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Working Paper 133
June 2021

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ISSN 1458-1191
ISBN 978-952-03-2034-8 (online)
The role of reporting institutions and image motivation in tax evasion and incidence*

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June 18, 2021

Abstract

We investigate effects of tax reporting mechanisms on evasion and incidence in experimental double auction markets where counterfactual reporting and market outcomes can be studied after convergence. There are two control conditions: (i) markets without taxes and (ii) markets where taxes are automatically levied. These are compared to (iii) markets with seller-reporting only and fines paid if low-probability audit discovers evasion, to (iv) markets with both seller- and buyer-reporting and a higher audit probability due to any gap in the numbers reported by the seller and her customers, and to (v) markets where, in addition, buyer-reporting is costly. The latter two mimic varying reporting incentives in the so called third-party reporting in tax enforcement. We find that 20% of the sellers are truthful when only sellers report, but that 80% and 66% of them are truthful under costless and costly third-party reporting, respectively. Pricing, incidence, and reporting patterns in all treatments can be explained by a model of lying costs with image concerns based on Gneezy et al. (2018).

JEL Codes: H21, H22, H26, D40, D44, D91

Keywords: Tax Evasion, Tax Incidence, Third-Party Reporting, Double Auction, Experiment.

*We thank A. Brockmeyer, J. Harju, M. Hovi, P.H. Matthews, G. Van Moer, J. Slemrod, and audiences at Helsinki GSE, MaTax, M-BEPS, MiddExLab Virtual Seminar, NCBEE, Stockholm School of Economics, VSE Prague, and ZEW Public Finance 2021 for helpful discussions. We also thank P. Doerrenberg and D. Duncan for kindly sharing their z-Tree code with us and the PCRClab at the U of Turku for hospitality. Nurminen gratefully acknowledges financial support from the OP Group Research Foundation, the Society of Swedish Literature in Finland and the Yrjö Jahnsson Foundation, Metsälampi from the Finnish Cultural Foundation, and Kotakorpi from the Academy of Finland (grant no. 277283).

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1 Introduction

Effective tax administration and enforcement are prerequisites for an extensive and well-functioning welfare state (e.g. Kleven (2014)). The so called tax systems approach to the analysis of taxation (Slemrod and Gillitzer (2014)), as well as literature on behavioral public finance more generally, emphasize that the reactions of economic agents to taxation may depend not only on tax rates and tax bases, but also on other design features of the tax system. Explaining these reactions requires understanding how the complex motivations of economic agents interact with the incentives generated by the tax system and other institutions (Coricelli et al., 2010; Attanasi et al., 2019; Bartling et al., 2021).

In particular, third-party sources of income information such as records held by employers, business partners and credit card companies are considered critical for effective tax enforcement (e.g., Slemrod (2007); Kleven et al. (2011)). The rise of electronic commerce has increased the amount of information held by third parties. At the same time advances in information technology enable more extensive use of such records in tax enforcement. It is therefore important to understand how the mechanism used to elicit tax reports affects compliance as well as real market outcomes. Further, to the extent that behavior is not fully explained by a standard, self-interested model, it is important to examine how these reactions may be mediated for instance by intrinsic motivation to appear honest (Abeler et al., 2019; Attanasi et al., 2019; Tergiman and Villeval, 2020; Dufwenberg and Nordblom, 2018).

The importance of third-party information as a determinant of tax compliance has been acknowledged, yet literature utilizing exogenous variation in third-party information is scarce. In addition, much of the empirical work on the deterrence effect of third-party information (e.g., Kleven et al. (2011) and numerous subsequent field experiments on tax enforcement) focus to a large extent on reporting responses, and in general real and reporting responses are difficult to disentangle from one another using field data. Moreover, the causal effects can typically be identified only for a short time period following (quasi-)random variation in the field. Given that it could take years before the interactive responses to changes in tax administration and policy have settled, it is unclear whether these responses capture well long-run effects in a steady state where agents have had time to react to each others’ reactions.

Controlled laboratory experiments with exogenous variation in taxation and deterrence allow comparing behavior and outcomes across institutions when market agents have frequent opportunity to learn both from other agents’ behavior and from
reactions to tax reports and the implied audits and effective taxes. This permits studying causal effects when markets have settled to an equilibrium. We argue that they are thus likely to provide valuable complementary market outcome insights for settings where real outcomes are difficult to observe in the field. They also provide an opportunity to examine the mechanisms behind reporting behavior and market outcomes.

In this paper we examine the impact of different tax reporting mechanisms on market clearing prices, quantities, tax incidence and compliance in the context of commodity taxation. We set up experimental induced cost-&-value double auction markets in which a unit sales tax is levied on sellers (Smith, 1962; Friedman, 1993). As benchmark conditions, we conduct a treatment without the tax and a treatment in which tax evasion is impossible and find typical results observed in the experimental literature coinciding with Walrasian predictions. Tax burden is thus shared equally between buyers and sellers in proportion to demand and supply elasticities, as predicted by standard theory.

We then allow for tax evasion, conducting three treatments in which the initial tax payment is based on self-reporting by the seller, accompanied by a chance of an audit and possible fines. In one condition the probability of the audit is exogenously set low at 10%. In the other two conditions, we allow buyers to report their trades, and seller’s audit probability increases if the seller under-reports relative to her customers. The audit probability is thus endogenously determined through the seller’s own report and information provided by third parties (i.e. the buyers).

While in most of the previous literature the existence (or not) of third-party information has been taken as given, it is not a priori clear that buyers in our setting should have incentives to supply third-party information by reporting truthfully. In particular, there is an equilibrium where buyers and sellers implicitly collude and do not report. To further analyze buyers’ incentives to provide third-party information, we compare the case in which buyer reporting is costless to a case in which there is a small fixed cost for reporting. Such a cost should facilitate tacit collusion as extrinsically motivated buyers now strictly prefer not to report. The importance of

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1 The experimental taxes are paid out to the state tax authority to improve external validity.
2 There is an extensive literature on laboratory experiments analyzing tax evasion; see e.g. Alm and Malézieux (2020) for a recent review. Predictions regarding transaction price dynamics in double auction markets are most precisely articulated in Gjerstad and Dickhaut (1998). Ruffle (2005) provides evidence on tax incidence equivalence in experimental competitive markets.
3 Asking for a receipt may be associated with a small cost for signalling distrust, for instance, or credit card payment may involve a small price margin.
understanding the comparative statics with respect to buyer net reporting costs is highlighted by Naritomi (2019) who finds in a Brazilian field setting that a small incentive to ask for a receipt increased both the amount of third party information and subsequent seller reporting. Our lab study allows us to further study market outcome and incidence implications of such changes.

We find that when there is no buyer-reporting, many sellers evade at least some of their taxes due, but still prices are higher and quantities lower than in the case without taxes. When the reporting institution makes use of complimentary third-party information provided by buyers, we find that both buyer and seller reporting is high and thus so is tax compliance, implying that market prices increase and quantities traded decrease. When reporting is costly to buyers, they report significantly fewer trades. However, somewhat surprisingly, tax compliance by sellers remains at a relatively high level.

We find that the incidence of the effective tax is close to the 50% predicted by the standard model when taxes are automatically remitted. By contrast, when sellers can unilaterally evade, the share of the tax burden borne by buyers is significantly higher than in other treatments. This is due to the puzzling observation that even as sellers heavily under-report their trades, competition does not drive down prices to the Walrasian prediction. In the treatments where buyers also report their trades, tax compliance is high and the standard incidence result re-emerges.

We therefore find that tax evasion by sellers breaks the incidence result from standard tax theory. To better understand the patterns that we find, we apply the model of Gneezy et al. (2018). The model analyzes lying behavior taking into account that even though agents may lie to increase their monetary payoff, lying entails a moral cost as agents prefer being perceived as honest. While there is an extensive theoretical literature on lying behavior, these models have to our knowledge not been previously applied in the tax evasion literature. We apply this type of a model to our double auction tax evasion setting, with separate trading and reporting stages and show that behavior in the trading stage can be influenced by image concerns. The model predicts that low ask prices by the sellers may be inhibited by image concerns associated with the information prices convey information about the higher

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4 Note that our result relates to incidence of the effective tax, and is different from the result in Kopczuk et al. (2016) who find that differences in tax evasion opportunities between different sides of the market, overturn the standard result that tax incidence (market price) does not depend on who has legal responsibility to remit the tax. The mechanism behind their result is simply that tax evasion lowers prices (which is what we also find) and hence nominal incidence may depend on point of tax collection, if the parties to a transaction differ in their tax evasion opportunities.
probability of evasion in the reporting stage. The novelty here is that image costs are not suffered directly in association with reporting, which is not observed by others, but due to the signal that market stage activities convey about upcoming tax evasion. Another novelty shared with the recent contributions of Tergiman and Villeval (2020), Halliday et al. (2021) and Benistant et al. (2021) is that there is competition between agents where lower proneness to intrinsic costs provides an advantage.

In addition to the behavioral literature on image motivation in lying (Fischbacher and Föllmi-Heusi, 2013; Abeler et al., 2019; Gneezy et al., 2018; Tergiman and Villeval, 2020; Barron et al., 2021; Benistant et al., 2021; Halliday et al., 2021), our work is related to several strands of literature. First, there are field studies examining the role of third-party information on tax compliance. In Kleven et al. (2011), variation in third-party reporting comes from certain types of income being subject to third-party reporting, while others (notably self-employment income) are not. In studying firm responses to an audit experiment, Pomeranz (2015) compares those line-items in the VAT declaration of firms that are covered by the paper trail (transactions between two firms) to line items that are not (sales to final consumers). Naritomi (2019) compares retail transactions (where the extent of third-party information increased due to a campaign that incentivized consumers to send in their receipts to the authorities) and wholesale transactions (not affected by the campaign). In addition, some recent studies have randomized the salience of third-party information in the field (e.g. Harju et al. (2020), Eerola et al. (2019)). Alm et al. (2009) study individual income tax compliance in the laboratory in a setting where subjects differ in the fraction of their income that is subject to third-party information reported to the tax authority. They find that subjects with relatively more third-party reported income are more compliant than subjects with relatively less third-party reported income.

Second, a couple of recent studies investigate collusive tax evasion. Balafoutas et al. (2015) study how the efficiency in experimental credence goods markets is affected by attempts to evade taxes. Abraham et al. (2017) analyze the impact of social norms on joint tax evasion in the lab. In related field studies, Doerr and Necker (forthcoming) conduct an experiment to study contractors’ compliance and pricing behaviors in online home improvement services markets. Björneby et al. (2018) implement a randomized audit study to provide evidence of joint tax evasion by workers and firms, while Paulus (2015) documents the same phenomenon using survey and register data. In the present paper we vary the reporting institution (i.e. the cost of providing third-party information) to explicitly examine the conditions
that may bring about collusion.

In the earlier literature, a paper perhaps closest to ours is *Doerrenberg and Duncan (2019)* which analyzes the effect of evasion opportunities on tax incidence using a similar laboratory market experiment. Like us, they find that providing sellers an opportunity to evade sales taxes implies that markets clear with higher quantities and lower prices than when evasion is not possible. They also find that the incidence of the (effective) tax falls more heavily on buyers when sellers have access to evasion. *Kopczuk et al. (2016)* provide field evidence on the relationship between evasion possibilities and tax incidence, focusing on how incidence depends on the point of tax collection when different market actors have differential possibilities for evasion. We complement this work by further asking how third-party reporting and evasion affects market clearing prices, quantities and tax incidence. We add to these papers by showing that the non-standard incidence result in the presence of tax evasion, as well as the other findings, can be explained by a model of lying behavior with image concerns: we show that even if reporting behavior of sellers follows the logic of the standard model (as image concerns do not play a role at the reporting stage since reporting decisions are not observed by agents on the other side of the market), image concerns affect pricing behavior, and how tax evasion is reflected in real behavior and market outcomes.

## 2 Experimental Design

We conduct a 25-period standard continuous laboratory double auction market (*Smith, 1962*), with 5 sellers and 5 buyers trading units of a homogenous good. In a market each seller can sell up to 4 units and each buyer can buy up to 4 units of the good. Each unit $k$ of seller $i$ has a different per unit production cost $c_{ik}$ and each unit $k$ of buyer $i$ has a different per unit reservation value $v_{ik}$. Cost and value schedules are randomly assigned to sellers and buyers, respectively, and vary across traders (Table A-1 and Figure 1 depicting the supply and demand curves). The roles and cost/value schedules do not change during the experimental session and are private information.

The market opens for trading for 100 seconds in each period. Each buyer and seller can trade her units one at a time, starting with the first unit ($k = 1$), then the

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^5^In addition, to help subjects get familiar with the environment and the interface, we ran three unpaid practice periods before the payoff relevant periods.

^6^Costs and values are first randomized into sets of four costs and four values. These sets of four (see Table A-1) are then randomly assigned to traders at the beginning of each experimental session.
second \((k = 2)\), and so forth. Traders may post offers to sell or buy at any time while the market is open. Each seller \(i\) may post an integer price \(p_{ik} \in \{c_{ik}, \ldots, P^S - 1\}\) where \(P^S\) denotes the current standing ask (or 300 if there are no posted asks so far). Each buyer may post an integer price \(p_{ik} \in \{P^B + 1, \ldots, v_{ik}\}\) where \(P^B\) is the current standing bid (or 0 if there are no posted bids so far). All traders observe the current standing bid and ask (if there are any).

A transaction takes place when a seller accepts a standing bid or a buyer accepts a standing ask. A seller can accept a current standing bid as long as \(P^B \geq c_{ik}\). A buyer can accept a current standing ask as long as \(P^S \leq v_{ik}\). When a transaction occurs, current standing prices are removed and the process of posting bids and asks begins again until the market closes. All accepted prices are displayed on traders’ screens for the entire duration of the trading phase.\(^7\) Communication is not allowed at any point.

Seller \(i\)’s gross profit for selling her \(k^{th}\) unit, \(\pi^S_{ik}\), is defined as \(\pi^S_{ik} \equiv p_{ik} - c_{ik}\), where \(p_{ik}\) is the price the seller receives from selling the unit. Buyer \(i\)’s gross profit from buying her \(k^{th}\) unit, \(\pi^B_{ik}\), is defined as \(\pi^B_{ik} \equiv v_{ik} - p_{ik}\), where \(p_{ik}\) is the price the buyer pays for the unit. Units that are not traded do not yield profits or losses. A trader’s market income from one period is the sum of the gross profits over all 4 units minus possible taxes and/or fines paid, and her final payoff consists of the sum of her market incomes over all 25 periods.

