1 Nominal tax rate

How do evasion opportunities affect the incidence of the nominal tax rate? The equilibrium price in the control group (with tax but no evasion opportunity) is 54.36 ECU (sd: 1.15), which is approximately 5 ECU above the "no-tax" equilibrium of 49.04 ECU. This suggests that the incidence of the nominal tax burden in the control group is approximately shared equally between buyers and sellers since the nominal tax rate is 10 ECU per unit. Again, this is consistent with the theoretical framework; since the demand and supply schedules have equal price elasticity in equilibrium, the burden is expected to be shared equally between buyers and sellers.

The next step is to determine the extent to which access to evasion affected the economic incidence of the nominal tax. The mean market clearing price in the treatment group (with tax and evasion opportunity) is 51.65 ECU (sd: 1.26). Considering the nominal tax rate of 10 ECU per unit and the no-tax benchmark of 49.04 ECU, this implies that buyers in the treatment group pay 26.1% (= (51.65 − 49.04)/10) of the *nominal* tax burden, compared to the ≈50% in the case without evasion. In other words, access to evasion reduced the economic incidence of the tax on buyers by about 24 percentage points. This treatment effect on incidence appears small when compared to the market price. However, we argue that the relevant comparison is the share of the nominal tax burden that the buyers paid in the control group. Since buyers paid 5 ECU of the nominal tax of 10 ECU in the control group, the largest expected effect of evasion is a reduction of 5 ECU. Therefore, using this baseline, a treatment effect of 2.71 ECU is very large. These results on the economic incidence of the nominal tax rate are summarized in Table 7.

5.2.2 Effective tax rate

Finally, we wish to know whether access to evasion changed the incidence of the effective tax rate. Because the effective tax rate is the same as the nominal tax rate in the control group, we already know that the effective tax rate is approximately shared equally between buyers and sellers in the control group. How does this incidence result change in the presence of tax evasion? Recall that the expected effective tax rate from equation (6) is estimated to be 2.56 ECU. If sellers with evasion opportunity continued to share the effective tax burden 50-50, we would expect the price in the treatment group to increase by approximately 1.28 ECU (= 2.56/2) relative to the "no-tax" equilibrium of 49.04

use the overall no-tax mean price as a benchmark for our incidence analysis. Note that subjects who played the no-tax treatment first were aware that a second part would follow, but they were not given the instructions until the first part of the experiment (i.e., trading without tax) was completed. This implies that behavior in the no-tax treatment among those who play no-tax first is not confounded by subsequent parts of the experiment. The results for subjects who played the no-tax scenario first are not published but were requested from the authors.

ECU; that is to 50.32. However, this is not what we observe. The price in the treatment group is 51.65 ECU, which suggests that sellers shift the full expected effective tax rate onto buyers; buyers bear 2.61 ECU (= 51.65 − 49.04) even though the effective tax rate is 2.56 ECU. As a result, about 101.95% (= (51.65 − 49.04)/2.56) of a seller's expected effective tax rate is shifted onto buyers.[39]

Interestingly, the incidence of the effective tax rate implies that the evasion-induced discount offered by sellers is consistent with the parameters of the evasion gamble. In particular, sellers experienced a roughly 50% reduction in their share of the tax and passed on all of this reduction to the buyers. Therefore, although all of the effective tax rate was passed on the buyers, this reflects a discount (relative to the control group) that is approximately equal to the expected savings to the sellers.

5.3 Additional Treatment

The full shifting of the effective tax rate raises an interesting question: why do we observe full shifting of the effective tax rate in the evasion treatment whereas we observe the theoretically expected 50-50 shifting in the control group? We suspect this is due to one of two reasons. First, this could be due the fact that the effective tax rate is lower in the treatment group. The lower effective tax rate in the evasion treatment might make it easier to shift more of the tax burden onto buyers. Second, this might be due to the evasion opportunity. Sellers might attempt to shift enough of their tax burden onto buyers because they desire to be compensated for the risk associated with evasion. We ran three additional sessions in order to separate this pure evasion effect from the effect of the lower effective tax rate. Below we describe the design and results from this additional treatment.

5.3.1 Design

The additional sessions are identical to the previous control sessions except that the effective tax is exogenously lowered to 2.5 ECU, which is the same as the effective tax rate in the evasion treatment.[40] As in the previous treatments, the nominal tax rate is set at 10 ECU, but sellers are told that they will receive a credit of 7.5 ECU for every unit they sell. Sellers do not make a reporting decision. Instead, all tax calculations including the tax credit adjustment are done automatically. Therefore, sellers in the additional treatment face an effective tax rate that is lower than their nominal tax rate. More importantly, there are no risks associated with this lowered effective tax rate. Although

[39]These results on the economic incidence of the effective tax rate are summarized in the first three rows of Table 8.

[40]The effective tax rate in the evasion treatment is actually 2.56 ECU. However, we opted for 2.5 ECU because it is easier for subjects to mentally calculate while making their sales and purchasing decisions.

the effective tax rate is the same as in the evasion treatments, sellers in those treatments had to take on audit risk in order to arrive at this lower effective tax rate.

Operationally, the only difference between the additional treatment and the control group (i.e., without evasion) is the inclusion of the tax credit; everything else is the same. The differences in the instructions that subjects read at the beginning of the experiment are highlighted in appendix section C. We ran three sessions – that lasted approximately 100 minutes each – at the same lab that we used for the first set of experiments (University of Cologne), but none of the subjects had participated in the previous sessions. There were 10 subjects (five buyers and five sellers) in each session, and the average pay-off was 22 EUR.

5.3.2 Results

The results from this additional treatment are reported in Figure 6 and Table 8. We find that the average equilibrium price in the additional treatment is **50.09 ECU** (sd: 2.16), which is lower than the price in both the evasion and control groups.[41] Though the equilibrium price in the additional treatment is more than 1.50 ECU lower than in the evasion treatments, we cannot reject the null that the price difference between these two treatments is zero. Still, this price difference is economically meaningful. Notice that consumers in the deduction treatment pay 1.05 ECU (= 50.09 − 49.04) of the nominal tax rate, while those in the evasion treatment pay 2.61 ECU and those in the control group pay 5.32 ECU. This implies that sellers in the additional treatment shifted 42.0% (= (50.09 − 49.04)/2.5) of their effective tax burden onto buyers.

Importantly, this shifting of the effective tax rate is considerably lower than the full shifting of the effective tax rate that we observe in the evasion treatments – despite the fact that the effective tax rate is the same. This provides suggestive evidence that the evasion opportunity itself, rather than the lower effective tax rate, is the main driver of the full shifting that we observe in the evasion treatments.

The net incomes of both sellers and buyers increase in the additional treatment relative to the control group; the increase amounts to 373 ECU for buyers and 326.75 ECU for sellers, both relative to the control group without evasion opportunities. That is, for buyers the positive effect of the deduction is larger than the positive effect of the evasion opportunity (recall that the net income of buyers in the evasion treatment was 214.5 ECU higher than in the control group). This is consistent with the observation that the equilibrium price in the deduction treatment is lower than in the evasion treatment. In contrast, because sellers in the deduction treatment face the same tax rate as in the evasion treatment, but receive a lower price, the positive effect of the deduction on net incomes of sellers is lower than the positive effect of the evasion opportunity (recall that

[41] As before, our empirical analysis is based on data from periods 15 to 27.

net income of sellers in the evasion group was 363.5 ECU higher than in the control group).

5.4 External Validity

As with almost all economic laboratory experiments, there remains doubt about the external validity of our results.[42] One general concern is that the setting in the lab is abstract and artificial. However, the literature shows that laboratory double auctions, which we use in our experiment, generate very plausible equilibria (e.g., Smith 1962; Holt 1995; Dufwenberg et al. 2005; Grosser and Reuben 2013). This suggests that our experimental setting is appropriate to study prices and quantities as outcome variables. In addition, although subjects trade in fictitious goods, they receive actual money pay-offs and thus face incentives similar to buyers and sellers in actual markets. Furthermore, the question of tax incidence (without tax evasion) has been widely studied in the laboratory setting (e.g., Riedl and Tyran 2005; Ruffle 2005; Cox et al. 2018; Grosser and Reuben 2013) and shown to lead to results that reflect theoretical predictions very well.

