The double dividend of relative auditing -
Theory and experiments on corporate tax enforcement

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Abstract

We show that, in theory, tax authorities can at the same time reduce tax evasion and boost output by conditioning audit efforts for individual firms on all tax returns in an industry. Next, we investigate if this double dividend is likely to arise in reality. We argue that RCTs or field experiments are impractical. Instead, we turn to laboratory experiments and test if the theoretical mechanism underlying the dividends is followed by humans. We find that both dividends, less evasion and higher output, materialize in the laboratory. However, the behavioural mechanism generating the higher output differs from the theoretical mechanism.

JEL Codes: H26; D43; K42
Keywords: corporate-tax evasion, relative audit rules, experimental tests

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1 Introduction

In the last decade, around the world, concerns about large firms avoiding or evading their taxes have gained in prominence. In response, governments have tightened the rules and have bolstered enforcement. The European Union, e.g., adopted ‘The Anti Tax Avoidance Directive’ in 2016. The UK parliament passed the ‘Criminal Finances Act,’ which increases the liability of firms for criminal activities (such as evasion) of their employees. The Australian Government recently gave their tax authority (ATO) new powers and introduced a 40 percent tax penalty on firms found breaking the rules. Beside these institutional changes, governments and tax authorities around the world have also been working on improving the information gathering process that leads to audits with the aim of better targeting the use of their resources. In 2014 more than 60 countries have agreed to automatically exchange bank account information of individuals and firms. Moreover, tax authorities around the world use analytical tools that calculate risk scores for individuals and firms (e.g. the Discriminant Inventory Function in the US).

The main discussion on the push against corporate-tax avoidance has focused on how enforcement techniques help to catch more evaders and avoiders. Much less, but at least some, attention has been paid to firms’ likely tax planning reactions to these new measures. The main focus of the discussion has been on the potential deterrence effect of the new measures. In contrast, the question if and how these new ways of enforcing corporate taxes might impact market outcomes have been widely neglected.

The idea that corporate tax enforcement can have an impact on market outcomes has only recently been introduced to the literature. Some theory papers have shown that the way how tax authorities go about enforcing corporate tax compliance can cause distortions in goods markets. Bayer and Cowell (2009, 2016) investigate audit rules that allocate a higher auditing effort to a firm that declares a low profit relative to its competitors in the same industry. They find that these rules create an externality in the goods market that increases output and therefore social welfare. A similar effect
can be theoretically achieved with relative enforcement rules of environmental regulation (Oestreich, 2014). Many tax authorities implicitly – or even explicitly – use audit rules that have a relative component. Examples are the use of the Discriminatory Inventory Function by the IRS in the US or the Risk Differentiation Framework by the Australian Taxation Office. Whenever the likelihood or the thoroughness of an audit or an investigation depends on the degree of suspicion, then this necessarily results in a relative rule in the sense of the theory, if a company that reports a low profit compared to their competitors looks suspicious to the authorities.

This paper empirically tests if the incentives created by relative rules actually work as predicted by theory. For this purpose we build the simplest theoretical environment where it is possible to show the benefits relative audit rules can theoretically provide. We look at relative rules where the detection probability for a company smoothly increases with the difference between its own and the competitor’s declaration but also consider the more extreme jump rule, where the detection probability only depends on whether a firm declares more, less or the same profit as it’s competitor. For our empirical tests we take the environment and the different rules to the laboratory.

Ideally, for an empirical test we would like to randomly assign different audit rules to otherwise identical industries in the field and then compare taxes evaded and output decisions. This is highly impractical for a variety of reasons. No two identical industries exist. Randomizing audit rules across industries in a country is difficult to achieve. Moreover, the multinational nature of firms in many oligopolies adds a dimension that is likely to confound the audit-rule effect. Finally, tax evasion is not directly observable and using audit results as measure provides a selected sample. For these reasons, we conclude that using laboratory experiments is the preferred second-best methodology for an empirical test. Note that our laboratory experiments are not designed with the aim of exactly replicating the situation a company finds itself in. Instead of building an environment that looks as similar to the real world as possible, we use an extremely stylized game, which provides a minimum working example for the mechanism underlying the theoretical double dividend. This allows us to cleanly test if the incentive mechanism
generated by relative audit rules works as predicted by theory if an intelligent, pecuniarily motivated person is confronted with them. We give the mechanism its best shot to succeed.