### 2.1 Treatments

We have five treatments that differ in whether a per-unit sales tax is imposed on the sellers, and how the tax is collected. The experiment was framed, i.e. we explicitly used the words ”buyer”, ”seller” and ”tax”.\(^8\) In the No Tax (NT) treatment, there is no sales tax. A trader’s market income is the sum of gross profits from each traded unit: \(\Pi^S_i \equiv \sum_{k=0}^4 (d_{ik}p_{ik} - d_{ik}c_{ik})\) for sellers and \(\Pi^B_i \equiv \sum_{k=0}^4 (d_{ik}v_{ik} - d_{ik}p_{ik})\) for buyers, where \(d_{ik} = 1\) if the seller or buyer traded her \(k^{th}\) unit and 0 otherwise. In the Automatic (A) treatment, a per-unit sales tax \(\tau = 40\) ECU is imposed on the sellers.\(^9\) The tax is automatically collected, making tax evasion impossible. Hence a

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\(^7\)See Appendix D for an example of a seller’s trading screen.

\(^8\)See Appendix D for English translations of instructions for treatment Seller + BuyerC. The full set of instructions is available from the authors.

\(^9\)The tax equals 25\% of the predicted median market equilibrium price of the No Tax condition and approximately 32\% (21\%) of the median cost (value). It therefore closely corresponds to the general VAT rate of 24\% in Finland.
seller’s market income is given by \( \Pi_i^S \equiv \sum_{k=0}^{4} (d_{ik}p_{ik} - d_{ik}c_{ik}) - \tau s_i \), where \( s_i \) denotes the number of units the seller sold in the market.

In the Seller Only (SO) treatment, sellers are asked to file a tax report stating how many units they sold in the current period. A seller can report \( r_i \in \{0, ..., s_i\} \), where \( r_i \) denotes the number of units seller \( i \) reports as sold. The sales tax is collected for each unit reported as sold, unless an audit is conducted, in which case the tax is collected for each unit actually sold. In addition, an audit implies the seller is fined \( f = 40 \) ECU for each sold unit the seller failed to report. The probability of an audit is exogenously fixed at 10%, and it is independent across sellers. Now seller \( i \)’s market income from trading in the current period is given by

\[
\Pi_i^S = \begin{cases} 
\sum_{k=0}^{4} (d_{ik}p_{ik} - d_{ik}c_{ik}) - \tau r_i, & \text{if seller } i \text{ is not audited} \\
\sum_{k=0}^{4} (d_{ik}p_{ik} - d_{ik}c_{ik}) - \tau s_i - f(s_i - r_i), & \text{if seller } i \text{ is audited.}
\end{cases}
\]

The Seller + Buyer (SB) treatment is otherwise as the Seller only treatment but with an endogenously determined audit probability. More specifically, for each unit they bought in the current period, buyers are asked to decide whether to costlessly report or not report that unit.\(^{10}\) The probability of an audit for a seller is 10%, unless the seller reports less sold units than the buyers who bought from her, in which case the audit probability is 80%.\(^{11}\) The seller only learns whether she was audited, not what her trading partners reported.

Finally, the Seller + BuyerC (SBC) treatment is otherwise as the Seller + Buyer treatment but reporting is now made costly to the buyers. If a buyer reports a positive number of units, she incurs a fixed reporting cost of 10 ECU.

### 2.2 Procedures

We conducted 30 sessions with 10 subjects in the PCRC lab of the University of Turku. In each session, we implemented one treatment condition. A total of 300 subjects, predominantly students at the University of Turku, participated in the experiment. There were 60 participants in each treatment. Summary statistics of participants’ demographic variables are shown in Table A-2. Participants were solicited through an online database using ORSEE (Greiner, 2015), and the experiment was run using the

\(^{10}\)There is no option of saying "I prefer not to tell/report" which might be a way for buyers to achieve collusive tax evasion without having to lie.

\(^{11}\)We choose an audit probability below 100% to reflect the fact that the audit may fail to detect the full extent of evasion.
experiment software z-Tree (Fischbacher, 2007). After the experiment, subjects filled out a short questionnaire on background characteristics, level of tax morale, trust and risk preferences.\textsuperscript{12} Sessions lasted up to 110 minutes, and participants earned, on average, 10.00 EUR for the experiment, including a 5 EUR showup fee. All tax revenue collected in the experiment was donated to the Finnish State Treasury, and this was common knowledge among the participants. Before conducting any sessions, we submitted a pre-analysis plan at the Open Science Framework (link).

3 Predictions

3.1 Reporting Behavior

By not reporting a sold unit, the seller avoids having to pay the tax of 40 ECU. At the same time, she faces a risk of being audited and having to pay the 40 ECU tax and a 40 ECU fine. In the Seller only treatment, the probability of an audit is exogenously fixed 10\%. Given our (low) audit and penalty rates, the standard deterrence-model (Allingham and Sandmo, 1972) predicts full non-compliance.\textsuperscript{13} Yet, sellers may have intrinsic motivation to report truthfully.\textsuperscript{14} In Section 5, we apply a model based on Gneezy et al. (2018) to understand how such motivation changes the predictions not only for reporting but also for market outcomes.\textsuperscript{15}

In Seller + Buyer, buyers can provide third-party information by costlessly reporting the trades they make. This information is then automatically matched with the reported units by a given seller. In case a seller reports less transactions than

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\textsuperscript{12} Tax morale is elicited by asking subjects to choose whether ”cheating on taxes if you have a chance” is ”always justified, something in between or never justified”. This question is very similar to the one used in the World Values Survey (www.worldvaluessurvey.org) and is a frequently used measure of tax morale (see e.g. (Alm and Torgler, 2006; Doerrenberg and Peichl, 2018; Doerrenberg and Duncan, 2019)). Risk preferences are elicited by directly asking subjects to assess, on a scale from 0 to 10, their willingness to take risks ”in general” (for behavioral validity of this measure, see Dohmen et al. (2011)). The complete post-experimental questionnaire is included in the pre-analysis plan submitted at the Open Science Framework.

\textsuperscript{13} A risk neutral and money-maximizing seller optimally reports zero units sold as the marginal benefit from evasion, 40 ECU, exceeds the marginal expected cost $0.1 \cdot (40 + 40) = 8$ ECU.

\textsuperscript{14} There may, for example, exist a social norm that dictates truthful tax reporting (e.g. Dwenger et al. (2016)), or the subjects may have a cost to lying in general (e.g. Abeler et al. (2014)).

\textsuperscript{15} Due to random assignment to treatments, potential intrinsic (dis)incentives to report should be distributed in the same way among sellers in Seller only, Seller + Buyer and Seller + BuyerC. Therefore, eventual differences in compliance rates across these three treatments must be due to differences in the reporting institutions. For more literature on tax evasion and intrinsic motivation, see Dufwenberg and Nordblom (2018), Fortin et al. (2007) and Coricelli et al. (2010).
the buyers she traded with, the seller has an 80% chance of being audited. Seller reporting behavior will thus depend on the expectations about the audit probability which over the periods are predicted to adjust to being correct or coincide with past audit rates. By design, the expected audit probability lies between 10% and 80% and is increasing in the extent of the seller’s underreporting and the buyers’ reporting rate. The sellers’ incentives to report more truthfully and the optimal number of units reported are increasing in the probability of audit and thus in the reporting rate of the buyers. This implies that reporting a positive number of units sold in the Seller + Buyer treatment may be optimal, depending on how truthfully buyers report trades.

Formally, a self-interested risk-neutral seller $i$ minimizes

$$V(r_i, s_i) = r_i \tau + \prod [r_i < s_i] \gamma_X(r_i, s_i)(s_i - r_i)(f + \tau)$$

with respect to reported units $r_i$, where $\gamma_X(s_i, r_i)$ denotes the audit probability in treatment $X$ as a function of $s_i$ and $r_i$, and $\prod [r_i < s_i]$ is the indicator taking value one if under-reporting and zero otherwise.

In Seller only, the probability of audit is constant $\gamma_{SO} = 0.1$. In Seller + Buyer and Seller + BuyerC treatments, the auditing probability is endogenous and depends on the gap between the reports of the seller and her customers. In addition to $s_i$ and $r_i$, the expected audit probability depends also on the probability with which buyers report trades. To model the probability of audit, we make the simplifying assumption that a buyer’s decision to report a given trade is independently and identically distributed across buyers and trades. Hence, each reporting decision is independently Bernoulli distributed, and we denote the success probability by $p^{SB}$ and $p^{SBC}$ in Seller + Buyer and Seller + BuyerC, respectively. Given that a seller sells $s_i$ units, the number of trades buyers report is thus distributed according to $Bin(s_i, p^X)$, in which $X \in \{SB, SBC\}$. Moreover, for $X \in \{SB, SBC\}$, we estimate $p^X$ by dividing the total number of trades reported by buyers in treatment X by the total number of trades in treatment X. With these assumptions, the expected audit

\[16\] Kleven et al. (2011) model the endogeneity of the audit probability in a situation where third-party information is available on a subset of tax items and derive the prediction that reporting will be truthful on third-party reported income items. In that analysis, the existence of third-party information on certain items is taken as given, and the audit probability is common knowledge.
probability is given by

$$
\gamma_X(s_i, r_i) = \gamma(s_i, r_i; p^X) = \left[ \sum_{k=0}^{r_i} \left( \frac{s_i}{k} \right) (p^X)^k (1 - p^X)^{s_i-k} \right] \cdot 0.1 \\
+ \left[ \sum_{k=r_i+1}^{s_i} \left( \frac{s_i}{k} \right) (p^X)^k (1 - p^X)^{s_i-k} \right] \cdot 0.8.
$$

(2)

For a given seller $i$, we can thus use the observed quantities $s_i$ and $r_i$ to calculate expected audit probabilities according to equation 2 where $p^X$ is the rate of reported units by the buyers in treatment $X$ on average in periods 11-25 (where behavior has converged).

When buyer reporting is costless, rational and money-maximizing buyers are indifferent between reporting and not reporting the units they bought. On the one hand, if we assume that indifferent buyers report truthfully (see Demichelis and Weibull (2008), for instance), it is optimal for buyers to report truthfully and thus incentives for seller reporting are high as well: 80% audit probability implies an effective unit tax of 56 ECU on unreported units and thus reporting truthfully is optimal for the sellers in this case. On the other hand, if buyers coordinate on the payoff-maximizing equilibrium realizing that their reporting behavior is associated with greater tax evasion incentives by the sellers and thus with lower prices, selfish buyers would not report their trades, and the expected audit probability should be close to 10%. In this case, the incentives of risk-neutral self-interested sellers coincide with those in Seller only, and reporting zero sold units is optimal.

The situation is slightly different in Seller + BuyerC. Since buyers have to bear a cost of 10 ECU if they report a positive number of units, selfish and money-maximizing buyers are no longer indifferent between reporting and not reporting but rather strictly prefer not reporting at all. Thus, sellers’ reporting incentives again coincide with those in Seller only, and reporting zero sold units is optimal.

Our pre-registered hypotheses are aligned with the description above, though we articulate comparative statics only of reporting behavior across our key treatments rather than point equilibrium predictions. In Section 5, we present an ex-post behavioral model based on Gneezy et al. (2018) to even better organize the observed

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17 For laboratory experiments on collusive tax evasion, see Abraham et al. (2017) and Balafoutas et al. (2015). For a field experiment, see Bjorneby et al. (2018).

18 Kotakorpi and Laamanen (2017) argue, in the context of a study analyzing the effect of prefilled income tax returns on compliance, that the fixed cost of filing appears to be a key determinant of the reporting decision.
patterns and take as given the buyer reporting rates deriving predictions for sellers’ market and reporting behavior across treatments assuming that sellers have both direct and image costs of lying.\footnote{See Gneezy et al. (2018), Dufwenberg and Dufwenberg (2018), Tergiman and Villeval (2020), Barron et al. (2021).}

### 3.2 Market prices and quantities

Figure 1. Supply and demand

This figure plots the predicted market outcomes. Demand schedule is fixed throughout the treatments. Light blue line depicts supply in the \textsc{no tax} and dark blue in the \textsc{automatic} treatment. Dotted vertical lines indicate the predicted price intervals in these two control conditions. Solid green line depicts predicted supply in \textsc{seller only}, \textsc{seller + buyerC}, and \textsc{seller + buyer} (in case of full non-compliance); dotted green line depicts predicted supply in \textsc{seller + buyer} (in case of full compliance).

For treatments \textsc{no tax} and \textsc{automatic}, standard economic theory offers precise quantitative predictions displayed in Figure 1.\footnote{Due to the discrete nature of the market, the supply and demand functions are step-functions. This implies that the equilibrium prediction for the price is an interval.} The fact that the Walrasian equilibrium predicts double auction market outcomes has been known since Smith (1962).
Yet, it was not before Easley and Ledyard (1993) and Gjerstad and Dickhaut (1998) that a theory with adequate market microstructure was developed with predictions coinciding with the Walrasian predictions.21

Rather than building on the full-fledged dynamic theory of Gjerstad and Dickhaut (1998), we capture the key individual optimality condition which associates seller ask prices or accepted bids and the quantities offered by the seller. The reserve price \( a^*_{i,X} \) of an experienced seller \( i \) of type \( \theta_i, \alpha_i \) as \( t \to T \) is predicted to satisfy

\[
\begin{align*}
\kappa_i(s^*_{i,X}) + \tilde{V}(s^*_{i,X}) - \tilde{V}(s^*_{i,X} - 1) \\
\leq a^*_{i,X} \leq a^*_{W,X} \leq \kappa_i(s^*_{i,X} + 1) + \tilde{V}(s^*_{i,X} + 1) - \tilde{V}(s^*_{i,X}),
\end{align*}
\]

where \( \kappa_i(s) \) is the marginal cost of selling the \( s \)-th unit, \( s^*_{i,X} \) is the quantity sold by seller \( i \) in equilibrium of treatment \( X \), and \( a^*_{W,X} \) is the Walrasian equilibrium price. These inequalities capture the idea that a (experienced) seller anticipates the expected effective taxes paid at the reporting stage, and the Walrasian market price, and optimizes the reserve price and sold quantities so that selling a unit more or less will result in lower profits.

In the absence of the sales tax, the \( V \)-terms in (1) are all zero and only marginal cost matters for sellers’ supply decisions. Supply equals demand at 17 units in the Walrasian equilibrium. This corresponds to a market clearing price between 158 ECU and 162 ECU. Imposing a 40 ECU per-unit sales tax on sellers implies a 40 ECU upward shift in the supply curve. Therefore, markets clear with a lower quantity of 13 units and a higher price between 178 ECU and 182 ECU.