In order to make the tax evasion decision as realistic as possible we used actual tax terminology and announced to the participants that all tax revenue would be donated to the German Red Cross, a non-ideological charity organization that is usually perceived as reliable and transparent. That is, we made clear to participants that the revenue from the laboratory tax does not simply flow back to our research budget. This design choice thus contributes to mimicking the real-world situation where tax revenues are spent for a purpose and are not just wasted.[43]

Additionally, although evasion may occur among buyers as well, the real-world problem seems to be more relevant among sellers; sellers are usually responsible for remitting sales taxes to the government. In this sense, our laboratory setting mimics the operation of most transaction taxes in the real world in that we also have a set-up in which sellers remit the tax.[44] We acknowledge that prices and quantities on real-world markets, such as the retail commerce market, are not determined in a competitive double auction setting with full information of all actors. However, many real-world markets are considerably close to competitive markets and are characterized by a situation where both sellers and buyers have full information about prices (especially now that prices are

[42]The generalizability of lab experiments is discussed by Falk and Heckman (2009). We restate some of their arguments here and translate them to our specific context.

[43]Tax morale research (Torgler 2007) finds that taxpayers are more likely to comply with tax laws if they believe that the tax revenue is spent transparently. Eckel and Grossman (1996) show that dictators share more in dictator games if the recipient is the American Red Cross. Overall, we donated EUR 332 to the Red Cross (including the additional treatment).

[44]The political purpose of transaction taxes such as VAT usually is that buyers pay the tax while sellers remit it. However, just as in our experiment, the actual economic burden of the tax in the real world is eventually determined in the interplay between demand and supply of buyers and sellers.

very transparent online and easy to compare) and where these prices are determined in the interplay between supply and demand.

A further concern of generalizability relates to the costs of evasion in our empirical design. While our audit rate of 10% seems low, there is evidence of "real-world" tax systems with significantly lower audit rates. For example, a recent news article revealed that the tax agency in the state of Mississippi "audited just 2 percent of businesses operating in the state [in fiscal year 2012]."[45] While this does not necessarily imply that each firm faced an audit rate of 2%, it does suggest that our audit rate of 10% is not unreasonable.

6 Conclusion

We use data generated in a controlled laboratory experiment to identify the effect of tax evasion among sellers on consumption prices and traded quantities. We find strong evidence that tax-evasion opportunities cause lower prices and higher numbers of traded units. This findings suggests that pricing and evasion decisions of firms in our set-up are not separable. Instead, our findings are consistent with the simple rationale that the evasion opportunity allows firms to reduce their tax liability and therefore offer goods at lower prices. We additionally find that sellers increase their after-tax incomes through the evasion opportunity, despite lower prices at which they trade their goods in the presence of evasion access.

Our findings further reveal interesting results about the incidence of taxes with and without evasion possibilities. In particular, relative to the baseline case where buyers face ≈50% of the nominal tax burden, buyers in the treatment group only face approximately 26% of the nominal tax burden. Although buyers pay lower prices than they otherwise would, we find that sellers fully shift the expected effective tax onto buyers. An additional treatment show that prices are different between markets with and without evasion opportunity even if the effective tax burden is the same. In other words, endogenous evasion-induced changes in the effective tax burden have different price effects than exogenous changes in the effective tax burden of equal magnitude. This finding suggests that the full shifting of the effective tax burden observed in the evasion treatment is due to the evasion opportunity itself rather than the evasion-induced lower effective tax rate. One possible explanation for this finding is that evaders desire to be compensated for the risk of evasion and therefore trade at higher prices.

These results potentially have implications for the effects of recent policies aiming

[45]The article was published on the website of WTVA news: `http://www.wtva.com/mostpopular/story/Sales-tax-dodging-on-the-rise-in-Mississippi/dg14bG-Prk60APNSt96RHQ.cspx`.

at the reduction of tax evasion and tax avoidance.[46] In particular, our findings suggest that such policies can increase prices and lower sold quantities.

Therefore, our results are relevant in countries such as the United States where the Supreme Court's ruling in *South Dakota v Wayfair* is expected to change the way out-of-state merchants are treated with respect to retail sales tax collection. In particular, a number of states are expected to follow South Dakota's lead in requiring out-of-state firms to serve as tax collectors, thus changing the tax evasion opportunities that previously existed with the *Use-Tax*. There have also been a push to restrict the sale of "zappers", which are used to evade sales taxes among firms. Our findings suggest that, *all else equal*, such measures are likely to result in higher prices as affected sellers fully adjust to the retail sales tax. While we focus on sales taxes here, the findings also suggest that other anti-tax evasion initiatives, such as the Foreign Account Tax Compliance Act (FATCA), are likely to affect the level of economic activity as affected parties respond to the reduced evasion opportunities. The general rationale behind our results also applies to tax avoidance and recent measures to reduce avoidance activities of firms (such as OECD Base Erosion and Profit Shifting, BEPS or Country by Country Reporting, CbCR). As with evasion, tax avoidance possibilities allow firms to reduce their tax liability and therefore potentially offer goods at lower prices. In this regard, our results suggest that anti-avoidance policies potentially increase prices and reduce traded quantities.

While we show that tax-evasion opportunities affect prices and quantities, we acknowledge that it is not clear that the magnitude of the effects is the same across all types of taxes and/or 100% comparable to cases with avoidance possibilities. Conditional on the ease with which taxes can be evaded/avoided, it is also possible that the mechanism of evasion/avoidance matters. For example, Tran and Nguyen (2014) show that Vietnamese firms evade VAT by artificially increasing their sales and material costs, which is facilitated by colluding with other producers in the supply chain. The presence of collusion as a means of evasion suggests lower competitive pressure, which may lead to different incidence outcomes under a VAT compared to retail sales taxes where collusion among firms is not necessary for evasion. Given recent calls for the adoption of VAT in the USA, we argue that this potential difference is worth investigating in future research. More generally, it would be interesting to know if and how evasion mechanisms in different tax systems affect prices and sold quantities.

We identify several further avenues for future research that emerge from our findings. The (tax accounting) literature studies the relationship between risk/uncertainty and tax planning decisions (e.g. Kim et al. 2011; Rego and Wilson 2012; Guenther et al. 2017; Dyreng et al. 2019). Relating to this literature, one interesting question is if our results

[46] While we focus on tax evasion, note that our results also have implications for tax avoidance because the underlying rationale for our findings also applies to avoidance: just as evasion, avoidance allows firms to reduce their tax base and therefore gives scope to trade at lower prices.

would be similar in an institutional set-up in which there is uncertainty about the audit process and in which the desire for risk compensation is thus complicated. Another valuable follow-up study could investigate if the effect of evasion opportunities on prices and quantities is conditional on buyers' knowledge of a seller's actual evasion behavior. Relating to the economics literature on the tax liability-side equivalence, it could also be interesting to explore if the price effects of our set up are similar in situations in which buyers (rather than sellers) are responsible for remitting the tax to the authority. Finally, it would fruitful to check whether the the treatment effects we estimate depend on the type of market structure and the degree of competition.

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Tables and Figures

Tables

Table 1: Demand and Supply Schedules

Buyer			Seller		
Subject	Value 1	Value 2	Subject	Cost 1	Cost 2
1	82	52	1	18	48
2	77	72	2	23	28
3	67	37	3	33	63
4	62	42	4	38	58
5	57	47	5	43	53

Notes: Reported are demand and supply schedules.

Table 2: Summary statistics of Demographic Variables

	Gender	Age	German	Tax Morale	Econ	Compliance
	Control Group (Non-Evaders)					
Mean	0.43	24.90	0.72	0.25	0.43	–
St. Dev.	0.50	6.87	0.46	0.44	0.50	–
N. of Subjects	40	40	39	40	40	–
	Treatment Group (Evaders)					
Mean	0.60	26.93	0.83	0.23	0.53	0.07
St. Dev.	0.50	12.25	0.38	0.42	0.51	0.23
N. of Subjects	40	40	40	40	40	40
P-value	0.12	0.23	0.26	0.79	0.37	–

Notes: Reported are the mean characteristics of treatment and control groups. Gender is a dummy that is equal to 1 if male, German is a dummy that is equal to 1 if native language is German, tax morale is a dummy that is equal to 1 for subjects who believe cheating on taxes can never be justified and Econ is a dummy that is equal to 1 if field of study is economics. One subject in the control group did not report his/her language. P-value is for the Wilcoxon rank-sum test; null hypothesis is that there is no difference in the characteristics between the two groups.