We find strong support for the first dividend of relative rules. All relative rules tested reduced the fraction of profits shaded significantly compared to a fixed rule. While this reduction in evasion was not delivered by crisp equilibrium play, regression analysis recovers an average strategy that qualitatively conforms with the theoretical mechanism. The exception is a smooth relative rule with a moderate reactivity, where the reduction in evasion is much larger than predicted by theory, and where individual play is not compatible with equilibrium logic. The relative rules also on average yield the theoretically predicted quantity increases and consumer surplus increases. While the size of this second dividend on average nicely corresponds to the theory prediction, closer inspection shows that the underlying mechanism is different. Instead of intricate equilibrium logic, subjects’ insight that having a higher gross profit than the competitor is helpful in the tax-declaration stage, drives the quantity increase. This incentive considerably reduces the occurrences of symmetric collusion compared to the case under a fixed rule, where there is no benefit from having a higher gross profit for tax-declaration purposes. Together with the typical noise in experimental data this mechanism leads to the same average outcomes that crisp equilibrium play would yield. Despite the difference in the underlying mechanism this is still good news: the additional competitive incentive created by a relative audit rule spills over into the goods market. This does not happen exactly as theory predicts, since humans have cognitive limitations that make it hard for them to perform backward induction in complex environments but, all the same, leads to improved welfare in goods markets.

2 Related Literature

The economics literature on corporate tax enforcement is surprisingly thin. Early theoretical papers (like e.g. Marrelli and Martina, 1988; Lee, 1998) just adapted the standard model for income-tax evasion (Allingham and Sandmo,
Next followed the insight that firm-internal agency problems and incentive structures might have an important influence on firms’ tax reporting behavior. This was demonstrated by theoretical contributions (Crocker and Slemrod, 2005, 2007; Chen and Chu, 2005) and shown in empirical studies (see e.g. Desai and Dharmapala, 2006, 2009). The link between market structure and corporate tax avoidance has also received some attention. Cai and Liu (2009) show that in China there is more tax avoidance in industries that are more competitive. Desai et al. (2006) find that of the firms operating in the US the larger, more international, and the firms with extensive intra-firm trade and high R&D intensities, are the most likely to use tax havens. The negative impact of the audit probability on evasion and avoidance has been documented in the accounting literature (Hoopes et al., 2012). The additional deterrence effect of an endogenous audit rule, where the likelihood of detection increases with evasion, has been theoretically documented for income-tax evasion by Yitzhaki (1987). The idea that endogenous audit rules that condition on the declarations of all firms in a market not only reduce evasion but can also create a welfare enhancing competition externality in the goods market has recently been shown by Bayer and Cowell (2009, 2016).

While income-tax evasion has been extensively studied in the laboratory, there is little experimental work on corporate tax enforcement. There are some experimental studies that look at enforcement of taxes or regulation through relative rules. Tan and Yim (2014) investigate how strategic uncertainty introduced by an audit rule that audits a fixed number of tax payers that report a low income and find that the introduced strategic uncertainty influences behavior in the predicted direction. Gilpatric et al. (2015) use a similar approach with similar findings in the context of regulatory compliance. The rank-order tournament auditing used by Cason et al. (2016) in the context of enforcing the declaration of previously chosen output comes closest to our setting. This paper is to our knowledge the only paper besides ours, where both output is not exogenous and a relative rule is employed. Consistent with theory and the other studies mentioned above, the experiments confirm that the relative rule reduces misreporting compared to a fixed
rule. The main difference to our setup is that firms (due to the environmental framing of the paper) report output instead of profit. This implies, that the audit rule in equilibrium does not affect optimal output choices, since one firm’s output choice does not directly impact on the other firm’s reporting quantity. Despite this theoretical neutrality prediction, lower output is observed under a relative rule.

This paper contributes in a variety of ways to the literature. Firstly, we clarify the mechanisms by which relative audit rules, which result in detection probabilities that monotonously decrease in a firm’s own and increase in the competitors’, affect profit-declaration behavior and production decisions. This extends some of our own theoretical work, which only considered smooth relative rules that generate interior equilibria. Secondly, we are the first to test the mechanism behind the two dividends of relative auditing empirically. Finally, we identify an alternative behavioral mechanism that yields similar results as the theoretically predicted.