In Seller only, sellers can avoid (some of) the tax by choosing not to report (some of) the units sold and thereby lower their effective unit tax, implying that the supply curve shifts up by less than 40 ECU. Since the audit probability is independent of the extent of under-reporting, self-interested risk-neutral sellers do not report any units.22 The expected unit tax of a seller who does not report equals 8 ECU, i.e. \( \tilde{V}(s^*_{i,X}) - \tilde{V}(s^*_{i,X} - 1) = 10\% \times (40 + 40) = \tilde{V}(s^*_{i,X} + 1) - \tilde{V}(s^*_{i,X}) \), and thus the supply curve is predicted to shift up by 8 ECUs (see the solid orange line in Figure 1). The

\[21\text{See Friedman (1993) for a comprehensive survey.}
\]
\[22\text{This is different from Kleven et al. (2011) where increasing reporting marginally has an effect both on the margin and on the inframarginal under-reporting thus rendering positive reporting optimal even for a self-interested decision maker.} \]
market price (quantity) is thus predicted to increase (decrease) slightly vis-à-vis the price (quantity) in NO TAX.

More generally, depending on the level of compliance, we thus expect the market price (quantity) in SELLER ONLY to be above (below) the market price (quantity) in NO TAX, especially if some sellers decide not to evade to a full extent. However, the market price (quantity) in SELLER ONLY is also expected to be lower (higher) than in AUTOMATIC. As the effective tax is lower than when taxes are fully enforced, the distortion in market prices and quantities is expected to be smaller.

As discussed in the previous section, audit probabilities in SELLER + BUYER necessarily lie between 10% and 80%. In the equilibrium where buyers are fully compliant, audit probability is 80% and thus sellers are also fully compliant. Thus, equilibrium price and quantity are equal to those in AUTOMATIC (see the dashed orange line in Figure 1). In the payoff-maximizing collusive equilibrium where buyers are not reporting any units, the audit probability is 10% and thus sellers are reporting zero units as well (see the previous subsection). Thus, the equilibrium price and quantity are equal to those in SELLER ONLY (the upward sloping solid orange line in Figure 1).

More generally, the effective unit tax in SELLER ONLY should provide a lower bound for the effective unit tax, and thereby we expect the market outcomes in SELLER + BUYER to lie between those in the SELLER ONLY and in the AUTOMATIC treatments.\textsuperscript{23} The exact outcome depends on the extent to which sellers and buyers tacitly collude not to report truthfully.

Following the same logic, audit probabilities in SELLER + BUYER\textsubscript{C} should be lower than in SELLER + BUYER yet higher than 10%. As a consequence, the effective unit tax should be bounded above by the effective unit tax in SELLER + BUYER and from below by the effective unit tax in SELLER ONLY. We thus expect the market outcomes in SELLER + BUYER\textsubscript{C} to lie between those in SELLER + BUYER and SELLER ONLY.

Let’s take two examples. If buyers report 80% of the bought units in treatment X, then substituting $p_X = 80\%$ into $\gamma_X(s_i, r_i, 80\%)$ yields the following audit probability

\textsuperscript{23}It is possible that the effective tax in the SELLER + BUYER treatment actually exceeds 40 ECU if the seller(s) under-report(s) due to overly optimistic expectations regarding buyer reporting, and thereby end up paying both full taxes and fines. In principle, it is thus possible that the market price (quantity) is higher (lower) than in AUTOMATIC. However, we do not expect such biased expectations to survive for many periods, and as our predictions concern experienced behavior after some rounds of learning, the sellers should be able to constrain their effective unit taxes at 40 ECU (which they can always bring about by reporting truthfully).
schedule as a function of number of sold units (row) and reported units (column).

<table>
<thead>
<tr>
<th>$s_i/r_i$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>66%</td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>77%</td>
<td>55%</td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>79%</td>
<td>73%</td>
<td>46%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>80%</td>
<td>78%</td>
<td>67%</td>
<td>39%</td>
<td>10%</td>
</tr>
</tbody>
</table>

In this case, a seller increasing her under-reporting beyond the first unit will have negative effects both on the marginal unit and on inframarginal units (as in Kleven et al. (2011)). Therefore, under-reporting, at least beyond the first unit, tends not to be optimal. Plugging in the schedule into equation (1) yields a characterization for optimal reporting behavior as a function of $s_i$, and plugging the resulting optimal reporting schedule into (6) yields reserve prices for the standard type. The only cases where under-reporting is optimal is when $s_i = 3$ and $r_i = 2$ or when $s_i = 4$ and $r_i = 3$. When one or two units are supplied, truthful reporting is optimal.

Consider then another example where buyers report 50% of the bought units in treatment X. Plugging $p_X = 0.5$ into (2) yields the following audit probability schedule:

<table>
<thead>
<tr>
<th>$s_i/r_i$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>45%</td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>63%</td>
<td>28%</td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>71%</td>
<td>45%</td>
<td>19%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>76%</td>
<td>58%</td>
<td>32%</td>
<td>14%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Plugging this schedule into (1) reveals that it is optimal to under-report by one unit whichever amount has been produced. Further under-reporting is deterred by the high implied marginal effect of expected taxes and fines which is due to the negative effects on inframarginal units. The expected fine+tax for the first under-reported unit is almost as high as the unit tax. Thus, the reserve prices of the standard type are slightly below but close to the reserve prices in the automatic tax treatment.

---

24 A complete analysis is deferred to Appendix E
3.3 Tax Incidence

The incidence of the expected effective per-unit tax refers to the share of the expected effective tax that is shifted onto buyers. In Automatic, the expected effective tax equals the nominal tax, whereas in Seller only, Seller + Buyer and the Seller + BuyerC tax evasion is possible, and therefore the expected effective tax per unit may differ from the nominal per-unit tax if the seller under-reports units sold. In all of the equilibria with self-interested risk-neutral parties presented in the previous subsection, however, the supply and demand elasticities coincide at equilibrium, and thus tax burden is predicted to be equally shared in those equilibria.

To formalize the effective tax burden and to be able to describe its empirical dynamics, we denote the number of units seller $i$ sells and reports having sold in period $t$ by $s_{i,t}$ and $r_{i,t}$, respectively. The seller’s expected tax liability is then given by

$$
\gamma(s_{i,t}, r_{i,t}) (\tau_{s_{i,t}} + f(s_{i,t} - r_{i,t})) + (1 - \gamma(s_{i,t}, r_{i,t})) \tau_{r_{i,t}},
$$

in which $\gamma(s_{i,t}, r_{i,t})$ captures the audit probability in equation (2) now as a function of the period-specific $s_{i,t}$ and $r_{i,t}$, $\tau$ is the nominal per-unit tax and $f$ is the fine. The expected effective per-unit tax for seller $i$ in period $t$ is then obtained by dividing the expected tax liability by the number of units sold by the seller:

$$
\tau^e(s_{i,t}, r_{i,t}) = \frac{\gamma(s_{i,t}, r_{i,t}) (\tau_{s_{i,t}} + f(s_{i,t} - r_{i,t})) + (1 - \gamma(s_{i,t}, r_{i,t})) \tau_{r_{i,t}}}{s_{i,t}}. \quad (4)
$$

In the Seller only treatment, $\gamma(s_{i,t}, r_{i,t})$ is exogenous and thus $\gamma(s_{i,t}, r_{i,t}) \equiv \gamma$. With our parametrization (i.e. $\gamma = 0.1$, $\tau = 40$, and $f = 40$), the expected effective per-unit tax becomes $\tau^e(s_{i,t}, r_{i,t}) = 8 + 32(r_{i,t}/s_{i,t})$. It is easy to see that $\tau^e(s_{i,t}, r_{i,t})$ is decreasing in the extent of underreporting. Substituting from equation (2) into equation 4 then gives us the expected effective per-unit taxes, $\tau^e_{i,t}$.

Standard theory predicts that the burden of the expected effective tax is shared equally among buyers and sellers. However, the incentives to report on the seller side depend on the reporting rate of the buyers who, then again, are close to indifferent between whether or not to report. Yet, lower buyer reporting rate is expected in Seller + BuyerC than in Seller + Buyer and thus, likewise, seller reporting will be lower in Seller + BuyerC than in Seller + Buyer. In Section 5, we will present a lying aversion model where some buyers and sellers may have an intrinsic aversion to underreporting, and show that this type of model in fact predicts that effective tax incidence is distorted towards buyers when sellers can evade taxes.
sellers take advantage of evasion opportunities, but do not want to reveal themselves as evaders by offering very low prices. Hence, even though average prices are lower under evasion, they do not fully reflect the lower monetary costs of evaders.\footnote{Doerrenberg and Duncan (2019) argue that risky evasion opportunities could imply that sellers seek compensation for the risk related to evasion and shift more of the effective tax burden on buyers in the treatments with tax evasion. Further, given the strategic uncertainty inherent in the treatments involving buyer reporting, it is not clear a priori whether the outcome regarding tax incidence (for any given effective tax) should be similar in the treatments with buyer reporting as in Seller only.}

## Results

### Table 1. General descriptive statistics, periods 11-25

<table>
<thead>
<tr>
<th></th>
<th>No tax</th>
<th>Seller only</th>
<th>Seller + BuyerC</th>
<th>Seller + Buyer</th>
<th>Automatic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted</td>
<td>[158,162]</td>
<td>[161,167]</td>
<td>[161,167]</td>
<td>[161,182]</td>
<td>[178,182]</td>
</tr>
<tr>
<td>Observed (mean)</td>
<td>159 <strong>&lt;</strong> 168.9 &lt; 172.5 <strong>&lt;</strong> 177.6 &lt; 177.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observed (median)</td>
<td>160 <strong>&lt;</strong> 170 &lt; 171 <strong>&lt;</strong> 179 &lt; 180</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Units sold**   |        |             |                 |                |           |
| Predicted        | 17     | 16          | 16              | [13,16]        | 13        |
| Observed (mean)  | 17.4 **>** 15.1 > 14 > 13.1 > 12.8 |

| **Incidence of effective tax** |        |             |                 |                |           |
| Predicted          | - 50%  | 50%         | 50%             | 50%            | 50%       |
| Observed (mean)    | - 80.2% ≠ 37.4% ≠ 46.7% ≠ 46.5% |

| **Reporting rate** |        |             |                 |                |           |
| Sellers            | - 31%  | **<** 66%  | **<** 88%       | -              |
| Buyers             | - 44%  | **<** 81%  | -               | -              |

Notes: Summary of predicted and observed market outcomes, and observed reporting behavior. Predictions assume self-interest and risk neutrality (see section 3.2). Mean price is the mean price over all trades. Mean units sold is the mean number of units sold per period. Incidence of the expected effective tax in a treatment is calculated by dividing the increase in the mean price in a session vis-à-vis the mean price in the No tax condition by the expected effective per-unit tax. Reporting rate of sellers (buyers) is the total number of trades reported by the sellers (buyers) divided by the total number of trades. The greater than and smaller than signs specify the direction of a one-sided Wilcoxon ranksum test and unequal sign indicates a two-sided test. Tests are conducted using market level means across relevant periods. The stars designate conventional levels of statistical significance (*p* < 0.1, **p** < 0.05, ***p** < 0.01). Observations from periods 11-25.

### 4.1 Reporting Behavior

The right panel of Figure 2 displays the evolution of the buyers’ compliance rates by treatment. In Seller + Buyer, buyer reporting rate in rounds 11-25 is nearly truthful, about 80\% of the bought units are reported truthfully. 77\% of the buyers in that treatment report all of their units and 15\% report none in a given period.
Figure 2. Evolution of seller and buyer reporting rates by treatment

Thus nearly all variation in reporting is between buyers. Buyers seem to break the indifference in favor of truth-telling, thereby producing very informative third-party trail for tax deterrence resulting in an environment where sellers have material incentives to report truthfully as well. The first example in the end of Section 3.2 derives the prediction that when buyers report 80% of the units, it is optimal for the sellers supplying one or two units to report truthfully, and for sellers supplying three or four units to underreport by only one unit.\(^\text{26}\)

In Seller + Buyer\(^C\), buyer-reporting rate is 50%, and 40% report all units they bought whereas 50% report none in a given period. Thus again, nearly all within variation is between buyers. Reporting rate is significantly lower than in Seller + Buyer, but also much higher than the zero reporting rate predicted by self-interest. The reporting incentives for the sellers are therefore much stronger than in Seller only.

The left panel of Figure 2 displays the evolution of the sellers’ compliance rates by treatment. Four main observations stand out. First, tax compliance crucially depends on the reporting mechanism.\(^\text{27}\) Second, the compliance rate of 30% in Seller only.

\(^{26}\) Notice also that buyers do not engage in reciprocal gift-exchange (Fehr et al., 1993) where cheaper units would be rewarded with no reports.

\(^{27}\) A Kruskal-Wallis test confirms that compliance rates are statistically significantly different between treatments (\(p < 0.01\)). Furthermore, this difference is due to compliance rates being significantly different in all pairwise comparisons (\(p < 0.01\) for all three tests).
ONLY is significantly above the predicted zero rate. Third, the compliance rate is very high and increasing over time when costless third-party reporting is introduced, indicating that the availability of third-party information effectively deters tax evasion. On average, the compliance rate is between 80% and 90% in periods 11-25 in this treatment. Fourth, when reporting is costly to the buyers, the compliance rate of the sellers is on average 66% in rounds 11-25, well above the rate in SELLER ONLY.

In SELLER + BUYER and SELLER + BUYER C, the incentives to underreport by a unit or two are quite flat and underreporting more than two units is never optimal.

While the high reporting rate of the buyers provides incentives for sellers to report, zero reporting is optimal but not observed in SELLER ONLY. We will apply the theory of lying aversion of Gneezy et al. (2018) to the tax evasion context in Section 5 and see how well that theory is capable of organizing such observations, not only in the reporting but also in the market stage. Likewise, we will show that such a theory could explain the high reporting rate by buyers, even though tacitly collusive underreporting could reduce prices and thus benefit the buyers as well.

Figure 3. Underreporting

![Image of Figure 3. Underreporting]

Notes: Figure displays underreporting by 0, 1, 2, 3, 4 units in SELLER ONLY, SELLER + BUYER and SELLER + BUYER C over periods 11-25.

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28 For comparison, Doerrenberg and Duncan (2019) observe a compliance rate of about 7% in a closely related treatment.
4.2 Market prices and quantities

Figure 4. Evolution of mean prices and quantities

The evolution of mean market price and quantity are displayed in Figure 4. The dotted lines indicate the predicted market price and quantity in the No tax and Automatic benchmark conditions. Our results are largely consistent with these predictions, especially in later rounds when parties have had ample opportunity to learn and adapt their behavior. This highlights again the advantage of lab-experiments in allowing to study causal long-run effects of institutions on market outcomes. Prices are higher and quantities lower in Automatic than in No tax, corresponding to the theoretical predictions. These provide benchmarks against which the outcomes of the treatments with access to tax evasion are compared. As predicted, market prices are significantly lower and quantities traded significantly higher in Seller only than in

\[29\] We base our formal analysis on non-parametric tests based on ranks using market level means over periods 11-25 as units of observation thus obtaining 6 independent observations per treatment. The results are reported in Table 1 and Appendix A. In particular, the mean price in No tax in periods 11-25 is not statistically significantly different from 160 ECU, the mid-point of the equilibrium price range. The mean quantity sold, 17.4 units on average, is slightly higher than the predicted 17 units. Similarly, the mean price in Automatic is not statistically significantly different from 180 ECU in periods 11-25. Furthermore, the mean quantity per period is not statistically significantly different from the predicted 13.
prices still remain above, and quantities below, their no-tax equivalents, and higher than the 8 ECU upward shift of the supply curve predicted by self-interested risk neutrality, suggesting a potential role for behavioral factors. These outcomes are yet natural consequences of the fact that sellers in Seller only are less than perfectly compliant.