Table 3: Prices and Quantities by Treatment Group

Group	Price			Units sold	
	Mean	Median	Std. Dev.	Mean	Std. Dev.
			Panel A: Full Sample		
Non-evader	54.99	54.86	1.57	6.04	0.14
Evader	51.24	50.87	1.52	6.55	0.26
			Panel B: Period>14		
Non-evader	54.36	54.07	1.15	5.96	0.19
Evader	51.65	51.27	1.26	6.49	0.30
P-value	0.057	0.029	–	0.029	–

Notes: Reported is the market-level mean and market-level median of P, where P is the price at which each unit is sold in a given market period (see definition in the first paragraph of section 4.1). Units sold is the market-level mean of units sold in a given market period. All numbers and statistics are based on eight independent market-level observations. Panel A uses all completed contracts from periods 1 to 27 and panel B uses all completed contracts in periods 15 to 27. P-value is for the exact Wilcoxon ranksum test based on eight independent market-level observations; null hypothesis is that there is no difference between the two groups.

Table 4: Impact of treatment on mean market price

	Model 1	Model 2	Model 3	Model 4
	Panel A: Full Sample			
Treat	-3.750***	-3.750***	-4.300***	-4.300***
	(1.009)	(1.077)	(0.347)	(0.371)
Constant	55.008***	54.181***	48.868***	48.040***
	(0.727)	(1.247)	(2.632)	(3.407)
R2	0.499	0.517	0.737	0.754
N	216	216	216	216
	Panel B: Period>14			
Treat	-2.701***	-2.701***	-2.651***	-2.651***
	(0.795)	(0.847)	(0.075)	(0.081)
Constant	54.362***	54.297***	49.508***	49.443***
	(0.539)	(0.516)	(0.572)	(0.750)
R2	0.553	0.563	0.884	0.894
N	104	104	104	104
Control variables	No	No	Yes	Yes
Period FE	No	Yes	No	Yes

Notes: Robust standard errors adjusted for clustering at the market level are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Estimates are based on equation (7) with the dependent variable defined as mean market price in a given market period. Panel A uses all completed contracts from periods 1 to 27, panel B uses all completed contracts in periods 15 to 27. Period FE is period fixed effects. Control variables include the share of males, share of native German speakers, share of subjects who believe cheating on taxes can never be justified, and share of subjects whose field of study is economics. These shares are calculated at the market-level.

Table 5: Impact of treatment on median and ask market price

	Model 1	Model 2	Model 3	Model 4
	Panel A: Median Ask Price (P_{50})			
Treat	-2.087***	-2.087***	-1.589***	-1.589***
	(0.625)	(0.665)	(0.218)	(0.233)
Constant	53.779***	53.918***	60.175***	60.314***
	(0.089)	(0.222)	(1.655)	(1.809)
R2	0.538	0.563	0.853	0.878
N	104	104	104	104
	Panel B: Ask Price (P)			
Treat	-2.720***	-2.721***	-2.662***	-2.660***
	(0.798)	(0.808)	(0.065)	(0.069)
Constant	54.354***	54.255***	49.500***	49.481***
	(0.543)	(0.486)	(0.491)	(0.593)
R2	0.173	0.176	0.276	0.279
N	644	644	644	644
Control variables	No	No	Yes	Yes
Period FE	No	Yes	No	Yes

Notes: Robust standard errors adjusted for clustering at the market level are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Estimates are based on equation (7) with the dependent variable defined as median market price in a given market period in panel A; and the market price for each good in each market period in Panel B. All panels use completed contracts from periods 15 to 27. Period FE is period fixed effects. Control variables include the share of males, share of native German speakers, share of subjects who believe cheating on taxes can never be justified, and share of subjects whose field of study is economics. These shares are calculated at the market-level.

Table 6: Impact of treatment on units sold

	Model 1	Model 2	Model 3	Model 4
	Panel A: Full Sample			
Treat	0.336***	0.334***	0.320***	0.324***
	(0.064)	(0.068)	(0.027)	(0.035)
Constant	6.088***	6.525***	6.701***	7.186***
	(0.059)	(0.144)	(0.406)	(0.277)
R2	0.090	0.292	0.100	0.301
N	1,006	1,006	1,006	1,006
	Panel B: Period>14			
Treat	0.402***	0.403***	0.598***	0.594***
	(0.125)	(0.125)	(0.051)	(0.056)
Constant	5.939***	6.177***	7.891***	8.102***
	(0.118)	(0.323)	(0.756)	(0.878)
R2	0.148	0.262	0.191	0.303
N	476	476	476	476
Control variables	No	No	Yes	Yes
Period FE	No	Yes	No	Yes

Notes: Robust standard errors adjusted for clustering at the market level are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Estimates are based on equation (7) with the dependent variable defined as the number of units sold in a given market period. Panel A uses all completed contracts from periods 1 to 27, panel B uses all completed contracts in periods 15 to 27. "Period FE" is period fixed effects. Control variables include the share of males, share of native German speakers, share of subjects who believe cheating on taxes can never be justified, and share of subjects whose field of study is economics. These shares are calculated at the market-level.

Table 7: Overview of Results and Economic Incidence of Per-unit Tax

Condition	Price	Units	Incidence Nominal Tax
No-Tax	49.04	7.03	–
Control	54.36	5.96	53.2%
Treatment	51.65	6.50	26.1%
Treat Effect	-2.71	0.54	-27.1

Notes: The results in "No Tax" row are from Grosser and Reuben (2013) who use identical supply and demand schedules in an experimental double auction without taxes. "Control" and "Treatment" refer to the groups without and with evasion opportunity, respectively. Reported are the mean prices and number of units traded. "Incidence Nominal Tax" is the share of the nominal tax rate (10 ECU) that is shifted onto buyers. "Treat Effect" indicates the non-parametric treatment effect defined as the difference between treatment and control group. All numbers expressed in Experimental Currency Units.

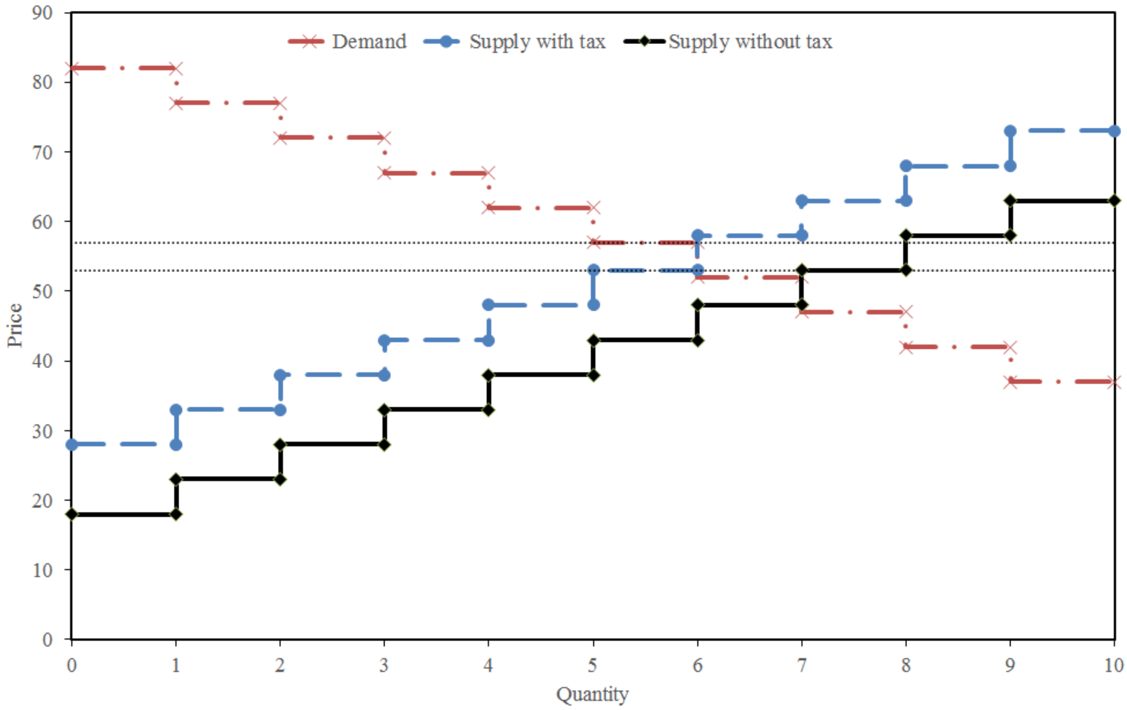
Table 8: Additional Treatment and Incidence of Effective Tax Rate

Condition	Price	Units	Incidence Effective Tax
No-Tax	49.04	7.03	–
Control	54.36	5.96	53.2%
Treatment	51.65	6.50	101.95%
Tax Credit	50.09	6.89	42.0%

Notes: The results in "No Tax" row are from Grosser and Reuben (2013) who use identical supply and demand schedules in an experimental double auction without taxes. "Control" and "Treatment" refer to the groups without and with evasion opportunity, respectively. "Tax Credit" refers to the additional treatment without evasion opportunity and a tax credit of 7.5 ECU. Reported are the mean prices and number of units traded. "Incidence Effective Tax" is the share of the effective tax rate (10 ECU in Control, 2.56 ECU in Treatment, 2.5 ECU in Tax Credit) that is shifted onto buyers. All numbers expressed in Experimental Currency Units.