3 Theoretical Background

In what follows, we explain the underlying theoretical setting. Note that the setting is highly stylized. We made the many simplifying assumptions with the experimental subjects in mind. Providing them with the simplest environment, in which the more general logic of the double dividend of relative auditing holds, reduces confounding confusion and allows for a clean test if the theoretical mechanism actually works with human agents.

Two firms compete in a market with an underlying standard Cournot game with a unique, stable Nash equilibrium. More precisely, we assume that the Cournot best-response functions are non-increasing and have an absolute slope smaller than unity everywhere. This is sufficient for the existence of a stable equilibrium (Vives, 1999; Novshek, 1985) and is satisfied by the models typically used in applied research. Denote firm $i$’s gross profit as $\Pi_i(q_i, q_{-i})$ and the equilibrium quantities that would arise from Cournot competition as $q^C$. Once firms have chosen their production quantities and have learned their and the competitor’s gross profit, they declare their profit for tax purposes.
Firm $i$’s declaration is denoted by $d_i$. Firms don’t have to declare truthfully but are punished if caught under-reporting. In what follows we will outline the resulting equilibrium behavior under three different audit regimes that all result in the same total probability of the detection of tax evasion.

### 3.1 Fixed audit rule

We start with an audit rule, where the effort exerted by the auditors when checking the firms’ books is the same across companies and independent of the declarations. So all firms face the same probability of potential evasion being detected. Further suppose that detected tax evasion is punished by the confiscation of the gross profit\(^1\). Then, denoting the fixed detection probability as $\alpha$, the proportionate tax rate as $t$, and firm $i$’s declaration as $d_i$ we can write the expected net profit of firm $i$ as:

$$EU_i := \begin{cases} (1 - \alpha) (\Pi_i - t d_i) & \text{if } d_i < \Pi_i \\ \Pi_i (1 - t) & \text{if } d_i = \Pi_i \end{cases}.$$ 

Due to the linearity of the expected after-tax profit, a risk-neutral, profit-maximizing firm either reports truthfully or shades all its profits. The crucial condition for full evasion to be optimal is

$$(1 - \alpha) \Pi_i \geq \Pi_i (1 - t)$$ 

$$\Rightarrow \alpha \leq t.$$ 

In order to make things interesting we assume for the remainder of the paper that $\alpha < t^2$, which implies full evasion under this regime. We have

$$d_i^* = 0 \forall i \in \{1, 2\}.$$ 

Moving to the production decision, we realize that the best a firm can do is

\(^1\)This admittedly strong assumption, is not crucial for the theoretical results but makes the situation much easier to understand for experimental subjects.

\(^2\)Our analysis does not apply to countries where the politically determined resource use for auditing large firms implies $\alpha > t$. 

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to maximize it’s gross profit, as the expected after-tax profit is a fraction of it. As both firms face the same problem this results in firms choosing the Cournot quantities in equilibrium

\[ q^f_i = q^C. \]

The well-known result of the neutrality of a profit tax arises.

### 3.2 Relative audit rule

Now introduce a relative audit rule that is defined as

\[ \alpha_i(d_i, d_{-i}) := \alpha - \beta (d_i - d_{-i}). \]

This audit rule leaves the average audit rate constant at \( \alpha \). However, the auditing effort is redistributed such that the firm that declares less receives more attention. Every Dollar a firm declares less (more) than the competitor increases (decreases) the detection probability by \( \beta \). The parameter \( \beta \) captures the reactivity of the rule.\(^3\)

Under this rule, once gross profits are revealed, the expected net profit of firm \( i \) is given by:

\[
EU_i := \begin{cases} 
(1 - \alpha + \beta (d_i - d_{-i})) (\Pi_i - td_i) & \text{if } d_i < \Pi_i \\
\Pi_i(q_i, q_{-i})(1 - t) & \text{if } d_i = \Pi_i
\end{cases}
\]

The relative audit rule introduces an additional incentive to declare income. Declaring more now has not only the negative effect of higher tax payments but also the beneficial effect of reducing the risk of detection. Declaring an additional Dollar decreases the net income by \( t \) Dollars but increases the probability that evasion is not detected by \( \beta \). A taxpayer wants to increase the declaration (if \( d_i < \Pi_i \)), whenever the marginal benefit is

\(^3\)Linearity of the rule is not crucial for the results and has been chosen to keep the environment as simple as possible for participants.
positive, i.e.
\[ \beta (\Pi_i - td_i) - t(1 - \alpha + \beta (d_i - d_{-i})) > 0. \]

Investigating this condition shows that the incentive to declare more is the stronger the lower the current declaration and the higher the competitor’s declaration is. The relative rule causes declarations to become strategic complements. A firm has an incentive to increase the declaration if the competitor does.