On the other hand, with third-party information about transactions in Seller + Buyer, market prices and quantities are very close to those in Automatic. Accordingly, market prices are higher and quantities lower than in Seller only. Costless third-party reporting therefore is an effective deterrence mechanism.

Finally, when reporting is costly to the buyers, the picture emerging is less clear. First, the mean price is lower in Seller + BuyerC than in Seller + Buyer in periods 11-25 and in Automatic. Furthermore, the mean quantity traded per period in Seller + BuyerC is higher than the mean quantity in Automatic and Seller + Buyer. Thus, as discussed in Section 4.1, costly reporting decreases the amount of available third-party information. As a consequence, sellers evade more pushing down the prices. However, lower prices only translate into a weakly higher market activity in terms of quantities traded. Comparing Seller + BuyerC to Seller only, we find that there is no significant difference in the mean price nor mean quantities traded in periods 11-25. The non-significant difference in market activity is noteworthy, given that the compliance rate among the sellers in Seller + BuyerC is over twice the compliance rate in Seller only.

We also check the robustness of our findings using periods 1-25, as well as the median price instead of the mean price as our variable of interest. All our conclusions regarding market prices continue to hold irrespective of whether we use mean or median prices. We report the results of the robustness checks in Appendix B.

4.3 Tax Incidence

Figure 5 shows how the share of the expected effective tax borne by buyers evolves over the course of the 25 periods. The effective incidence converges strikingly close to the theoretical 50-50 prediction in No Tax, Automatic and Seller + Buyer, and even in Seller + BuyerC it is not significantly different from this prediction:

---

30 We thus qualitatively confirm the corresponding result in Doerrenberg and Duncan (2019).
31 We apply equation 4 to calculate for each seller in each period her expected effective tax rate by using the observed number of trades and reported trades in that period. As the basis for our incidence results, we further calculate the mean expected effective per-unit tax as the average of $\tau_{i,t}$ over both $i$ and $t$ in a given market.
Figure 5. Incidence of expected effective tax

![Graph showing the evolution of mean incidence of the expected effective tax by treatment in periods 1-25.](image)

Notes: The figure plots the evolution of mean incidence of the expected effective tax by treatment in periods 1-25.

Considering the main periods (11-25) buyers bear 46.5% of the tax burden in AUTOMATIC, which is consistent with our prediction that the burden is shared equally among sellers and buyers. The incidence is nearly the same, 46.7%, in the SELLER + BUYER treatment and 37.4% in SELLER + BUYER C.

In contrast, in SELLER ONLY, sellers are able to shift a large share of the effective tax burden onto buyers. Figure 6 shows the average trading prices of sellers by their evasion decision in SELLER ONLY (panel A), SELLER + BUYER (panel B) and SELLER + BUYER (panel C). The histograms report frequencies within each treatment. In SELLER ONLY a notable proportion of fully evading sellers sell at the NO TAX predicted equilibrium price, but an even larger share of fully evading sellers sell at higher prices. In other words, a proportion of sellers in SELLER ONLY evade fully, yet set their prices as if they were to report truthfully. The price setting and reporting behavior of this group of sellers largely explains why sellers are able to shift a significant share of the tax burden onto buyers, contrary to the 50-50 split predicted by standard theory.

In the next section, we apply the lying aversion model of Gneezy et al. (2018) to our setup and show that not only are the effective tax incidence patterns but also reporting and market behavior consistent with the model. In the model, sellers take
advantage of evasion opportunities by (privately) underreporting sales, but due to image concerns do not want to reveal themselves as evaders by offering low prices in the market stage. Hence, even though average prices are somewhat lower under evasion, they do not fully reflect the lower monetary costs of evaders. This explains why incidence is heavily distorted towards buyers in the Seller only treatment where evasion is prevalent. In treatments Seller + Buyer and Seller + BuyerC, where the extent of evasion is low due to effective deterrence, the standard incidence result re-emerges.
Figure 6. Trading prices by seller’s reporting decision

A. **SELLER ONLY**

B. **SELLER + BUYER**

C. **SELLER + BUYER C**

Notes: Frequencies of average trading prices by sellers’ reporting decision within a treatment using seller-period level data from periods periods 11–25. Vertical lines indicate the predicted market clearing prices without taxes (160 ECU) and with taxes (180 ECU).
5 Theory: lying, social image and incidence

Our focus here is on explaining the individual variation in reporting behavior, \( r_i \) of the sellers, indexed by \( i \), and their reserve prices \( a_i \) and sold quantities \( s_i \) in later rounds, 11-25, when the seller is experienced and has well-calibrated expectations and thus stable reserve prices.

In our model, there is individual heterogeneity in reporting behavior, sold quantities, and reserve prices, however. This heterogeneity is driven by an aversion to lying when reporting the sold units, and by a motivation to appear honest in the market stage. Such models in the context of lying behavior alone have been proposed by Gneezy et al. (2018), Khalmetski and Sliwka (2019) and Abeler et al. (2019).\(^{32}\) The novelty of the present model is to apply these models to a context where lying takes place at the reporting stage\(^{33}\) but the image costs accrue due to supplying at an excessively low price suggesting tax evasion.

Timing and intrinsic payoff

Denote by \( s_i \) and \( r_i \) the number of sold units and reported units by seller \( i \), respectively. We follow Gneezy et al. (2018) in assuming that there is a fixed cost of lying

\[
C(s_i, r_i; \theta_i) = \theta_i
\]

if \( i \) underreports, i.e. \( r_i < s_i \), and the there is zero cost if \( r_i = s_i \).\(^{34}\) Here \( \theta_i \) is a type-specific fixed cost. The type \( \theta_i \) is private information to the seller.

\(^{32}\)See Attanasi et al. (2019), Tergiman and Villeval (2020), and Bartling et al. (2021) for evidence that intrinsic motivation influences behavior in market and other institutional settings, and Dufwenberg and Dufwenberg (2018) for a model where liars care about the perceptions of others regarding the extent of the lie.

\(^{33}\)In our setup the units sold are observable to the experimenter and the seller knows this and thus, as in Gneezy et al. (2018) observable game, image plays little role in reporting itself.

\(^{34}\)This is in line with Gneezy et al. (2018), Khalmetski and Sliwka (2019) and Abeler et al. (2019), with the exception that Gneezy et al. (2018) adopt a more complicated formulation

\[
C(s_i, r_i; \theta_i) = \theta_i + c(r_i, s_i)
\]

and provide evidence in favor of their model. In particular the evidence favors a specification where \( c(r_i, s_i) \) is weakly increasing and non-convex. Yet, their experimental treatments allow them to identify some people whose behavior is consistent with \( c(s, r) \) being increasing and strictly convex in \(|s - r|\) so that the maximal lie is not told. In our case, these predictions would translate into zero sold units being the modal underreport but also sellers inaccurately reporting some sold units. As the evidence in favor of the lying cost having curvature is not particularly strong, we simplify and assume it is constant and thus best captured by a type-specific fixed cost.
As in Gneezy et al. (2018), there is also an image benefit of being considered an honest type. In the tax evasion context, market activities are visible to market participants whereas tax reports are made privately. Thus, the market activities – prices and sold quantities – convey about the honesty of the seller, not the tax reports directly. As Gneezy et al. (2018), we assume that seller $i$’s image benefit is increasing in the strength of the belief that buyers and other sellers hold about $i$ being an honest type conditional on transaction price $a_i$ written as \( \rho(a) = \frac{h(a)}{h(a) + d(a)} \),

where

\[
 h(a) = \sum_{s=1}^{4} \int \int \left\{ (\theta, \alpha): x(\theta, \alpha, \theta) = s(\theta, \alpha) \right\} \sigma(a, s|\theta, \alpha) dF(\theta, \alpha)
\]

and

\[
 d(a) = \sum_{s=1}^{4} \int \int \left\{ (\theta, \alpha): x(\theta, \alpha, \theta) < s(\theta, \alpha) \right\} \sigma(a, s|\theta, \alpha) dF(\theta, \alpha)
\]

and $\sigma(\theta, \alpha)$ is the market stage strategy of type $(\theta, \alpha)$ and $F(\ldots)$ is the c.d.f. of types in the population. Proneness to image concerns is captured by parameter $\alpha$ and thus the image benefit is captured by $\alpha \rho(a)$ which enters additively into the utility of the seller. Type $\alpha$ is private information to the seller. There is a two-dimensional continuum of types with supports $\theta \in [0, \bar{\theta}]$ and $\alpha \in [0, \bar{\alpha}]$, respectively, including standard types $\alpha = 0 = \theta$.

The reporting stage

Since none of the other sellers or buyers observe the seller’s report, the social image concern does not play any role at the reporting stage. Incorporating lying-aversion into the preferences of the sellers in the reporting stage, player $i$ of type $\theta_i$ minimizes

\[
 V(r_i, s_i; \theta_i) = r_i \tau + \prod [r_i < s_i] \gamma(r_i, s_i, px)(s_i - r_i)(f + \tau) + \prod [r_i < s_i] \theta_i \quad (5)
\]

where the last term is novel and did not appear in equation (1). \footnote{The image benefit is independent of the number of units supplied as only price offers made and accepted, not quantities, are saliently observed in the market place (see decision screens in the appendix).}
In Seller only the audit probability is constant $\gamma_{SO} = 0.1$ In Seller + Buyer and Seller + BuyerC treatments, the auditing probability is endogenous and depends on the gap between the reports of the seller and her customers, and the expected audit probability of seller $i$ selling $s_i$ units and reporting $r_i$ units in treatment $X$ is given by (2).

We assume that in the market stage, each party correctly anticipates her/his reporting behavior. Thus, we will denote the indirect reporting utility as $\tilde{V}(s_{i,X}; \theta_i) = V(r^*_i(s_{i,X}; \theta_i), s_{i,X}; \theta_i)$. These costs now depend on the lying cost parameter $\theta$.

**Market stage**

The reserve price $a^*_{i,X}$ of an experienced seller $i$ of type $\theta_i$, $\alpha_i$ as $t \to T$ is predicted to satisfy

$$k_i(s^*_{i,X}) + \alpha_i[\rho(a^*_{i,X} - 1) - \rho(a^*_{i,X})] + \tilde{V}(s^*_{i,X}, \theta_i) - \tilde{V}(s^*_{i,X} - 1, \theta_i) \leq a^*_{i,X} \leq a^*_{W,X} \leq k_i(s^*_{i,X} + 1) + \alpha_i[\rho(a^*_{i,X}) - \rho(a^*_{i,X} + 1)] + \tilde{V}(s^*_{i,X} + 1, \theta_i) - \tilde{V}(s^*_{i,X}, \theta_i),$$

where $k_i(s)$ is the marginal cost of selling the $s$:th unit, $s^*_{i,X}$ is the quantity sold by seller $i$ in equilibrium of treatment $X$, and $a^*_{W,X}$ is the Walrasian equilibrium price, and $a^*_{i,X}$ is the maximum price at which $s$ units could be sold. Notice that if lower prices are associated with more tax evasion, then the model predicts that image motivation (higher $\alpha_i$) is associated with greater reserve price for a given level of supplied quantity, and therefore seller types with higher $\alpha$ tend to produce smaller amounts than types with $\alpha = 0$. Yet, if $\theta$ is zero or close to it, and there is no pecuniary motivation to be truthful, the seller type still evades taxes and thus has a lower reserve price than truthful types, and thus produces more than a truthful type.

This is the key mechanism in the predictions that follow.

In No tax and Automatic, where all sellers automatically report truthfully, truthful reporting does not correlate with produced quantity or price. Thus the image terms are independent of the price and the predicted reserve prices coincide with those in Easley and Ledyard (1993) and Gjerstad and Dickhaut (1998). In the model of Gjerstad and Dickhaut (1998) agents’ expectations are not merely adaptive but incorporate a better counterfactual understanding than in Easley and Ledyard (1993). Applied to the present context, there is thus an even better counterfactual
understanding of the association between lower prices and more evasion which is central for our image motivation.

**Treatments**

**No tax**

The reserve price of an experienced seller \(i\) at \(t \to T\) is predicted to satisfy (6). The buyers’ induced value schedule and the sellers’ induced cost schedule constitute the demand curve and the supply curve, respectively (see Figure 1), and it is easy to show that the demand and supply price elasticities coincide. Thus the tax burden is predicted to be shared equally between buyers and sellers. In line with theory and with the literature following Smith (1962)\(^{36}\), we find that the average equilibrium quantities coincide with the theoretical predictions (see Table 1 and Figure 1).

**Automatic tax**

In case of automatic taxes, there is no choice but to report all sold units, i.e. \(r_i = s_i\) by restriction and thus \(-r_i(a_{i,AT}, \theta_i)\tau = -s_i(a_{i,AT}, \theta_i)\tau\). In the market stage, the reserve price of an experienced seller \(i\) at \(t \to T\) is predicted to satisfy

\[
k_i(s_i^{*}) + \tau \leq a_{i,AT}^* \leq a_{W,AT}^* \leq k_i(s_i^{*} + 1) + \tau.
\]

Thus the price is equal to marginal cost plus the per unit tax rate. In other words, the predicted equilibrium price lies at the level where the supply curve (aggregated sellers’ induced cost schedule shifted up by \(\tau\)) intersects the demand curve (the buyers’ induced value schedule). Again, since elasticities are unchanged, tax burden is predicted to be shared equally between buyers and sellers. Indeed, as above in NO TAX, we find that the average equilibrium quantities coincide with the theoretical predictions and buyers bear on average 46.5% of the tax burden in periods 11-25 (see Figure 5).

\(^{36}\)Overviewed in Friedman (1993).
Seller only

Reporting stage. In Seller only, heterogeneity in the intrinsic motivation of the sellers enters the picture. The optimal reports are given by the solution to the problem

\[ \min_{r_i} \left\{ r_i \tau + [\theta_i + 0.1(s_i - r_i)(f + \tau)] \prod [r_i < s_i] \right\}, \]

where \( \theta_i \) is the intrinsic fixed lying cost.