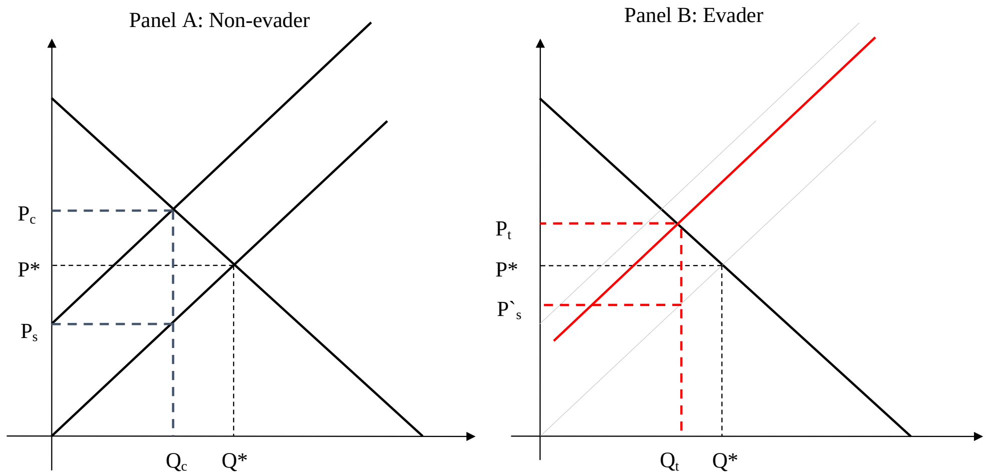
Figures

Figure 1: Supply and Demand Schedule



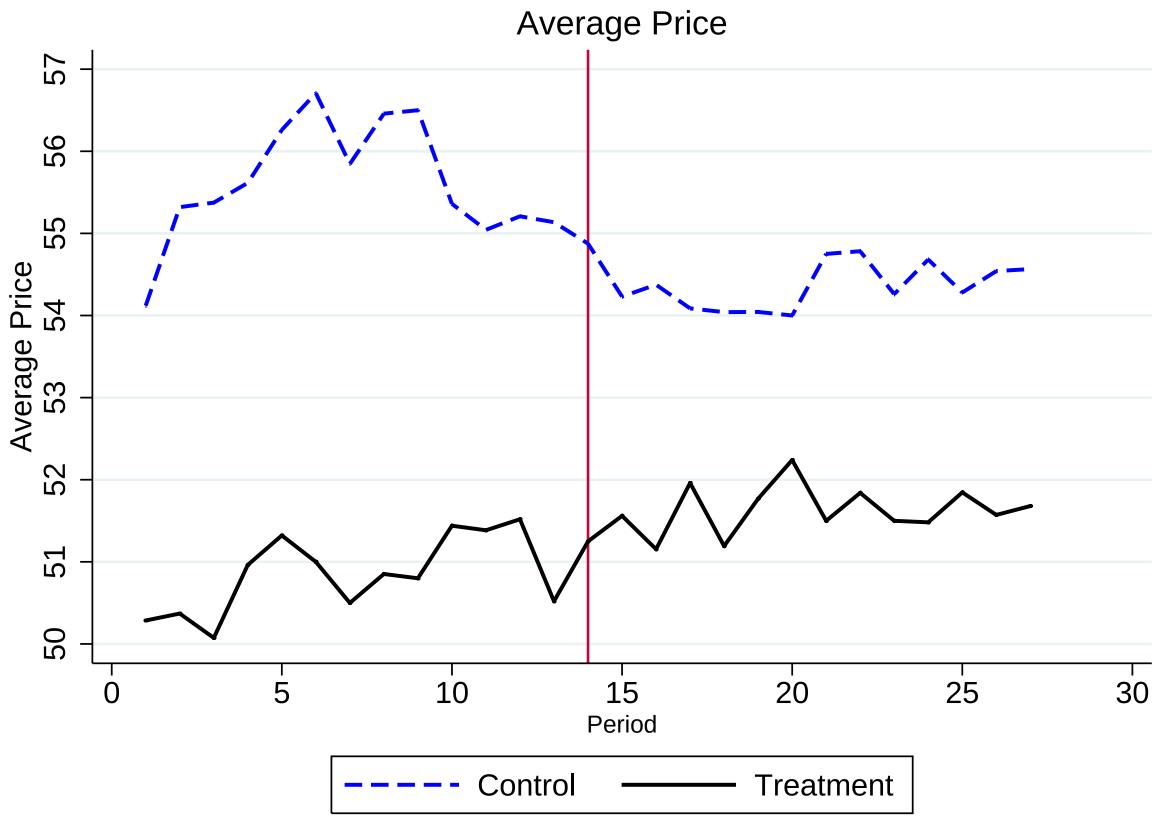
Note: The figure is adapted from Grosser and Reuben (2013, page 42, Figure 1). It shows the demand schedule for buyers and the supply schedule for sellers with and without the per unit tax. The predicted equilibrium occurs where the curves intersect: quantity $q = 7$ and price p between 48 and 52 without tax and quantity $q = 6$ and price p between 53 and 57 with the ECU 10 per unit tax.

Figure 2: Economic incidence of tax on seller



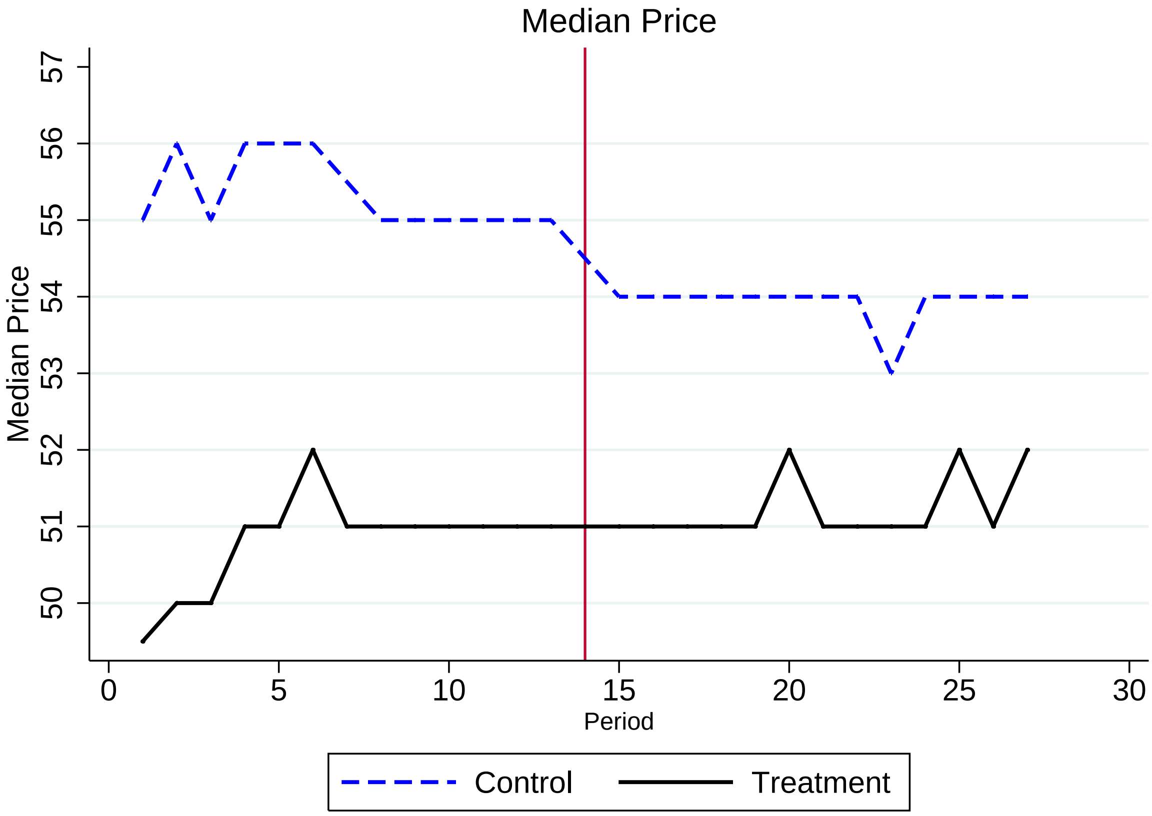
Notes: The imposition of a per-unit tax would ordinarily cause the supply curve to shift to the left and the market equilibrium to move from point (P^*, Q^*) to (P_c, Q_1) as illustrated in panel A. Because sellers are able to evade the tax, the supply curve shifts by a smaller amount causing the equilibrium to move from (P^*, Q^*) to $(P_c^{'}, Q_1^{'})$ as illustrated in panel B, where $P_c^{'} < P_c$.