The first order condition gives the following best responses:

\[
d^*_i(d_{-i}) = \begin{cases} 
0 & \text{if } d_i \leq \frac{1-\alpha}{\beta} - \frac{\Pi_i}{t} \\
\frac{\beta \Pi_i - t (1-\alpha)}{2 \beta t} + \frac{d_{-i}}{2} & \text{if } \frac{1-\alpha}{\beta} - \frac{\Pi_i}{t} < d_i < \frac{1-\alpha}{\beta} + \Pi_i (2 - \frac{1}{t}) \\
\Pi_i & \text{if } \frac{1-\alpha}{\beta} + \Pi_i (2 - \frac{1}{t}) \leq d_i 
\end{cases}
\]

The equilibrium declarations become

\[
d^*_i = \frac{2 \Pi_i + \Pi_{-i}}{3t} - \frac{1-\alpha}{\beta}, \tag{1}
\]

for an interior solution with the following conditions for its existence:

\[
\frac{1-\alpha}{\beta} - \frac{\Pi_i}{t} \quad < \quad \frac{2 \Pi_{-i} + \Pi_i}{3t} - \frac{1-\alpha}{\beta} < \frac{1-\alpha}{\beta} + \Pi_i (2 - \frac{1}{t}) \quad \rightarrow \quad \frac{(1-\alpha) t}{\beta} \in \left[ \frac{\Pi_{-i} + 2 \Pi_i}{3} - 2t \Pi_i, \frac{\Pi_{-i} + 2 \Pi_i}{3} \right] \quad \forall i \neq -i.
\]

If the ratio \((1-\alpha) t / \beta\) lies above the interval for an interior solution then zero declarations are an equilibrium, while full declarations occur, if the ratio is below. Hence, we can get positive and even full declaration, even with \(\alpha < t\), when a fixed rule leads to firms not reporting any of their profits. This is the case for high gross profits (and a high reactivity \(\beta\)). In general, for given parameters and gross profits a relative rule leads to weakly less tax evasion. This is the first dividend of relative auditing.

Let us move to the quantity stage. A firm maximizes the expected net profit taking into account the optimal declarations that will follow. For
profits that lead to interior declarations the expected subgame-perfect continuation profit is given by

$$EU(d^n) := \frac{[\beta (\Pi_i - \Pi_{-i}) + 3(1 - \alpha)t]}{9t^2}.$$  

Taking the first-order condition and invoking symmetry yields the following condition:

$$\frac{\partial \Pi_i}{\partial q_i} - \frac{\partial \Pi_{-i}}{\partial q_{-i}} = 0,$$

which implies that the equilibrium quantities with a relative rule that causes interior declarations satisfy

$$\frac{\partial \Pi_i}{\partial q_i} = \frac{\partial \Pi_{-i}}{\partial q_{-i}} < 0,$$

from which the second dividend follows:

$$q_i^{rel} > q_i^{fix} = q^C.$$  

Note that the second dividend of higher equilibrium quantities (and therefore more consumer surplus) assumes an interior solution for the declaration game. In the case of corner solutions in declarations following for all quantities choices the quantity increasing effect does not occur in equilibrium.\(^*\)

Generally, a relative rule has the potential for a double dividend. Under certain conditions a relative rule reduces evasion and at the same time leads to higher output. Bayer and Cowell (2016) show in simulations of linear Cournot duopolies how the size of the second dividend depends on enforcement and industry parameters. It is instructive to consider the intuition behind the second dividend. Reducing profit of the other firm by producing a bit more pays, as it reduces the attention of the tax man via a reduced declaration of the competitor. In equilibrium firms balance the marginal benefit from this effect and the marginal loss in gross profit by producing more than in a Cournot Equilibrium.

\(^*\)See Bayer and Cowell (2009) for the general case.
4 Jump rule

In a similar setting Bayer and Cowell (2016) also show that the size of the second dividend increases with the reactivity of the relative rule, as long as the equilibria remain interior. Taking the reactivity to the limit, which results in a rank-order tournament, where the firm with a lower declaration bears the full brunt of the audits, is not necessarily maximizing the second dividend though. However, the logic for why a firm might want to produce more than the Cournot quantity is most intuitive under such a rule.