If the seller decides to report truthfully \( r_i = s_i \), the goal function takes value \( s_i \tau \). If the seller under-reports, then a lying cost is incurred and the probability of audit is independent of the report at 10%. Conditional on under-reporting, it is optimal not to report any units and the goal function takes value \( \theta_i + 0.1 \times s_i \times (f + \tau) \). This is weakly greater than \( s_i \tau \) and thus \( i \) reports truthfully\(^{37}\) if and only if

\[ \theta_i \geq s_i \times (0.9 \times \tau - 0.1 \times f) = s_i \times 0.8 \times 40, \]

which does not hold for \( \theta_i = 0 \) and thus full evasion is optimal for a standard seller. Yet, for \( \theta_i \) sufficiently high, truth-telling is optimal. Third, partial evasion is never optimal (just as in the observable game of Gneezy et al. (2018), see footnote 29). Finally, incentives for tax evasion are increasing in the number of supplied units. Indeed, the Seller only treatment is closest to the die-rolling lying experiment paradigm (Fischbacher and Föllmi-Heusi, 2013) as full lies are optimal for self-interested sellers. A key difference is that in our setup the true number (of sold units) is endogenously chosen in the market stage (not exogenously randomized as in the dice-roll task) and under-reporting comes with an explicit punitive frame and a 10% chance of a monetary fine. Notice also that unlike a typical Fischbacher and Föllmi-Heusi (2013) setup and in line with the observable game of Gneezy et al. (2018), the true number is public knowledge between the experimenter and the participant and other market participants do not observe the report. Thus image motivation, \( \alpha \), plays no role in the reporting stage and only the preference for truthtelling, \( \theta \), matters.

Figure 3 shows that in Seller only about 52% of reports are fully evasive, and 18% report truthfully, consistent with the idea that sellers’ intrinsic motivation is heterogeneous.\(^{38}\) Yet, the remaining 30% evade partially. The partially evading

\(^{37}\) Assuming that indifferent types report truthfully as in Demichelis and Weibull (2008), for instance.

\(^{38}\) Notice also that the share of truthful reports in Seller only coincides with that in the field experimental settings of Kleven et al. (2011) and Dwenger et al. (2016) suggesting that external validity might not be too severely compromised in the laboratory. It is noteworthy that supplied
reports are not consistent with the model but they are consistent with the evidence in the observable game of Gneezy et al. (2018) where 32% of those who lie do so only partially.\textsuperscript{39} The model of Gneezy et al. (2018), which our model is based on, also abstracts from the complications of partial lying.

\textit{Market stage.} The audit probability is not sufficient to deter tax evasion of a standard seller $\alpha = 0 = \theta$. Thus, in the market stage, a standard seller’s reserve price and supplied quantity are predicted to satisfy

$$k_i(s_{i,SO}^{*}(0,0)) + 0.1(f + \tau) \leq a_{W,SO}^*(0,0) \leq k_i(s_{i,SO}^{*}(0,0) + 1) + 0.1(f + \tau).$$

where $a_{W,SO}^*$ is the Walrasian equilibrium price. Therefore, if all sellers of a session happen to be standard or their $\alpha:s$ and $\theta:s$ are small, the prediction in \textit{Seller only} coincides with the prediction of self-interested in Section 3.2. This is what happens in Sessions 14 and 15 in \textit{Seller only} (see Appendix C).

As is typical for these models, the predicted effects of image motivation are discovered by a fixed point argument: an intrinsically motivated seller with $\theta_i < s_{i,SO}^*(\theta_i, \alpha_i)[0.9 \times \tau - 0.1 \times f]$ will not report the sold units but cares about social image. Thus, provided that tax-evaders are more likely to agree on lower prices, an image-motivated seller suffers a marginal image cost of $\alpha_i[\rho(a_{i,SO}^*(\theta_i, \alpha_i)) - \rho(a_{i,SO}^{*,s+1} (\theta_i, \alpha_i))]$ for agreeing on a marginally lower price than her reserve price. Thus, her reserve price for a given unit must be higher than that of the standard type to cover the additional cost, and therefore the predicted number of units will be smaller than for a standard seller. This confirms the idea that types without image motivation are predicted to hold lower reserve prices.

Finally, an intrinsically motivated seller whose fixed lying cost satisfies $\theta_i \geq s_{i,SO}^*(\theta_i, \alpha) \times 0.8 \times 40$ will report all units. She also cares about social image and thus her reserve price must cover the marginal image cost. Moreover, truthful reporting means that the implied full tax on the marginal unit $\tau$ must be covered. Thus predicted reserve prices are higher and the predicted number of units sold will be lower than for other seller types.

Consider types who do not have a sufficiently high $\theta_i$ to curb tax evasion but who do care about image. They are expected not to charge too low prices to sustain their image in the market place where their actions are observable to other parties. They are rather predicted to mimic the prices of truthful types and thus sell lower quantities are highest in \textit{Seller only} and lowest in \textit{Seller + Buyer C}.\textsuperscript{39}See also Abeler et al. (2019) for evidence in previous experiments.
quantities than types who evade and do not care about their image. Why is it then that truthful types do not want to deviate upwards and separate to signal their truthfulness? Simply because no buyer is willing to trade at such price and the seller would not be able to sell.

Therefore, if all sellers of a session happen to be have high $\alpha$:s and some of them have high $\theta$:s, the prediction in such SELLER ONLY sessions is that prices are much higher than in the self-interested prediction of Section 3.2, even up to the levels of the AUTOMATIC treatment. The sellers with a high $\theta$ report truthfully and those with low $\theta$ evade fully. This is what happens in Sessions 13, 16-18 in the SELLER ONLY treatment (see Appendix C).

Notice that a Walrasian equilibrium predicts a single price. The law of one price is not literally true in continuous double auctions and the Walrasian equilibrium rather predicts the average price. Some within-session price variation across rounds and sellers is observed. It should be noted that in SELLER ONLY, a substantial fraction of the price variation is across sessions. On the one hand, there are sessions where prices are high and both full evaders and truthful sellers sell at those prices (13, 16-18). In these sessions the fact that evaders do not compete the price down is consistent with the marginal image costs. There are also sessions where competition is tough, prices are bid at NO TAX Walrasian equilibrium levels, and evasion is widespread (14, 15). This effect is consistent with random selection of types with little intrinsic motivation who face extreme competitive pressure to bid low and evade. Similar explicit selection effects and variation across sessions is observed in Halliday et al. (2021). More generally, the Walrasian equilibrium price should be a function of the profile of types of sellers in a given session. Competition is tougher when seller types do not much differ from the standard values. When the $\alpha$:values of the sellers are higher, higher prices can be sustained and sellers with a low $\theta$ evade taxes. Notice moreover, that the image motivation of the sellers must be driven by counterfactual but correct beliefs about the types and tax evasion in case prices were competed down to the bottom, exactly as in Halliday et al. (2021) where the effect of selection and competition on lying is explicitly studied.

Although self-interest predicts that 10% audit probability is not sufficient to deter tax evasion and thus prices will be close to those in the NO TAX, image-motivation predicts that the average price in SELLER ONLY is higher and sold quantities are lower. Moreover, self-interested sellers who are predicted to belong to the fully evading group of sellers, are predicted to (at occasions) trade at a price which undercuts that at
which the partially evading or truthful sellers trade. They are also predicted to sell higher quantities.

In line with these predictions, we see that lower prices are more likely to be agreed by fully evading sellers (Figure 6): only about 10% of the sellers agreeing on a price lower than or equal to 162 (the No tax equilibrium price) are reporting truthfully, 20% of those agreeing on a price between 162 and 170 are truthful, and 36% of those selling at a price higher than 178 (the Automatic equilibrium price) are truthful.40

A truthful seller supplies 2.4 units whereas a fully evading seller supplies 3.1 units on average (see Figure 7). These facts are consistent with the predictions that full evaders have lower reserve prices given supplied quantity and they supply more units than truthful sellers.

As the average price of the truthful types is 10 ECU above the (both predicted and observed) No tax price, the truthfully reporting 18% of the sellers are able to pass on average only about a quarter of the 40 ECU unit tax on the buyers. The 52% of the sellers who fully evade pay on average an 8 ECU effective unit tax. As Figure 6 shows, the fully evading sellers charge an average price exactly 8 ECU above the No tax equilibrium price. This means that fully evading sellers are able to pass on average 100% of their effective tax onto buyers.41 The fully evading sellers whose image motivation prevents them from selling at the lowest prices but who nevertheless fully under-report, pass the highest share of the tax burden onto buyers. As this group of seller reports is the largest, in aggregate, the effective tax burden is heavily distorted towards the buyers, unlike in the Automatic and No tax. The average tax burden borne by the buyers is 80% on average over periods 11-25.

**Seller + Buyer**

If all agents were of standard type, there would exist a collusive equilibrium where all buyers and sellers report zero units.

Yet, any standard type buyer in that equilibrium is indifferent between reporting and not reporting truthfully at the reporting stage and that equilibrium is thus not robust to the introduction of intrinsically motivated buyer types. The model of Gneezy et al. (2018) predicts truthful reporting by any buyer with slightest intrinsic

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40The average price distributions of fully evading and partially evading seller are significantly different (Kolmogorov-Smirnov test) from each other whereas those of the partial and truthful sellers are not (top-row panes in Figure 6).

41Notice that the fraction of fully evading sellers is between 47% and 57% for each of the five cost profile types so there is no significant correlation between cost profiles and evasion.
Figure 7. Trading prices by sold units and seller’s reporting decision

SELLER ONLY

Notes: Frequencies of average trading prices by number of units sold and seller’s reporting decision using seller-period level data from periods 11–25 in Seller only treatment. Vertical lines indicate the predicted market clearing prices without taxes (160 ECU) and with taxes (180 ECU).

In line with that model, 80% of the bought units are reported in Seller + Buyer and thus \( \gamma_{SB}(s_i, r_i, 80\%) \). This yields the audit probability schedule presented in Table Y in Section 3.2.\(^{42}\) In Section 3.2, we learned that this implies that the only cases where under-reporting is optimal is when \( s_i = 3 \) and \( r_i = 2 \) or when \( s_i = 4 \) and \( r_i = 3 \) and the seller is of standard type with \( \theta_i = 0 \). When one or two units

\(^{42}\)This approach of course misses the session-specific variation in buyer reporting behavior based on which sellers adapt their reporting and sales behavior (recall that we focus on rounds 11 to 25 where sellers have had ample opportunity to learn from the buyers behavior in that session). Nevertheless, the model is tractable and simple this way and helps the reader’s understanding the central trade-offs.
are supplied, truthful reporting is optimal even for the standard type. Thus, adding intrinsic motivation and the behavioral model does not increase much explanatory power on the seller side. Yet, it explains the high reporting rate on the buyer side.

Since seller-reporting is predicted to be at a high level, so are paid taxes. Even in the cases where the standard type under-reports the incentive to do so is quite flat and the expected tax+fine is quite close to the tax paid by truthful reporters. The fraction of sellers who under-report is predicted to be small and the reserve prices of standard and intrinsically motivated types are predicted to largely overlap, and therefore no major image effects of charging lower or higher prices are predicted unlike in Seller only. Thus, supply curves in Seller + Buyer approximate or slightly undercut those in Automatic (equally elastic supply and demand), and the effective tax burden is expected to be shared in equal proportions, just as predicted by the standard tax incidence model.

These predictions coincide with what is observed in the data (see Figure 3 and 4). About 78% of sellers’ reports are truthful and only 6% under-report more than one unit. Average prices of evaders are not significantly different from those of truthful reporters (also because under-reporting is so rare, see Figure 6). Sellers bear on average 47% of the tax burden in periods 11-25, not significantly different from the predicted 50% (see Figure 5).

**Seller+BuyerC**

As reporting is costly for buyers, a standard buyer type now prefers not to report. Yet, as the cost of reporting is small, some intrinsic motivation is sufficient to make truthful reporting optimal.

Consistent with this prediction, the reporting rate of buyers is 50% which is significantly lower than in Seller + Buyer. In Section 3.2 we learned that the implied audit probabilities, for the standard type with \( \theta_i = 0 \), it is optimal to under-report by one unit whichever amount has been produced. Further under-reporting is deterred by the high implied marginal effect of expected taxes and fines which is due to the negative effects on inframarginal units. The expected fine+tax for the first under-reported unit is almost as high as the unit tax. Thus, the reserve prices of the standard type are slightly below but close to the reserve prices in the automatic tax treatment. As extrinsic incentives already effectively deter evasion beyond

\[ 43 \text{It is also at about the same level as non-zero reporting by sellers in Seller only where extrinsic incentives are also small.} \]
unit under-reporting, very little intrinsic motivation is sufficient to deter any under-reporting and thus intrinsically motivated types are predicted to report truthfully in Seller + BuyerC.

Turning to our evidence, in Seller + BuyerC where any intrinsically motivated type should and a standard type should not report truthfully, about 43% of the sellers do so. Moreover, in line with the prediction, under-reporting is more common in Seller + BuyerC than in Seller + Buyer, and yet unit under-reporting is by far the most common form of under-reporting unlike in Seller only (see Figure 3). Both patterns are in line with the predictions of the model. About 30% under-report two or more units which is suboptimal even for a standard seller. This coincides with the fraction of suboptimal partial reporting in the Seller only.\footnote{The suboptimal behavior can be partially due to the highly stochastic feedback which makes it hard for sellers to estimate the expected fine for each level of under-reporting. The number of seller’s trades reported by her customers is Binomially distributed with equal success and failure rates. Recall that the only individual audit outcomes are observable to sellers after each round, not the reports nor the reporting rate of the buyers.}

Reserve prices of all reporting profiles are predicted to be higher than in Seller only. The reserve prices of unit under-reporting sellers are predicted to be slightly lower and/or the supplied quantities slightly higher than those of truthful sellers. Thus, some tendency for lower prices to signal under-reporting is predicted but this effect should be small and thus have little effect through image motivation on reserve prices. In fact in our data, the fraction of truthful reports is constant between 41% and 44% across price brackets below 162 (No Tax equilibrium price), 162-170, 170-178, and above 178 (Automatic equilibrium price) and the distribution of average prices of full and partial evaders are not significantly different from those of truthful reporters (Figure 6).

As no major under-reporting is optimal and supply curves approximate those in the automated treatment (equally elastic supply and demand), the tax burden is expected to be shared in equal proportions, just as predicted by the standard tax incidence model.