Figure 3: Average market price by period and treatment



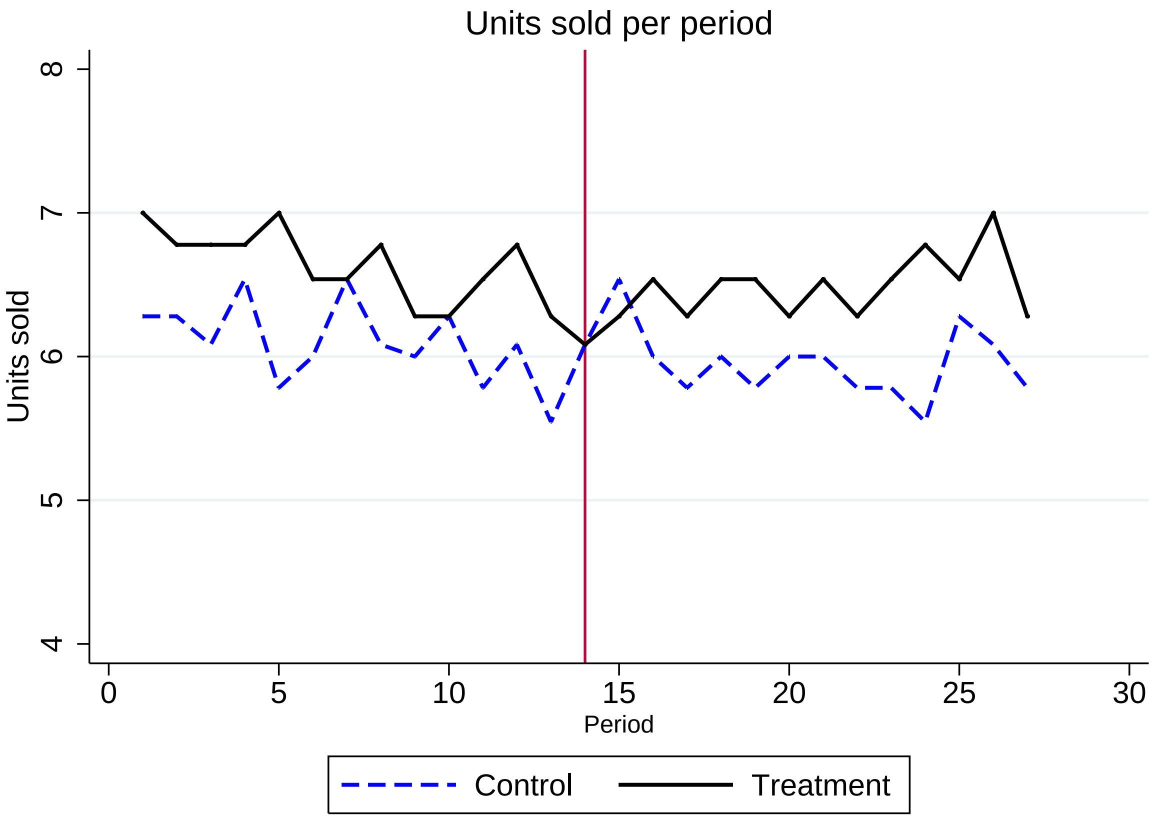
Notes: Reported is the average market price $\overline{P}$ in each period for the treatment and control groups. The vertical line indicates period 14; empirical results are based on market periods 15 to 27.

Figure 4: Median market price by period and treatment



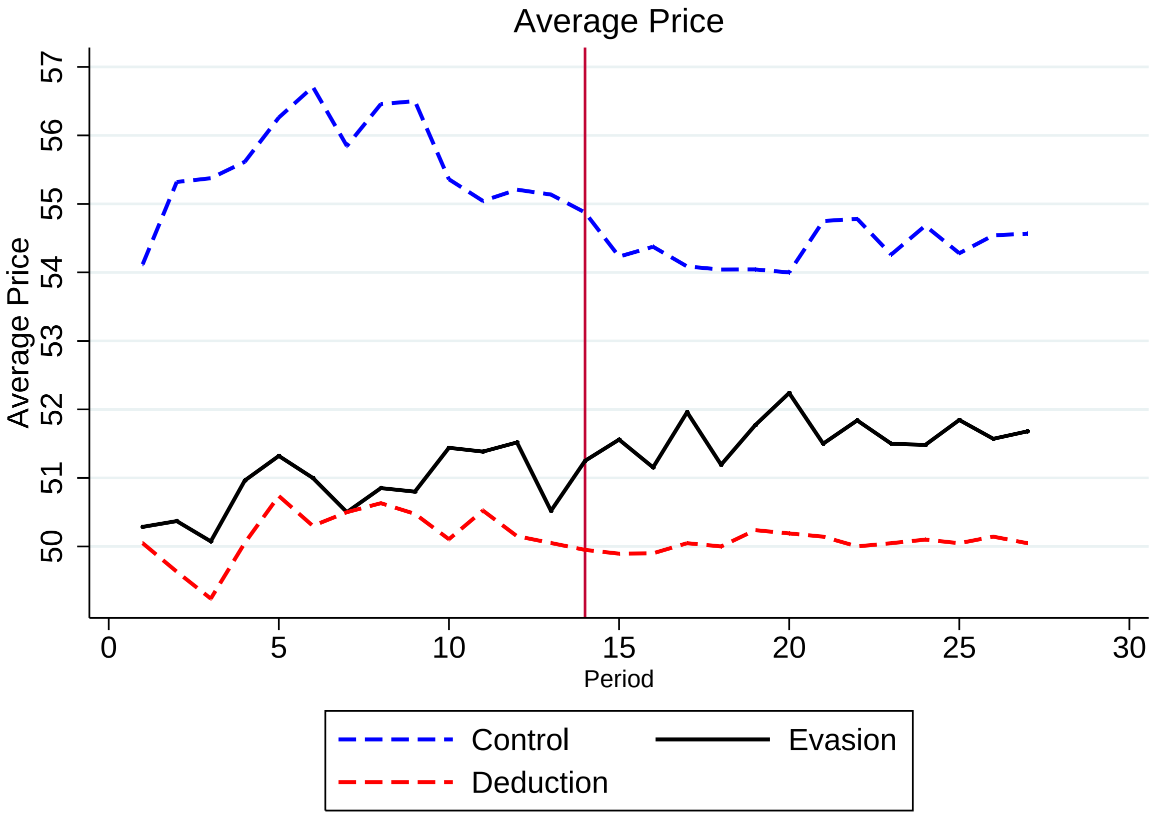
Notes: Reported is the median market price P_{50} in each period for the treatment and control groups.The vertical line indicates period 14; empirical results are based on market periods 15 to 27.

Figure 5: Units sold by period and treatment



Notes: Reported is the number of units sold in each period for the treatment and control groups.The vertical line indicates period 14; empirical results are based on market periods 15 to 27.

Figure 6: Additional treatment: Average market price by period and treatment



Notes: Reported is the average market price $\overline{P}$ in each period for the treatment group, control group and the additonal treatments. The vertical line indicates period 14; empirical results are based on market periods 15 to 27.

Appendices

A Tables

Table 9: Impact of treatment on market price and sales: adjustment for small number of clusters

	Price			Sales
	Mean	Median	Ask	
Treat	-2.701**	-2.087***	-3.077**	0.538**
	(1.123)	(0.743)	(1.398)	(0.232)
Constant	54.362***	53.779***	54.769***	5.923***
	(0.000)	(0.000)	(0.000)	(0.000)
R-Squared	0.553	0.538	0.162	0.234

Notes: Standard errors in parentheses are adjusted for clustering at the market level and corrected for the small number of clusters using the wild-bootstrap-t procedure described in Cameron et al. (2008). The correction is implemented using Stata code provided by Judson Caskey and is available here: `https://sites.google.com/site/judsoncaskey/data`. * significant at 10%; ** significant at 5%; *** significant at 1%. All columns use completed contracts from periods 15 to 27, and number of observations is 104.