For an extreme rule, which we call the jump rule, suppose the auditor throws all resources at the firm that declares less income regardless of the magnitude of the difference. This is taking a relative rule to the extreme. The expected payoff for the declaration stage becomes

\[EU_i := \begin{cases} 
(1 - 2\alpha) (\Pi_i - td_i) & \text{if } d_i < d_{-i} \land d_i < \Pi_i \\
(1 - \alpha) (\Pi_i - td_i) & \text{if } d_i = d_{-i} \land d_i < \Pi_i \\
\Pi_i (1 - td_i) & \text{if } d_i > d_{-i} \lor d_i = \Pi_i 
\end{cases} \]

Finding the subgame perfect Nash continuation after firms having chosen the same quantities, resulting in identical profits $\Pi$ is straightforward. For any declaration $d_{-i} < \Pi$ of the competitor, declaring one Dollar (or any other smallest monetary unit) more than $d_{-i}$ is optimal, as it allows for the highest possible risk-free evasion.\(^5\) This implies that the only pure-strategy profile where no firm has an incentive to deviate is $d_i = d_{-i} = \Pi$.

A similar logic applies for different gross profits. The firm with the lower gross profit declares truthfully, while the other firm declares one Dollar more. Nobody has an incentive to deviate. The firm with the lower payoff does not want to declare more than its profit. There is also no incentive to declare less, as then the risk of losing everything dominates or at least offsets the tax saved. The firm with the higher gross profit can eliminate any risk of being caught for evasion by just declaring one Dollar more than the other firm. Denoting the smallest unit of declaration permissible as $\varepsilon$, the optimal

\(^5\)Note that this assumes that a firm is not better off by declaring nothing despite the full attention of the tax authority, which requires $\alpha \geq t/2$ under risk-neutrality.
declaration reduces to

\[ d_i^* = \min \{ \Pi_i, \Pi_{-i} + \varepsilon \}. \]

This, for small \( \varepsilon \), results in the (approximate) continuation payoff of

\[ EU_i(q_i, q_{-i}) = \Pi_i(q_i, q_{-i}) - t \min \{ \Pi_i, \Pi_{-i} \}. \]

It is helpful to keep in mind that this implies that

\[
EU_i(q_i, q_{-i}) = \begin{cases} 
(1 - t)\Pi_i(q_i, q_{-i}) & \text{if } q_i \leq q_{-i} \\
\Pi_i(q_i, q_{-i}) - t\Pi_{-i}(q_{-i}, q_i) & \text{if } q_i > q_{-i}
\end{cases}.
\]

It is easy to see that there is no symmetric pure-strategy equilibrium for the quantity choice. First observe that in situation with \( q_i = q_{-i} = q \) both firms will end up with an after-tax profit of \((1 - t)\Pi(q, q)\). This means that any unilateral change that increases the gross profit will be a profitable deviation, since then by subsequently declaring the full profit a firm can guarantee to do better after tax. This implies that any pair of \( q_i = q_{-i} = q \) were \( q \) is not the Cournot best-response to itself can be ruled out as an equilibrium. It remains to be shown, that \( q_i = q_{-i} = q^C \) is not an equilibrium. Recall that the expected net profit for \( q_i > q_{-i} = q^C \) is given by \( \Pi_i(q_i, q^C) - t\Pi_{-i}(q^C, q_i) \), differentiating and taking the right-sided limit \( q_i \to q^C \), we obtain \(-t\partial\Pi_{-i}(q^C, q_i)/\partial q > 0\), which implies a marginal increase of the quantity increases the payoff.

There are two pure-strategy equilibria that are asymmetric with one firm choosing a quantity \( q_i \) greater than \( q^C \), while the other firm chooses the Cournot best-response to this quantity. The equilibrium is implicitly defined by

\[
\frac{\partial \Pi_i(q_i^*, q_{-i}^*)}{\partial q_i^*} - t \frac{\partial \Pi_{-i}(q_{-i}^*, q_i^*)}{\partial q_i^*} = 0 \tag{2}
\]