In our experimental sessions, buyers’ effective tax burden in Seller + BuyerC is 37% (see Figure 5), which is not statistically significantly from 50%, the prediction of standard theory. Therefore, sellers have no benefit of tax evasion opportunities but rather bear a greater effective tax burden. To some extent, this is due to the suboptimally large tax evasion: 30% of the reports fall short of the true supplied quantity by two units or more which results in high and suboptimal expected effective prices.
tax rate.\textsuperscript{45}

6 Discussion

Some of the previous literature (Kleven et al., 2011) interprets the effectiveness of third-party information in deterring evasion as evidence that moral motivation is not an important factor in explaining tax evasion behavior: the key factor appears not to be that individuals are unwilling to cheat, but that they are unable to cheat due to the prevalence of third-party information, and a traditional deterrence model focusing on monetary costs and benefits appears according to this interpretation to be sufficient to understand evasion decisions.

We find, in line with that literature, that reporting is truthful and market outcomes coincide with the predictions of the standard model, not only in the treatments without taxes and where taxes are automatically levied (and thus deterrence is perfect) but also when effective third-party information is used in deterrence. Moreover, we also study the incentives of these third parties to provide information and find that ensuring incentives for buyer-reporting is quintessential to ensure truthful reporting by the sellers. Indeed, when buyer-reporting is costly, more complex patterns start to emerge where moral motivation, and models of lying aversion with image costs, help to increase the explanatory power beyond that of the standard model. When taxation is based on seller reports but audits are not based on third-party information, vast majority of reports are in line with standard self-interested theory. But image costs may still be important to many and have important repercussions to the market behavior and outcomes leading to significant departures from the incidence results of standard theory, just as our evidence suggests.

Our findings may at first sight appear puzzling in this regard. Indeed, we show that a model with intrinsic motivation and image concerns can explain the patterns of behavior found in our study, and our results on tax incidence in the presence of evasion are at odds with standard theory. However, the apparently conflicting interpretations can be reconciled: We show that even if the majority of reporting behavior of sellers follows the logic of the standard model (as only pure lying aversion and not image concerns play a role at the reporting stage, since reporting decisions are not observed

\textsuperscript{45}This is likely due to the difficulty of learning when variance in effective taxes is large due to Bernoulli-distributed buyer-reports with equal success and failure rates. Audit variance is considerably larger in SELLER + BUYER than in SELLER + BUYER which makes learning and optimization by the sellers more challenging and the suboptimal reporting is associated with high expected taxes and fines which increases the tax burden of sellers.
by agents on the other side of the market), image concerns affect real outcomes, i.e. pricing behavior, and give rise to the non-standard incidence result.

Regarding the effects of reporting institutions, we obtain a result that resembles findings from the corresponding field studies, that easy-to-provide costless third-party information is effective in deterring evasion. Our experiments and the behavioral model also help to understand when exactly the patterns are predicted to coincide or depart from the standard model. Existing discussions of third-party reporting typically take the existence (or the lack) of the required information as given. But for such information to exist in the first place, the third party must have incentives to provide it. In our experiment, if buyers take into account the indirect effect of tax evasion on prices, they should not provide reports that enable stricter tax enforcement. Nevertheless, we find that introducing buyer reporting has a very strong disciplining effect on evasion. Buyers and sellers are thus unable to tacitly collude on an outcome with a lower level of reporting, even though it would be in their joint monetary interest. We show in our theoretical model, that this can be explained by moral motivation: even very little (some) intrinsic motivation to report honestly is sufficient to destabilize the collusive equilibrium when buyer reporting is costless (costly). Making reporting more costly potentially facilitates such collusion, and indeed, buyers are less likely to report when reporting comes with a cost. Compliance of sellers decreases as well, but not by as much.

From a policy perspective, an interesting conjecture from these results is that taxpayer awareness of the mere possibility of the existence of third-party information may be a fairly effective deterrent on tax evasion. Tax administrators have traditionally been quite secretive about the type of information used in tax enforcement. Our findings point to a tentative policy implication, namely that it may be a good idea to make known at least the types of third-party information available to (if not the exact information held by) the tax authority. (Notifying taxpayers of the exact information held by the tax authority may in some cases backfire, a result found by Slemrod et al. (2017) and Carrillo et al. (2017) in a natural experiment setting. Okat (2016) shows in a theory model that it may be optimal not to use all available information in tax enforcement, in the sense that randomness in audit rules may be optimal to prevent learning by evaders; see Alm et al. (1992) for a related argument plus caveats). Naturally, providing information should be made as cheap as possible to the third

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\textsuperscript{46}A few previous lab experiments have discussed the impact of ambiguity – not having precise knowledge of objective audit probabilities – on tax evasion, and according to a recent review of tax experiments those papers found mixed results (Malézieux, 2018).
party. Costly information provision has two downsides: the reporting cost constitutes an efficiency loss, and may facilitate collusion between the buyer and seller to jointly evade taxes.

Let us briefly discuss some interesting future directions of research. First of all, it is of importance to further carefully test the behavioral theory which is found widely consistent with the observations in the present paper. Relatedly, in our study market agents are randomly assigned to market institutions and seller or buyer roles. To increase the external validity of the exercise and to understand the role of selection on competition and tax evasion, it would be of interest to endogenise the entry to markets. As the evidence in Halliday et al. (2021) suggests, it is conceivable that agents without moral costs are likely to select into markets where they benefit from their comparative advantage whereas agents prone to suffer from lying aversion, self-select into markets where deterrence is effective or lying is not necessary. What makes these considerations particularly interesting is that it is in every sellers interest to ensure that an important fraction of sellers are prone to image concerns as this helps to sustain higher prices and pass the tax burden of the buyers. If there is a sufficient fraction of honest types and image concerns are sufficiently widespread, the selection between these types of markets on the image concern dimension is unclear.
References


## A Additional tables

Appendix Table A-1. Demand and supply schedules

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Notes: Costs and values were randomized into sets of four. The sets of four costs/values were randomly assigned to traders at the beginning of each experimental session.
### Appendix Table A-2. Summary statistics of demographic variables

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<td>-</td>
<td>1.99</td>
<td>2.10</td>
</tr>
<tr>
<td>N. of Subjects</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td><strong>Seller only</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.75</td>
<td>28.02</td>
<td>1</td>
<td>0.62</td>
<td>5.37</td>
<td>5.85</td>
</tr>
<tr>
<td>St. Dev.</td>
<td>-</td>
<td>8.09</td>
<td>-</td>
<td>-</td>
<td>2.45</td>
<td>2.44</td>
</tr>
<tr>
<td>N. of Subjects</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td><strong>Seller + Buyer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.62</td>
<td>27.57</td>
<td>0.97</td>
<td>0.57</td>
<td>5.18</td>
<td>6.87</td>
</tr>
<tr>
<td>St. Dev.</td>
<td>-</td>
<td>5.58</td>
<td>-</td>
<td>-</td>
<td>2.24</td>
<td>2.17</td>
</tr>
<tr>
<td>N. of Subjects</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td><strong>Seller + BuyerC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.75</td>
<td>27.25</td>
<td>0.95</td>
<td>0.52</td>
<td>5.20</td>
<td>6.78</td>
</tr>
<tr>
<td>St. Dev.</td>
<td>-</td>
<td>7.94</td>
<td>-</td>
<td>-</td>
<td>2.11</td>
<td>1.90</td>
</tr>
<tr>
<td>N. of Subjects</td>
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<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>

| P-value | 0.40 | 0.45 | 0.12 | 0.001 | 0.46 | 0.26 |

Notes: Reported are the mean characteristics of the five treatment groups. Gender is an indicator that is equal to 1 if the subject is female. Finnish is an indicator that is equal to 1 if the subject’s native language is Finnish. Tax morale is an indicator that is equal to 1 if the subject reported that cheating on taxes is never acceptable. Risk attitude is the subject’s reported willingness to take risks (0 = ”not at all willing” to 10 = ”very willing”), and generalized trust is the subject’s reported propensity to trust other people (0 = ”one can never be too careful with other people” to 10 = ”most people can be trusted”). P-values are for $\chi^2$ test, apart from Age for which the p-value is for Kruskal-Wallis test. For each test, the null hypothesis is that there are no differences between the five treatment groups.
Appendix Table A-3. Treatment effects, mean prices, periods 11-25

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No Tax</th>
<th>Automatic</th>
<th>Seller only</th>
<th>Seller + Buyer</th>
<th>Seller + BuyerC</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Tax</td>
<td>(p &lt; 0.01)</td>
<td>(p &lt; 0.01)</td>
<td>(p &lt; 0.01)</td>
<td>(p &lt; 0.01)</td>
<td></td>
</tr>
<tr>
<td>Automatic</td>
<td>(p &lt; 0.01)</td>
<td></td>
<td>(p &gt; 0.4)</td>
<td>(p &lt; 0.05)</td>
<td></td>
</tr>
<tr>
<td>Seller only</td>
<td></td>
<td>(p &lt; 0.01)</td>
<td></td>
<td>(p &gt; 0.1)</td>
<td></td>
</tr>
<tr>
<td>Seller + Buyer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(p &lt; 0.05)</td>
</tr>
<tr>
<td>Seller + BuyerC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: The table shows approximate p-values from one-sided Wilcoxon rank-sum tests. The unit of observation is the mean transaction price across periods 11–25 in a session.

Appendix Table A-4. Treatment effects, mean quantities, periods 11-25

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No Tax</th>
<th>Automatic</th>
<th>Seller only</th>
<th>Seller + Buyer</th>
<th>Seller + BuyerC</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Tax</td>
<td>(p &lt; 0.01)</td>
<td>(p &lt; 0.01)</td>
<td>(p &lt; 0.01)</td>
<td>(p &lt; 0.01)</td>
<td></td>
</tr>
<tr>
<td>Automatic</td>
<td></td>
<td>(p &lt; 0.01)</td>
<td>(p &gt; 0.5)</td>
<td>(p &lt; 0.01)</td>
<td></td>
</tr>
<tr>
<td>Seller only</td>
<td></td>
<td></td>
<td>(p &lt; 0.01)</td>
<td>(p &gt; 0.1)</td>
<td></td>
</tr>
<tr>
<td>Seller + Buyer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(p &gt; 0.1)</td>
</tr>
<tr>
<td>Seller + BuyerC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(p &gt; 0.1)</td>
</tr>
</tbody>
</table>

Notes: The table shows approximate p-values from one-sided Wilcoxon rank-sum tests. The unit of observation is the mean quantity traded per period across periods 11–25 in a session.

Appendix Table A-5. Treatment effects, mean incidence of expected effective tax, periods 11-25

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No Tax</th>
<th>Automatic</th>
<th>Seller only</th>
<th>Seller + Buyer</th>
<th>Seller + BuyerC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic</td>
<td>(p = 0.055)</td>
<td></td>
<td>(p = 1.0)</td>
<td>(p = 0.20)</td>
<td></td>
</tr>
<tr>
<td>Seller only</td>
<td>(p = 0.055)</td>
<td></td>
<td></td>
<td>(p = 0.055)</td>
<td></td>
</tr>
<tr>
<td>Seller + Buyer</td>
<td></td>
<td></td>
<td></td>
<td>(p = 0.20)</td>
<td></td>
</tr>
<tr>
<td>Seller + BuyerC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: The table shows approximate p-values from two-sided Wilcoxon rank-sum tests. The unit of observation is the mean expected effective incidence across periods 11–25 in a session.
Appendix Table A-6. Additional descriptive statistics, periods 11-25

<table>
<thead>
<tr>
<th></th>
<th>No tax</th>
<th>Seller only</th>
<th>Seller + BuyerC</th>
<th>Seller + Buyer</th>
<th>Automatic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Division of revenue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total earnings</td>
<td>21,221</td>
<td>17,091</td>
<td>12,199</td>
<td>11,847</td>
<td>11,949</td>
</tr>
<tr>
<td>Earnings of sellers</td>
<td>10,363</td>
<td>8,741</td>
<td>4,938</td>
<td>5,309</td>
<td>5,578</td>
</tr>
<tr>
<td>Earnings of buyers</td>
<td>10,858</td>
<td>8,191</td>
<td>7,261</td>
<td>6,539</td>
<td>6372</td>
</tr>
<tr>
<td>Taxes collected</td>
<td>-</td>
<td>3000</td>
<td>6,487</td>
<td>7,493</td>
<td>7,707</td>
</tr>
<tr>
<td>Fines</td>
<td>-</td>
<td>473</td>
<td>1093</td>
<td>573</td>
<td>-</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum efficiency</td>
<td>21,420</td>
<td>20,280</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observed efficiency</td>
<td>21,221</td>
<td>*20,564</td>
<td>*19,779</td>
<td>*19,914</td>
<td>*19,656</td>
</tr>
<tr>
<td>Relative efficiency</td>
<td>100%</td>
<td>96.9%</td>
<td>93.2%</td>
<td>93.8%</td>
<td>92.6%</td>
</tr>
</tbody>
</table>

Notes: Earnings, taxes collected and fines are averages per session across relevant periods and expressed in ECU. Maximum efficiency is the maximum sum of seller and buyer surplus. Observed efficiency of a treatment is the mean total sum of earnings, collected taxes and fines. Relative efficiency is defined as the efficiency of a given treatment divided by the efficiency in the No tax treatment. The greater than and smaller than signs specify the direction of a one-sided Wilcoxon ranksum test and unequal sign indicates a two-sided test. Tests are conducted using market level means across relevant periods. The stars designate conventional levels of statistical significance (* p < 0.1, ** p < 0.05, *** p < 0.01). Observations from periods 11-25.
B Robustness checks

B.1 Periods 1-25

Appendix Table B-1. General descriptive statistics, periods 1-25

<table>
<thead>
<tr>
<th></th>
<th>No tax</th>
<th>Seller only</th>
<th>Seller + BuyerC</th>
<th>Seller + Buyer</th>
<th>Automatic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted</td>
<td>[158,162]</td>
<td>[161,167]</td>
<td>[161,167]</td>
<td>[161,182]</td>
<td>[178,182]</td>
</tr>
<tr>
<td>Observed (mean)</td>
<td>157.9</td>
<td>&lt;</td>
<td>168.7</td>
<td>&lt;</td>
<td>168.4</td>
</tr>
<tr>
<td>Observed (median)</td>
<td>160</td>
<td>&lt;</td>
<td>170</td>
<td>&lt;</td>
<td>170</td>
</tr>
</tbody>
</table>

| **Units sold**   |        |             |                 |                |           |
| Predicted        | 17     | 16          | 16              | [13,16]        | 13        |
| Observed (mean)  | 17.4   | >           | 15.2            | >              | 14.2      | >         | 13.4      | >         | 13.3      |

| **Incidence of effective tax** |        |             |                 |                |           |
| Predicted        | -      | 50%         | 50%             | 50%            | 50%       |
| Observed (mean)  | -      | 89.2%       | 29.4%           | 40.1%          | 46.1%     |

| **Reporting rate** |        |             |                 |                |           |
| Sellers           | -      | 32%         | <               | 64%            | <         | 84%       |
| Buyers            | -      | -           | 46%             | <              | 81%       | -         |