Table 10: Impact of treatment on market price

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Ask Price		Mean Ask Price		Median Ask Price	
Treat	-2.662***	-2.660***	-2.651***	-2.651***	-1.589***	-1.589***
	(0.065)	(0.069)	(0.075)	(0.081)	(0.218)	(0.233)
Age	-0.367***	-0.370***	-0.368***	-0.368***	-0.641***	-0.641***
	(0.017)	(0.017)	(0.021)	(0.022)	(0.059)	(0.064)
Gender	-21.352***	-21.389***	-21.435***	-21.435***	-17.990***	-17.990***
	(0.177)	(0.174)	(0.219)	(0.234)	(0.633)	(0.676)
German	29.607***	29.642***	29.663***	29.663***	22.833***	22.833***
	(0.347)	(0.329)	(0.410)	(0.438)	(1.186)	(1.267)
Tax Morale	-1.274***	-1.258***	-1.245***	-1.245***	-0.921	-0.921
	(0.219)	(0.222)	(0.254)	(0.271)	(0.735)	(0.786)
Economics	5.126***	5.141***	5.156***	5.156***	2.562***	2.562***
	(0.153)	(0.162)	(0.183)	(0.195)	(0.529)	(0.565)
Constant	49.500***	49.481***	49.508***	49.443***	60.175***	60.314***
	(0.491)	(0.593)	(0.572)	(0.750)	(1.655)	(1.809)
R2	0.276	0.279	0.884	0.894	0.853	0.878
N	644	644	104	104	104	104
Period FE	No	Yes	No	Yes	No	Yes

Notes: Robust standard errors adjusted for clustering at the market level are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Estimates are based on equation (7) with the dependent variable defined as the market price for each good in each market period in Models 1 and 2; mean market price in a given market period in Models 3 and 4; and median market price in a given market period in Models 5 and 6. All panels use completed contracts from periods 15 to 27. Period FE is period fixed effects. Gender is the share of males, German is the share of native German speakers, tax morale is the share of subjects who believe cheating on taxes can never be justified, and Field of study is the share of subjects whose field of study is economics. These shares are calculated at the market-level.

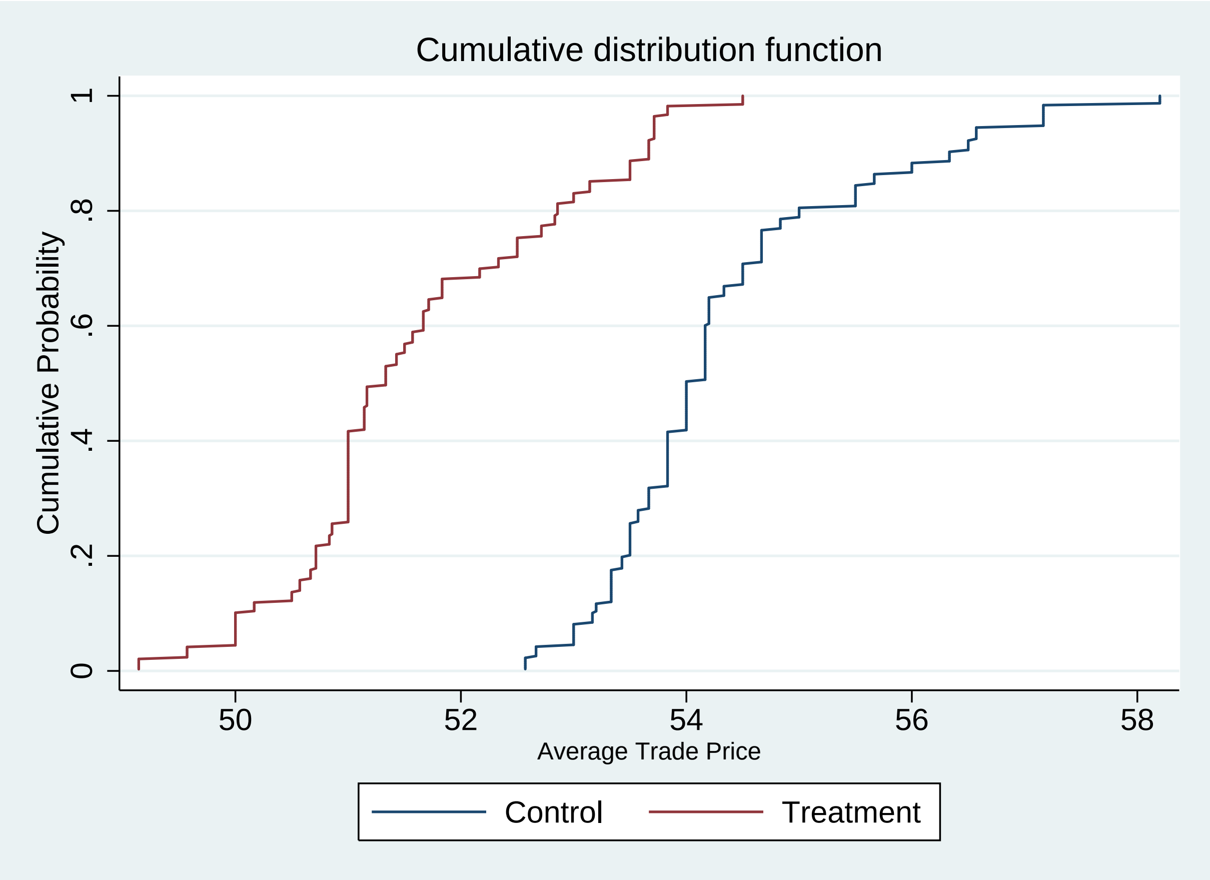
Table 11: Impact of treatment on units sold

	Model 1	Model 2	Model 3	Model 4
Treat	0.539***	0.540***	0.385***	0.383***
	(0.171)	(0.173)	(0.131)	(0.131)
Age			-0.017	-0.017
			(0.035)	(0.035)
Gender			2.349***	2.343***
			(0.353)	(0.363)
German			-2.000***	-1.973***
			(0.691)	(0.691)
Tax Morale			0.495	0.479
			(0.436)	(0.448)
Economics			-0.351	-0.349
			(0.305)	(0.305)
Constant	5.961***	6.147***	6.832***	7.005***
	(0.088)	(0.231)	(0.978)	(1.064)
R2	0.235	0.315	0.352	0.433
N	644	644	644	644
Control variables	No	No	Yes	Yes
Period FE	No	Yes	No	Yes

Notes: Robust standard errors adjusted for clustering at the market level are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Estimates are based on equation (7) with the dependent variable defined as the number of units sold in a given market period. Estimation is based on all completed contracts in periods 15 to 27. Period FE is period fixed effects. Gender is the share of males, German is the share of native German speakers, tax morale is the share of subjects who believe cheating on taxes can never be justified, and Field of study is the share of subjects whose field of study is economics. These shares are calculated at the market-level.