Notes: Summary of predicted and observed market outcomes, and observed reporting behavior. Predictions assume self-interest and risk neutrality (see section 3.2). Mean price is the mean price over all trades. Mean units sold is the mean number of units sold per period. Incidence of the expected effective tax in a treatment is calculated by dividing the increase in the mean price in a session vis-à-vis the mean price in the No tax condition by the expected effective per-unit tax. Reporting rate of sellers (buyers) is the total number of trades reported by the sellers (buyers) divided by the total number of trades. The greater than and smaller than signs specify the direction of a one-sided Wilcoxon ranksum test and unequal sign indicates a two-sided test. Tests are conducted using market level means across relevant periods. The stars designate conventional levels of statistical significance (* p < 0.1, ** p < 0.05, *** p < 0.01). Observations from periods 1-25.
### Appendix Table B-2. Additional descriptive statistics, periods 1-25

<table>
<thead>
<tr>
<th></th>
<th>No Tax</th>
<th>Seller only</th>
<th>Seller + BuyerC</th>
<th>Seller + Buyer</th>
<th>Automatic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>160</td>
<td>&lt; **</td>
<td>170</td>
<td>&lt; **</td>
<td>176</td>
</tr>
<tr>
<td><strong>Division of revenue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total earnings</td>
<td>35,302</td>
<td>28,311</td>
<td>19,545</td>
<td>19,128</td>
<td>19,790</td>
</tr>
<tr>
<td>Earnings of sellers</td>
<td>16,782</td>
<td>14,271</td>
<td>6,143</td>
<td>7,140</td>
<td>8,627</td>
</tr>
<tr>
<td>Earnings of buyers</td>
<td>18,520</td>
<td>13,694</td>
<td>13,402</td>
<td>11,988</td>
<td>11,163</td>
</tr>
<tr>
<td>Taxes collected</td>
<td>-</td>
<td>5,320</td>
<td>11,047</td>
<td>12,613</td>
<td>13,260</td>
</tr>
<tr>
<td>Fines</td>
<td>-</td>
<td>793</td>
<td>2,300</td>
<td>1,433</td>
<td>-</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum efficiency</td>
<td>35,700</td>
<td>33,800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observed efficiency</td>
<td>35,302</td>
<td>34,424</td>
<td>32,892</td>
<td>33,174</td>
<td>33,050</td>
</tr>
<tr>
<td>Relative efficiency</td>
<td>100%</td>
<td>97.5%</td>
<td>93.2%</td>
<td>94.0%</td>
<td>93.6%</td>
</tr>
</tbody>
</table>

Notes: Earnings, taxes collected and fines are averages per session across relevant periods and expressed in ECU. Maximum efficiency is the maximum sum of seller and buyer surplus. Observed efficiency of a treatment is the total sum of earnings, collected taxes and fines. Relative efficiency is defined as the efficiency of a given treatment divided by the efficiency in the No tax treatment. The greater than and smaller than signs specify the direction of a one-sided Wilcoxon ranksum test and unequal sign indicates a two-sided test. Tests are conducted using market level means across relevant periods. The stars designate conventional levels of statistical significance (* p < 0.1, ** p < 0.05, *** p < 0.01). Observations from periods 1-25.

### Appendix Table B-3. Treatment effects, mean prices, periods 1-25

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No Tax</th>
<th>Automatic</th>
<th>Seller only</th>
<th>Seller + Buyer</th>
<th>Seller + BuyerC</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Tax</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td>Automatic</td>
<td>p &lt; 0.01</td>
<td>p &gt; 0.2</td>
<td>p &lt; 0.05</td>
<td>p &gt; 0.3</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>Seller only</td>
<td>p &lt; 0.01</td>
<td>p &gt; 0.5</td>
<td>p &lt; 0.01</td>
<td>p &gt; 0.1</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>Seller + Buyer</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
<td></td>
</tr>
<tr>
<td>Seller + BuyerC</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
<td></td>
</tr>
</tbody>
</table>

The table shows approximate p-values from one-sided Wilcoxon rank-sum tests. The unit of observation is the mean transaction price across periods 1-25 in a session.

### Appendix Table B-4. Treatment effects, mean quantities, periods 1-25

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No Tax</th>
<th>Automatic</th>
<th>Seller only</th>
<th>Seller + Buyer</th>
<th>Seller + BuyerC</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Tax</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td>Automatic</td>
<td>p &lt; 0.01</td>
<td>p &gt; 0.5</td>
<td>p &lt; 0.01</td>
<td>p &gt; 0.1</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>Seller only</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.05</td>
<td>p &gt; 0.1</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>Seller + Buyer</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
<td></td>
</tr>
<tr>
<td>Seller + BuyerC</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
<td></td>
</tr>
</tbody>
</table>

The table shows approximate p-values from one-sided Wilcoxon rank-sum tests. The unit of observation is the mean quantity traded per period across periods 1–25 in a session.
Appendix Table B-5. Treatment effects, mean incidence of expected effective tax, periods 1-25

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No Tax</th>
<th>Automatic</th>
<th>Seller only</th>
<th>Seller + Buyer</th>
<th>Seller + BuyerC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic</td>
<td>p = 0.055</td>
<td>p = 0.34</td>
<td>p = 0.25</td>
<td>p = 0.025</td>
<td></td>
</tr>
<tr>
<td>Seller only</td>
<td>p = 0.025</td>
<td>p = 0.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seller + Buyer</td>
<td>p = 0.26</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seller + BuyerC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: The table shows approximate p-values from two-sided Wilcoxon rank-sum tests. The unit of observation is the mean expected effective incidence across periods 1–25 in a session.

B.2 Median prices

Appendix Table B-6. Treatment effects, median prices, periods 11-25

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No Tax</th>
<th>Automatic</th>
<th>Seller only</th>
<th>Seller + Buyer</th>
<th>Seller + BuyerC</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Tax</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.01</td>
<td></td>
</tr>
<tr>
<td>Automatic</td>
<td>p &lt; 0.01</td>
<td>p &gt; 0.3</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
<td></td>
</tr>
<tr>
<td>Seller only</td>
<td>p &lt; 0.01</td>
<td>p &gt; 0.1</td>
<td>p &lt; 0.05</td>
<td>p &lt; 0.05</td>
<td></td>
</tr>
<tr>
<td>Seller + Buyer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seller + BuyerC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table shows approximate p-values from one-sided Wilcoxon rank-sum tests. The unit of observation is the median transaction price across periods 11–25 in a session.

Appendix Table B-7. Treatment effects, median prices, periods 1-25

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No Tax</th>
<th>Automatic</th>
<th>Seller only</th>
<th>Seller + Buyer</th>
<th>Seller + BuyerC</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Tax</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.01</td>
<td>p &lt; 0.01</td>
<td></td>
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<td>Seller + BuyerC</td>
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The table shows approximate p-values from one-sided Wilcoxon rank-sum tests. The unit of observation is the median transaction price from periods 1–25 in a session.
C Additional figures

Appendix Figure C-1. Evolution of mean price by session

Appendix Figure C-2. Evolution of mean quantity by session
Appendix Figure C-3. Evolution of median price by session
Appendix Figure C-4. Evolution of profits, efficiency and incidence of nominal tax

Notes: This figure plots the evolution of mean profits of sellers and buyers, relative efficiency and incidence of nominal tax by treatment in periods 1-25.
Appendix Figure C-5. Trading prices by sold units and seller’s reporting decision

**Sellar + Buyer**

Notes: Frequencies of average trading prices by number of units sold and seller’s reporting decision using seller-period level data from periods 11–25 in Sellar + Buyer treatment. Vertical lines indicate the predicted market clearing prices without taxes (160 ECU) and with taxes (180 ECU).
Appendix Figure C-6. Trading prices by sold units and seller’s reporting decision

**SELLER + BUYER C**

Notes: Frequencies of average trading prices by number of units sold and seller’s reporting decision using seller-period level data from periods 11–25 in **SELLER + BUYER C** treatment. Vertical lines indicate the predicted market clearing prices without taxes (160 ECU) and with taxes (180 ECU).
Appendix Figure C-7. Trading prices by sold units and seller’s reporting decision

SELLER ONLY, Session 13

Notes: Frequencies of average trading prices by number of units sold and seller’s reporting decision using seller-period level data from periods 11–25 in SELLER ONLY session 13. Vertical lines indicate the predicted market clearing prices without taxes (160 ECU) and with taxes (180 ECU).
Appendix Figure C-8. Trading prices by sold units and seller’s reporting decision

**SELLER ONLY, Session 14**

Notes: Frequencies of average trading prices by number of units sold and seller’s reporting decision using seller-period level data from periods 11–25 in SELLER ONLY session 14. Vertical lines indicate the predicted market clearing prices without taxes (160 ECU) and with taxes (180 ECU).
Appendix Figure C-9. Trading prices by sold units and seller’s reporting decision

**Sellar only, Session 15**

Notes: Frequencies of average trading prices by number of units sold and seller’s reporting decision using seller-period level data from periods 11–25 in Seller only session 15. Vertical lines indicate the predicted market clearing prices without taxes (160 ECU) and with taxes (180 ECU).
Appendix Figure C-10. Trading prices by sold units and seller’s reporting decision

SSELLER ONLY, Session 16

Notes: Frequencies of average trading prices by number of units sold and seller’s reporting decision using seller-period level data from periods 11–25 in SELLER ONLY session 16. Vertical lines indicate the predicted market clearing prices without taxes (160 ECU) and with taxes (180 ECU).
Notes: Frequencies of average trading prices by number of units sold and seller’s reporting decision using seller-period level data from periods 11–25 in Seller only session 17. Vertical lines indicate the predicted market clearing prices without taxes (160 ECU) and with taxes (180 ECU).
Appendix Figure C-12. Trading prices by sold units and seller’s reporting decision

**Seller only, Session 18**

Notes: Frequencies of average trading prices by number of units sold and seller’s reporting decision using seller-period level data from periods 11–25 in Seller only session 18. Vertical lines indicate the predicted market clearing prices without taxes (160 ECU) and with taxes (180 ECU).
D Experimental instructions

Translated instructions for the Seller + BuyerC treatment

General instructions

This session is part of an experiment on decision making. If you follow the instructions and make good decisions, you can earn money. Your earnings will be paid to you privately in cash. How much you earn depends on your own decisions and the decisions of other participants.

There are 10 persons in this room taking part in this experimental session. You are not allowed to communicate with others during the experiment. We kindly ask that you read these instructions very carefully. If you have questions, please raise your hand and the experimenter will come to you and answer your questions. Your decisions throughout the experiment, and your earnings will be treated confidentially.

You can earn money in this experiment. Your earnings depend on your and other participants’ decisions and possibly chance. During the experiment, your earnings are calculated in an experimental currency called ECU (“Experimental Currency Unit”). At the end of the experiment your earnings will be converted to EURO so that 500 ECU = 1 EUR, and paid to you in private along with a 5 EUR participation fee.

The experiment

Roles

At the beginning of the experiment, the computer will randomly assign 5 participants to the role of “seller” and 5 participants to the role of “buyer”. Therefore, you will either be a buyer or a seller. Your role as buyer or seller will remain the same throughout the experiment. You will only know your own role, and not the roles of others.

Overview

The experiment consists of 3 practice periods and 25 actual periods. Only the 25 actual periods affect your earnings. At the beginning of a decision period there is a market phase, during which sellers and buyers 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 by trading in the market place, and your earnings depend on
your, and other participants’ decisions. Sellers are liable to pay a 40 ECU unit tax on each unit they sell. The tax is the same for all sellers and is due after each market phase. All ”tax revenue” collected in the experiment is donated to the Finnish State.

The market

Basics
The market place opens for trading for 100 seconds at the beginning of each period. In the market traders trade a fictitious good. Each seller can sell up to 4 units, and each buyer can buy up to 4 units of the fictitious good. Trade is conducted through a trading screen.

Goods, costs and values
If you are a seller, at the beginning of the experiment, you will be randomly assigned the production costs ("costs" from now on) for 4 units of the fictitious good. These units are denoted ”Good 1”, ”Good 2”, ”Good 3” and ”Good 4”. The cost of Good 1 is lower than the cost of Good 2, the cost of Good 2 is lower than the cost of Good 3 and the cost of Good 3 is lower than the cost of Good 4. These costs will remain the same to you throughout the experiment. The costs of each seller differ from the costs of other sellers’ goods. Each seller only knows her own costs.

If you are a buyer, at the beginning of the experiment, you will be randomly assigned the values for 4 units of a fictitious good. These goods are denoted ”Good 1”, ”Good 2”, ”Good 3” and ”Good 4”. The value of Good 1 is higher than the value of Good 2, the value of Good 2 is higher than the value of Good 3 and the value of Good 3 is higher than the value of Good 4. These values will remain the same to you throughout the experiment. The values of each buyer differ from the values of other buyers’ goods. Each buyer only knows her own values.

Asks, bids, and trading
Sellers can make offers to sell and buyers can make offers to buy during the market phase. The lowest standing offer to sell and the highest standing offer to buy are visible to everyone on their trading screen. The screen also states whether you are a seller or a buyer, how much time is left in the market phase and the costs or values that you were assigned for each of your 4 goods.

Each seller first has to sell Good 1 (the good with the lowest cost), then Good 2,
then Good 3 and finally Good 4. Accordingly, each buyer first has to buy Good 1 (the good with the highest value), then Good 2, then Good 3 and finally Good 4.

Sellers cannot sell goods at a price that is lower than the cost for the respective good. Buyers cannot buy units at a price that exceeds the value for the respective good.

Sellers can post offers to sell any time during the market phase but each offer to sell has to be lower than the current lowest offer to sell on the market. Accordingly, buyers can post offers to buy any time during the market phase but each offer to buy has to be lower than the current highest bid on the market.

A transaction takes place when either a seller accepts an offer to buy or a buyer accepts an offer to sell. The transaction price for the good then equals the accepted offer to sell or buy.

See Image 1: Example of a seller’s trading screen, and Image 2: Example of a buyer’s trading screen.

Image 1: Market Trading Screen

The upper bar of the trading screen displays the current period and how much time is left for trading. Seller’s costs, gross profits, number of goods sold in the current period and a reminder of the per-unit tax are displayed on the left in the middle section. Note that the costs and tax in this example are not the same as those in this experiment. The trading prices are displayed on the right in the order in which the goods have been traded. The lower part of the screen shows the current
standing offer to sell and current standing offer to buy. The seller can accept an offer to buy by pressing the "Sell at this price" button. To post a lower offer to sell, the seller has to write the offer in the empty field next to the "Make a lower offer" button and press the button.
The upper bar of the trading screen displays the current period and how much time is left for trading. Buyer’s value, gross profits and the number of goods bought in the current period are displayed on the left in the middle section. Note that the values in this example are not the same as those in this experiment. The trading prices are displayed on the right in the order in which the goods have been traded. The lower part of the screen shows the current standing offer to sell and current standing offer to buy. The buyer can accept an offer to sell by pressing the ”Buy at this price” button. To post a higher offer to buy, the buyer has to write the offer in the empty field next to the ”Make a higher offer” button and press the button.