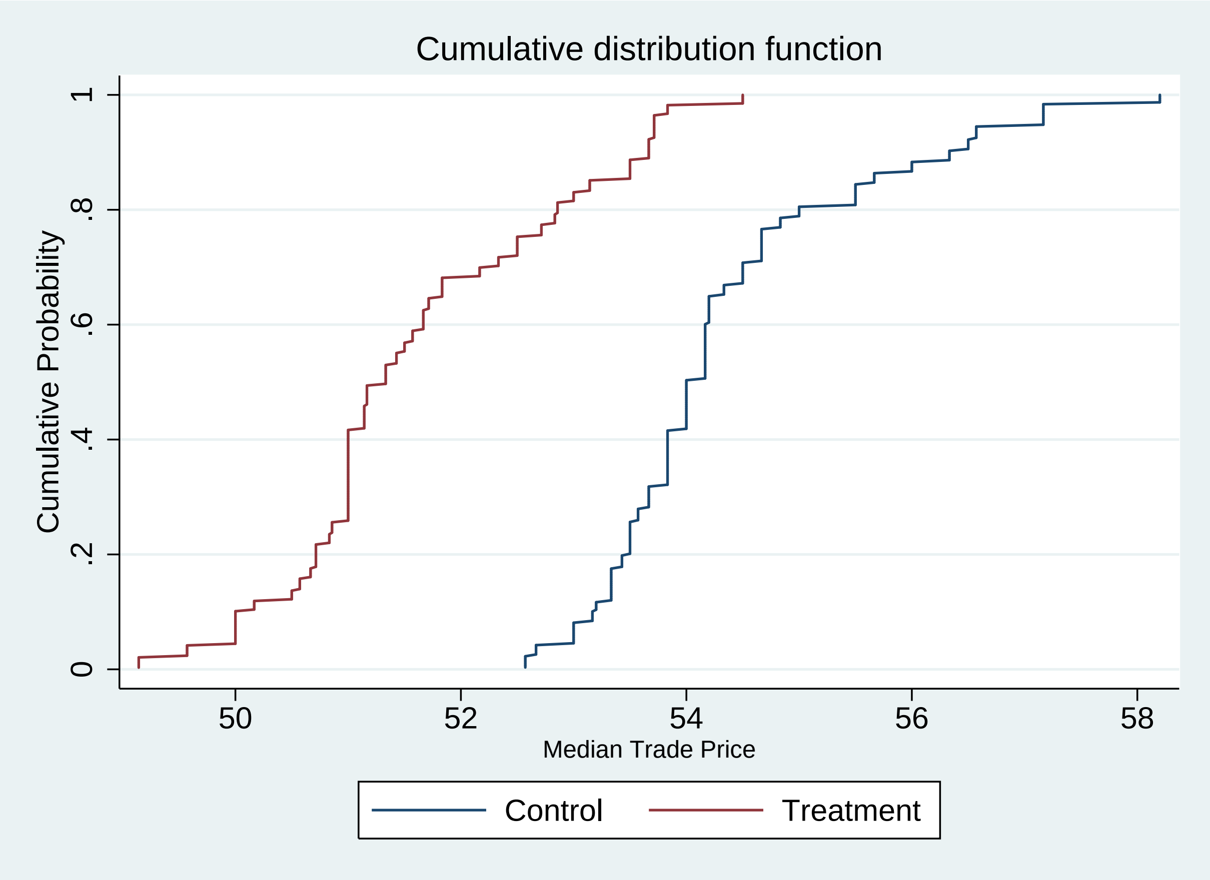
B Figures

Figure 7: Cumulative distribution of average market price by treatment



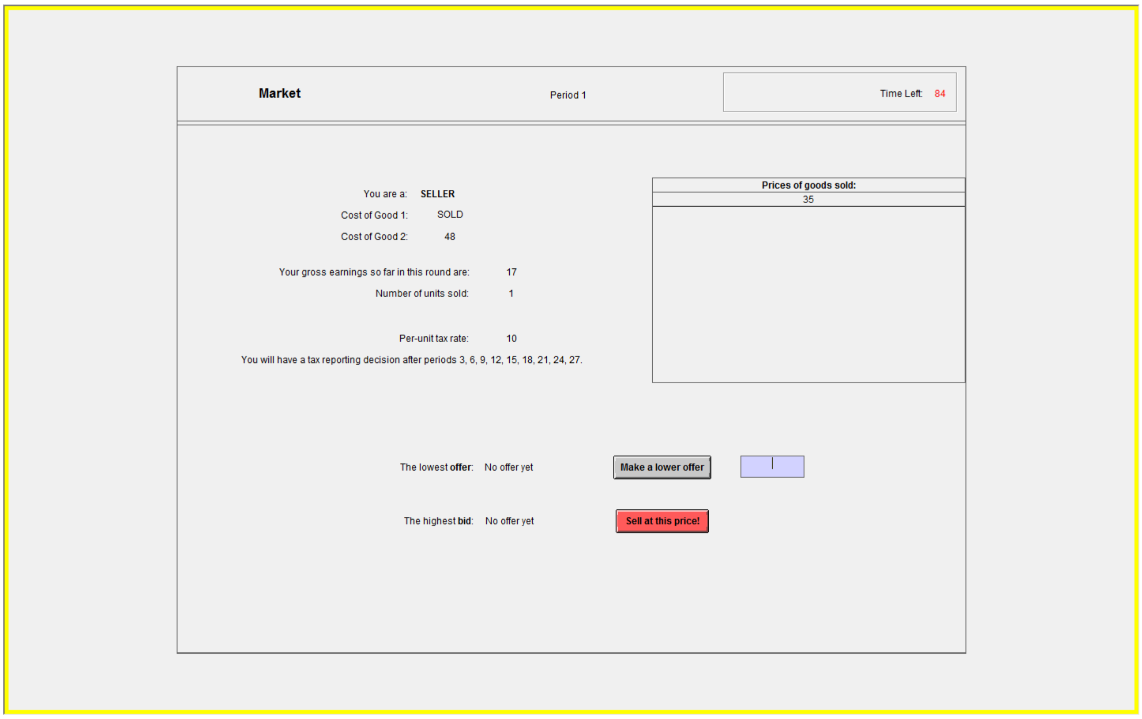
Notes: Reported is the cumulative distribution of average market price $\overline{P}$ for the treatment and control groups. Distributions are based on data from market periods 15 to 27. Two-sample Kolmogorov-Smirnov test for equality of distribution functions reports a maximum difference in distributions of 0.770 with pvalue of 0.000. This implies that the null hypothesis that the distributions are equal is rejected.

Figure 8: Cumulative distribution of median market price by treatment



Notes: Reported is the cumulative distribution of median market price P_{50} for the treatment and control groups. Distributions are based on data from market periods 15 to 27. Two-sample Kolmogorov-Smirnov test for equality of distribution functions reports a maximum difference in distributions of 0.751 with pvalue of 0.000. This implies that the null hypothesis that the distributions are equal is rejected.

Figure 9: Screenshot of the Market Place



Note: Screenshot of the lab experimental double-auction market place. The screen displays the market place for a seller in the treatment group with evasion opportunity. The seller has sold her first unit at a price of 35. The cost for the first unit was 18, yielding a current gross-income of 17. Her second unit with cost 48 is not traded at this point. The screen shown is translated to English, the original experiment was conducted in German. The market place is based on Grosser and Reuben (2013).

C Instructions

The following pages contain the translated instructions. The instructions for all groups were identical except for slight variations. In the following, we display the instructions for the control group and indicate the differences between groups in brackets. The original German versions of the instructions are available from the authors upon request.

Instructions

Welcome and thank you for participating in our experiment. From now on until the end of the experiment, please refrain from communicating with other participants. If you do not abide by this rule, we will have to exclude you from the experiment.
We kindly ask you to read the instructions thoroughly. If you have any questions after reading the instructions or during the experiment, please raise your hand and one of the instructors will come to you and answer your question in person. Your payment and your decisions throughout the experiment will be treated confidentially.
You can earn money in this experiment. How much you earn depends on your decisions and the decisions of other participants. During the experiment, your payments will be calculated in a virtual currency: Experimental Currency Units (ECU). **30 ECU correspond to 1 Euro**. After the experiment, your pay-off will be converted to Euro and given to you in cash. Additionally, you will receive a show-up fee of 2.50 Euro.

The Experiment

Roles
At the beginning of the experiment, the computer will randomly assign five participants to the role of **"sellers"** and five other participants to the role of **"buyers"**. Therefore, you will either be a buyer or a seller. Your role as seller or buyer will remain the same throughout the experiment. You will only know your own role and not the roles of other participants.