**Gross earnings from trading**
Goods that are not bought or sold do not yield profits or losses. Gross profit from each traded good is the following:

**Sellers**
- Gross profit from selling Good = Trading price of Good 1 - Cost of Good 1
- Gross profit from selling Good 2 = Trading price of Good 2 - Cost of Good 2
- Gross profit from selling Good 3 = Trading price of Good 3 - Cost of Good 3
- Gross profit from selling Good 4 = Trading price of Good 4 - Cost of Good 4

**Buyers**
- Gross profit from buying Good 1 = Value of Good 1 - Trading price of Good 1
- Gross profit from buying Good 2 = Value of Good 2 - Trading price of Good 2
- Gross profit from buying Good 3 = Value of Good 3 - Trading price of Good 3
- Gross profit from buying Good 4 = Value of Good 4 - Trading price of Good 4

Gross earnings from trading equal the sum of gross profits.

**Reporting of trades**
After the trading phase each seller and buyer makes a decision concerning the reporting of the goods he traded in the current period.

**Seller’s reporting decision**
Sellers are liable to pay a per-unit tax (40 ECU) for each good they trade, and the sum of taxes payable is determined by the number of trades a seller reports unless the report is checked for accuracy (see ”The effect of reports” below). A seller can report any number between zero and the number of goods he traded in the current period. The reporting decision is sent by pressing the ”OK” button.

**Buyer’s reporting decision**
A buyer makes a reporting decision concerning the goods he bought in the current period. A buyer pays a 10 ECU reporting cost if he reports one or more goods he bought in the current period. A buyer reports by ticking a box next to every good he bought. The reporting decision is sent by pressing the ”OK” button.

**The effect of reports**
Whether a seller’s reported number of trades equals the number of goods she actually sold in the current period can be checked. The probability of a seller’s report being checked is determined as follows:

- In the basic case the seller’s report is checked for accuracy with a probability of 10%.
- In addition, the seller’s and her trading partners’ (buyers who bought from her) reports are cross-checked. If there is a mismatch between the reports so that the number of goods the seller reported as sold is lower than the number of goods bought from the seller reported by her trading partners, the probability that the seller’s report is checked for accuracy is 80%. If, instead, the number of goods reported by the seller is larger than the number reported by her trading partners, the probability of the check for accuracy is not affected.

The probability of a seller’s report being checked is not affected by the seller’s possible previous checks nor whether other sellers’ reports are checked in the current period.

Example: Seller A sold all her 4 goods, but reports selling 1 good.

a If at most one of Seller A’s trading partners reports having bought a good sold by her, the probability that Seller A’s report is checked for accuracy is 10% (one in ten).

b If two or more of Seller A’s trading partners report having bought goods sold by her, the probability that Seller A’s report is checked for accuracy is 80% (eight in ten).

**Calculation of net earnings**

*Sellers’ net earnings*

After the reporting phase the screen displays how many goods you sold and your gross profits. Your net earnings depend on the taxes you pay and possible fines. After the reporting phase, one of the following takes place:

1 **The seller’s report is not checked for accuracy:** In this case the seller’s profit after taxes, i.e. net earnings, equals the sum of gross profits earned in the current period minus taxes. Taxes payable equal the number of goods reported by the seller times the 40 ECU tax:
   \[
   Net\ earnings = \text{sum of gross profits} - (\text{reported number of goods sold} \times 40\ ECU\ tax)
   \]

2 **The seller’s report is checked for accuracy:** In this case the seller’s profit after taxes, i.e. net earnings, equals the sum of gross profits earned in the current period minus taxes and possible fines. Taxes payable equal the number of goods actually sold by the seller times the 40 ECU tax. If the number of goods reported by the seller is smaller than the number of goods he actually sold, the seller has to pay a fine that equals the per unit tax (40 ECU) for each good he did not report in addition to the missing taxes:
   \[
   Net\ earnings = \text{sum of gross profits} - (\text{actual number of goods sold} \times 40\ ECU\ tax) - (\text{number of goods not reported} \times 40\ ECU\ tax)
   \]
Buyers’ net earnings

After the reporting phase the screen displays how many goods you bought and your earnings is one of the following. Buyer’s net earnings depend on the reporting cost. Buyer’s net earnings is either of the following:

1 Buyer’s net earnings in case she does not report any trades:
   \[ \text{Net earnings} = \text{sum of gross profits} \]

2 Buyer’s net earnings in case she reports atleast one of his trades:
   \[ \text{Net earnings} = \text{sum of gross profits} - 10 \text{ ECU reporting cost} \]

Example 1: Seller’s earnings
Seller A sold 2 goods. The cost of Good 1 is 112 ECU and the trading price 200 ECU, and the cost of Good 2 is 140 ECU and the trading price 171 ECU. The net earnings of Seller A:
   i If Seller A reports both trades: 200 - 112 + 171 - 140 - 2*40 = \textbf{39 ECU}
   ii If Seller A reports 0 trades and the report is not checked for accuracy: 200 - 112 + 171 - 140 = \textbf{119 ECU}
   iii If Seller A reports 0 trades and the report is checked for accuracy: 200 - 112 + 171 - 140 - 2*40 - 2*40 = \textbf{-41 ECU}

Example 2: Buyer’s earnings
Buyer B buys 3 goods. The value of Good 1 is 213 ECU and trading price 180 ECU, the value of Good 2 is 118 and trading price 100, and the value of Good 3 is 110 and trading price 105 ECU. Buyer B’s net earnings:
   i If Buyer B reports 0 trades: 213 - 180 + 118 - 100 + 110 - 105 = \textbf{56 ECU}
   ii If Buyer B reports one or more trades: 213 - 180 + 118 - 100 + 110 - 105 - 10 = \textbf{46 ECU}

Payoffs
The first 3 periods are practice periods during which you cannot earn money. The 25 periods after the practice periods are payoff relevant, and your total earnings from the experiment consist of your net earnings from these periods and a 5 EUR participation fee.

If the sum of your net earnings is negative, you will be paid the participation fee, so you cannot make losses in this experiment and you will earn at least 5 EUR. Your total earnings will be paid to you in cash after the experiment.

Final note
The experiment ends after 28 periods. After this, we kindly ask you to fill out a short questionnaire while we prepare the payments. All information gathered in the questionnaire, as well as other data gathered in the experiment, will be handled confidentially and used solely for scientific research. After you have completed the questionnaire we ask that you stay seated until we invite you to collect your payment.
E Behavioral model

Despite the remarkable success of the double auction mechanism in allocating goods efficiently in experimental settings (Friedman, 1993), there is no consensus on a formal canonical model of multiparty multi-unit dynamic double auctions (see also Easley and Ledyard (1993) and Gjerstad and Dickhaut (1998)).

Gjerstad and Dickhaut (1998) present a model which is consistent with observed patterns in double auction experiments where price converges to the Walrasian equilibrium over time and where allocational efficiency is thus reached. In that model sellers have unit-specific reserve prices which adjust during a market interaction so that in the end the reserve price of the unit which the seller holds coincides with the marginal cost of the seller. The within-trading period dynamics of the reserve price has the characteristics of a finite horizon search model (Cox and Oxaca, 1989), where bids follow a stochastic process reflecting the highest standing bid on the market. As double auction market sellers gain experience over rounds, they learn to anticipate the Walrasian equilibrium prices which flattens the within-period reserve prices dynamics keeping it close to the Walrasian equilibrium price for all units.

Seller + Buyer

Given the high reporting probability of the buyers, even sellers with no intrinsic motivation are predicted to find it suboptimal to under-report. To see this, notice that given supplied quantity $s_i$ and reported quantity $r_i \leq s_i$, reporting one unit less than $r_i$ is optimal on the margin if and only if

$$\tau > \gamma(s_i, r_i - 1, 0.8)(s_i - r_i + 1)(f + \tau) - \gamma(s_i, r_i, 0.8)(d_i - r_i)(f + \tau) + \prod_{s_i = r_i}[\theta_i]$$

The benefit of under-reporting is the unpaid tax on the marginal unit, $\tau$, on the left-hand side. The cost on the margin is driven by the induced marginal effect on expected audit payments. The term with the indicator captures the idea that the marginal cost is higher for the first underreported unit because of the fixed cost of lying. This inequality can be equivalently written as

$$\tau > \gamma(s_i, r_i - 1, 0.8)(f + \tau) + [\gamma(s_i, r_i - 1, 0.8) - \gamma(s_i, r_i, 0.8)](s_i - r_i)(f + \tau) + \prod_{s_i = r_i}[\theta_i]$$

where $\gamma(s_i, r_i - 1, 0.8)(f + \tau)$ is the expected audit payment on the additional underreported unit and $[\gamma(s_i, r_i - 1, 0.8) - \gamma(s_i, r_i, 0.8)](s_i - r_i)(f + \tau)$ is the effect via increased probability of getting audited on the inframarginal underreported units. Notice that $\gamma(s_i, r_i - 1, 0.8)$ and $\gamma(s_i, r_i, 0.8)$ are any two consecutive numbers on the same row in the lower diagonal matrix above. It is easy to see that the only cases where underreporting is optimal is when $s_i = 3$ and $r_i = 2$ or when $s_i = 4$ and $r_i = 3$ and the seller is of standard type with $\theta_i = 0$. Underreporting by one unit is optimal if and only if three or four units have been sold. There are no further cases where any underreporting is optimal even for the standard type with $\theta = 0$. When one or two units are supplied truthful reporting is optimal.

47 The model of Gjerstad and Dickhaut (1998) has similar structure and succeeds in capturing even more of the patterns observed in experimental markets.
Optimal reserve price of the standard type satisfies

\[ k(s_i) + \tau + \prod_{s_i = 3}[[\gamma(s_i, s_i - 1, 0.8))((f + \tau) - \tau]]
\]

\[ + \prod_{s_i = 4}[[\gamma(s_i, s_i - 1, 0.8)) - \gamma(s_i - 1, s_i - 2 - 1, 0.8))((f + \tau)]
\]

\[ \leq a^*_i,SB \leq pW,SB \leq
\]

\[ k(s_i + 1) + \tau + \prod_{s_i = 2}[[\gamma(s_i + 1, s_i, 0.8))((f + \tau) - \tau)]
\]

\[ + \prod_{s_i = 3}[[\gamma(s_i + 1, s_i, 0.8)) - \gamma(s_i, s_i - 1 - 1, 0.8))((f + \tau)],
\]

where the terms with indicator terms are all negative but smaller than \( \tau \) in absolute value.\(^{48}\) Therefore the standard type’s reserve price is either equal to the reserve price in the automatic tax treatment or between the reserve price in the no tax and automatic tax treatments, depending on how many units the seller with a given cost profile produces.

Intrinsic motivation increases reporting and reserve prices in the few cases of underreporting. Thus for any price, every seller is expected to be truthful and there are no marginal image effects on pricing. The only case where intrinsic motivation changes reporting behavior is when \( s = 3 \) or \( s = 4 \) is the optimal supply for a standard type. In this case \( \theta \) sufficiently high, however, the intrinsic motivation successfully deters the unit underreporting. For such high \( \theta \), the reserve price coincides with that in the automatic tax treatment.

As no major underreporting is optimal and supply curves approximate those in the automated treatment (equally elastic supply and demand), the tax burden is expected to be shared in equal proportions, just as predicted by the standard model.

**Seller + BuyerC**

Given the empirical frequencies of buyer reporting in our data, we can estimate the following audit probability schedule for the SELLER+BUYER-C treatment.

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<tr>
<td>4</td>
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<td>58%</td>
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<td>14%</td>
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</table>

\(^{48}\)The indicators are needed to capture the effects of unit underreporting when 3 or 4 are supplied.
This implies the following expected tax-and-fine schedule as a function of the supplied quantity and number of units reported.

\[
s_i/r_i \begin{array}{cccc}
0 & 1 & 2 & 3 & 4 \\
0 & 0 & \text{0} & \text{0} & \text{0} \\
1 & 36 & 0 & \text{0} & \text{0} \\
2 & 101 & 22 & 0 & \text{0} \\
3 & 170 & 72 & 15 & 0 \\
4 & 243 & 125 & 51 & 11 & 0
\end{array}
\]

The reporting rate of buyers, 50\%, is slightly lower than in the SELLER+BUYER treatment. For the standard type with \(\theta_i = 0\), it is optimal to underreport by one unit whichever amount has been produced. Further underreporting is deterred by the high implied marginal effect of expected taxes and fines which is driven mainly by the negative effects on inframarginal units. A standard supplier’s cost on the margin thus consists of the marginal cost of production, \(k(s_i)\), the unit tax paid for the additional unit, \(\tau\), net of the change in the probability of detection times the audit payment for the underreported unit, \(f + \tau\), i.e.

\[
k(s_i) + \tau + \left[\gamma(s_i, s_i - 1, 0.5) - \gamma(s_i - 1, s_i - 2, 0.5)\right](f + \tau)
\]

\[
\leq a_i^{*,\text{SBC}} \leq p_{i,W,\text{SBC}} \leq k(s_i + 1) + \tau + \left[\gamma(s_i + 1, s_i, 0.5) - \gamma(s_i, s_i - 1, 0.5)\right](f + \tau).
\]

The probability differences are all negative: supplying and reporting one unit more while keeping on underreporting one unit, reduces the probability of audit. Depending on the number of units supplied this effect is at most 17 percentage points and decreasing in absolute value with the number of sold units. Therefore the reserve price of the standard type is slightly below but close to the reserve price in the automatic tax treatment.

Intrinsic motivation increases reporting and reserve prices of the intrinsically motivated types. There is some tendency for lower prices to signal underreporting but this effect is not at all as strong as in the SELLER ONLY treatment, firstly, because the standard types have less incentive for underreporting and, secondly, when doing so the reserve price effect is small. The unit underreporting is more easily deterred by intrinsic motivation and in that case, the reserve price of such intrinsically motivated sellers coincides with that in the automatic tax case. Therefore the reserve prices of the intrinsically motivated sellers are close or equal to those in the automatic tax case.

As no major underreporting is optimal and supply curves approximate those in the automated treatment (equally elastic supply and demand), the tax burden is expected to be shared in equal proportions, just as predicted by the standard tax incidence model.
Summary predictions

Standard type, predicted sales quantities by treatment and cost-profile

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Full compliance, predicted sales quantities by treatment and cost-profile

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