Overview
[***Control Group:***
The experiment consists of 3 practice rounds and 27 paying rounds. At the beginning of each round, all buyers and sellers trade a fictitious good in a **market place**. As a buyer, you can buy units of the fictitious good and as a seller you can sell units. You can earn ECU in the market place and your earnings depend on your decisions and the decisions

of the other participants. Each unit sold will be subject to a per **unit tax of 10 ECU** for sellers. The tax rate is the same for all sellers and is due at the end of every third round. Details on the market place will be explained further below. All tax revenues paid by you and all other participants will be donated to the German Red Cross.
]

[***Treatment Group with Evasion Opportunity:***
The experiment consists of 3 practice rounds and 27 paying rounds. At the beginning of each round, all buyers and sellers trade a fictitious good in a **market place**. As a buyer, you can buy units of the fictitious good and as a seller you can sell units. You can earn ECU in the market place and your earnings depend on your decisions and the decisions of the other participants. Each unit sold will be subject to a per **unit tax of 10 ECU** for sellers. The tax rate is the same for all sellers and is due at the end of every third round. At the end of every third round, sellers are asked to report the number of units that they sold in the previous three market rounds. There is a 10% chance that the reported decision will be checked for accuracy. Details on the market place will be explained further below. All tax revenues paid by you and all other participants will be donated to the German Red Cross.
]

[***Additional Treatment with Tax Credit:***
The experiment consists of 3 practice rounds and 27 paying rounds. At the beginning of each round, all buyers and sellers trade a fictitious good in a **market place**. As a buyer, you can buy units of the fictitious good and as a seller you can sell units. You can earn ECU in the market place and your earnings depend on your decisions and the decisions of the other participants. Each unit sold will be subject to a per **unit tax of 10 ECU** for sellers. Sellers additionally receive a **tax credit** of 7.50 ECU for each unit sold. The tax rate is the same for all sellers and is due at the end of every third round. Details on the market place will be explained further below. All tax revenues paid by you and all other participants will be donated to the German Red Cross.
]

The Market Place

Basics

The market place is opened for two minutes at the beginning of each round. All buyers and sellers trade a fictitious good. In each market period, each **seller can sell two units** of the fictitious good and each **buyer can buy two units** of the good.

Units, costs, and values

If you are a seller, you will be given the **costs** for two units of a fictitious good at the beginning of the experiment. These units shall be denoted "Unit 1" and "Unit 2", where Unit 1 costs less than Unit 2. The cost of these units to you is the same in all rounds. However, the cost of each seller's units will differ from the cost of other sellers' units. Each seller only knows her own costs.

If you are a buyer, you will be given the **values** for two units of a fictitious good at the beginning of the experiment. These units shall be denoted "Unit 1" and "Unit 2" where Unit 1 values more than Unit 2. The value of these units to you is the same in all rounds. However, the value of each buyer's units will differ from the value of other buyers' units. Each buyer only knows her own values.

Asks, Bids, and Transactions

Sellers can make "asks" and Buyers can make "bids" during the trading period. All asks and bids are visible to everyone through the screen that appears during the two minutes of trading. This screen will also state your type (Seller or Buyer), the time left in the trading period and the costs or values that you were assigned for each Unit. Each Seller can first sell Unit 1 and afterward Unit 2. Accordingly, Buyers can first buy Unit 1 and then Unit 2.

Sellers cannot sell goods at prices lower than the assigned cost for the respective Unit.
Buyers cannot buy at prices that exceed their assigned value for the respective Unit.

Sellers can make asks at any time during the trading period but each ask has to be lower than the current lowest ask on the market. Similarly, Buyers can always propose bids as long as they are larger than the current largest bid on the market.

To realize a **transaction**, Sellers can either accept a bid or buyers can accept an ask. The transaction price for the unit will then be equal to the accepted ask or bid.

(Gross) Earnings in the Market Place

Units that are not traded do not yield any earnings. Gross earnings for each Unit are as follows:

For Sellers:

Gross Earnings from selling Unit 1 = transaction price of Unit 1 - cost of Unit 1

Gross Earnings from selling Unit 2 = transaction price of Unit 2 - cost of Unit 2

For Buyers:

Gross Earnings from buying Unit 1 = value of Unit 1 - transaction price of Unit 1

Gross Earnings from buying Unit 2 = value of Unit 2 - transaction price of Unit 2

Screenshots from trading market

Sellers:

Here Screenshot Sellers

Sellers can accept a current bid by pressing "Sell at this Price". To make a new ask, Sellers have to enter their ask price into the field to the right of the "Make a smaller ask" button and press the button to submit the ask.

Buyers:

Here Screenshot Buyers

Buyers can accept the current ask by pressing "Buy at this Price". To make a new bid, Buyers have to enter their bid into the field to the right of the "Make a smaller bid" and press the button to submit the bid.

[*Added in the* ***treatment group with evasion opportunity****:*

The Reporting Decision for Sellers

After three consecutive trading periods, you will be shown the number of units traded over the three previous trading rounds and the respective gross earnings on those units. For each unit traded in the three previous periods, a per-unit tax of **10 ECU is due for sellers**.

Sellers will then be asked to report the number of units sold in the previous three rounds for tax purposes. The reported amount may be between zero and the total number of units that were actually sold over the previous three rounds. After the reporting decision is submitted by pressing the "OK" button, the computer will determine if it is checked whether the reported number equals the actual number of units sold over the last three periods. The computer makes this call by randomly selecting an integer number between 1 and 10. The reporting decision will **only** be checked if the computer selects the number 1. Therefore, there is a random chance of 10% that the reporting decision will be checked.
]

[*Net income information in the* ***control group:***

<u>Calculation of Net Income for Sellers</u>

After three consecutive trading periods, the screen shows how many units of the fictitious unit you have traded over the previous three rounds and the resulting gross income from the previous three periods. For each unit traded in the three previous periods, a per-unit tax of **10 ECU is due for sellers**

Therefore, a seller's payment – the net income – , consists of her sum of all gross earnings from the three previous rounds (henceforth denoted "sum gross income") minus the tax payment. The tax payment is the number of units sold over the previous three periods multiplied by the tax rate of 10 ECU. Hence:

<u>Net Income</u> = sum gross income - (number of units sold in previous 3 rounds * per-unit tax rate)

]

[*Net income information in the* ***treatment group with evasion opportunity:***

<u>Calculation of Net Income for Sellers</u>

Sellers will be informed of the outcome of the random draw, and will be faced with one of the following two scenarios:

1. Computer selects a number between 2 and 10 (2, 3, 4, 5, 6, 7, 8, 9 or 10):

The reporting decision will *not* be checked. A seller's earnings after taxes – the net income –, in this case, consists of the sum of all her gross earnings from the three previous periods (henceforth denoted "sum gross income") minus the tax payment. The tax payment is the **reported** number of units sold multiplied by the tax rate of 10 ECU. Hence:

<u>Net income</u> = sum gross income - (reported number of units sold * per unit tax rate)

2. Computer selects number 1:

The reporting decision *will* be checked. A seller's earnings after taxes – the net income –, in this case, consist of sum of all her gross earnings from the three previous periods (henceforth denoted "sum gross income") minus the tax payment. The tax payment is based on the number of units **actually** sold over the last three periods. If the number of units was **not** reported correctly, a seller will additionally have to pay a penalty that is equal to the amount of **tax liability that was not paid**. Hence:

Net income = sum gross income - (actual number of units sold * per unit tax rate) - (number of units *not reported* * per unit tax rate)
]

[*Net income information in the **additional treatment with tax credit:***

Calculation of Net Income for Sellers
After three consecutive trading periods, the screen shows how many units of the fictitious unit you have traded over the previous three rounds and the resulting gross income from the previous three periods. For each unit traded in the three previous periods, a per-unit tax of **10 ECU is due for sellers**. In addition, sellers receive a tax credit of **7.5 ECU** for each unit sold.
Therefore, a seller's payment – the net income – , consists of her sum of all gross earnings from the three previous rounds (henceforth denoted "sum gross income") minus the tax payment. The tax payment consists of the per-unit tax of 10 ECU per unit sold minus the tax credit of 7.5 ECU per unit sold. Hence:

Tax payment
= (number of units sold * per-unit tax rate) - (number of units sold * tax credit)
= number of units sold * (10 - 7.5)

Net income then is:

Net Income
= sum gross income - tax payment
= sum gross income - (number of units sold * (10 - 7.5))
]

Payment
The first 3 rounds serve as practice rounds, in which you cannot earn money. The subsequent 27 rounds are paying rounds.
Buyers do not pay taxes so that gross earnings equal net earnings. A buyer's payoff hence equals the sum of gross earnings from all 27 trading periods.
Sellers receive a payoff that consists of the sum of all net incomes, each of which is earned after every third paying round (i.e., after paying rounds 3, 6, 9, 12, 15, 18, 21, 24, 27.)

You will be paid the payoff in cash at the end of the experiment. Additionally, each participant receives a show-up fee of 2.50 Euro. If the sum of all gross or net incomes is negative or zero, you will be paid the show-up fee; that is, you cannot make losses and will earn a minimum amount of 2.50 Euro.

Final Remarks

After the completion of all 30 rounds – 3 practice round plus 27 paying rounds – the experiment is finished. You will be asked to complete a short questionnaire at the end of the experiment while we prepare the payments. All information collected through this questionnaire, just like all data gathered during the experiment, are anonymous and exclusively used for scientific purposes. After you have completed the questionnaire, please remain seated at your booth until we call you to come up front to pick up your payment.