\[
\frac{\partial \Pi_{-i}(q_{-i}^*, q_i^*)}{\partial q_{-i}^*} = 0 \tag{3}
\]
It is easy to show that in standard Cournot Duopolies, a jump rule implies a greater aggregate quantity than Cournot. The intuition is as follows. In standard Cournot Duopolies best responses are decreasing in the competitor’s quantities with slopes of less than one. The slope of less than one guarantees stability of the equilibrium. Now start from the Cournot equilibrium and marginally increase the quantity of the firm (say firm $i$) that will end up with the higher payoff and let the other firm $-i$ best-respond to it. Due to the slope of the reaction function, firm $-i$ is reducing its quantity by less than the quantity increase by firm $i$ to which it is reacting to. This implies that the aggregate quantity increases. Increasing the quantity of firm $i$ and letting $-i$ best respond until (2) holds, further increases the aggregate quantity.\footnote{For brevity we ignore the mixed-strategy equilibrium, which also results in a higher expected industry output than under Cournot.}

We have
\[ q_i^{jump} + q_{-i}^{jump} > q_i^{fix} + q_{-i}^{fix} = 2q^C. \]

5 The two dividends

From the Section above it is easy to see the double dividend relative and jump rules provide.

**Dividend 1** Under a relative and a jump rule for given gross profits firms declarations are weakly greater than under a fixed rule.

**Dividend 2** Under a relative and under a jump rule production quantities are weakly greater than under a fixed rule.

The first dividend is both more intuitive and also more important in its size than the second dividend. It is straight-forward to understand that reducing the likelihood of being caught by increasing the declaration is a good idea. The intuition for the second dividend is somewhat involved. Firms have an incentive to produce more such that an advantage in the declaration game overcompensates the reduced gross profit from over-producing. The natural question to ask is if managers actually understand and act on this logic?
One behavioral reason why the second dividend might not exist in reality is the documented difficulty of humans to obey subgame perfection. Even in simple games like an ultimatum game where social motives are controlled for, humans have problems to learn subgame-perfection (see e.g. Andreoni and Blanchard, 2006).\textsuperscript{7} Moreover, it is not clear how participants that deviate from Nash play either due to social preferences or bounded rationality, will react to the additional externality imposed by the relative rule. In Cournot oligopoly experiments we observe deviations from Cournot equilibrium. Depending on the setting and the information given to participants collusive but also more competitive play than Cournot equilibrium has been observed.\textsuperscript{8} So it is ex-ante not clear how the addition of a declaration stage will influence quantity decisions. Finally, the second dividend might not be detectable, since it is too small in size or because indivisibilities in production wipe them out.

The behavioral doubts warrant an empirical test. Ideally, we would like to use field data from randomized controlled trials for this purpose. This is not practical for many reasons. One would require a large number of identical duopolies (or oligopolies) where on a random basis different enforcement rules are implemented. Besides the legal problem of treating otherwise identical firms differently, there are the bigger problems that we cannot think of any two duopolies which are identical. Finally, by definition true gross profits are not observable, which makes it hard to evaluate if a first dividend exists.

As a second-best empirical approach we turn to laboratory experiments. We are aware that laboratory experiments might suffer from a lack of external validity. In particular, in our case one might argue that, participants who are predominantly university students and are playing for sums of twenty to thirty Dollars, are hardly representative for the behavior of CEOs and CFOs of large companies. In general, we want to test, if educated, numerate humans that are provided with the incentives described by theory behave in a way theory predicts. We believe that the answer to this question is informative

\textsuperscript{7}Similarly, Dufwenberg and Essen (2018) find that many subjects do not obey backward induction in very simple king-of-the-hill games.

\textsuperscript{8}Deviation from Cournot play in oligopolies are documented in many papers (e.g. Cox and Walker, 1998; Holt, 1985; Huck et al., 1999, 2001).
for how plausible the double dividend of relative auditing in reality is.

6 Experimental design

In what follows, we set up a standard linear Cournot duopoly experiment with tax evasion opportunity. Then we conduct an experimental horse race among different audit rules that all exhibit the same total detection probability. The two dimension of interest are the ability of the rules to raise revenue (Dividend 1) and to increase the surplus created in the market (Dividend 2). The different audit rules we test are:

1. a traditional fixed rule, which theoretically does not provide any dividend;

2. a relative rule with a high reactivity, which theoretically should erase evasion without providing a second dividend;

3. a relative rule with a low reactivity, which should provide a very small first dividend but a sizeable second dividend;

4. a jump rule, which is conjectured to provide both a sizeable first and second dividend.

6.1 Parameterization and equilibria

We are aiming for a particularly simple underlying Cournot duopoly, as we would like to keep the level of confusion stemming from the market game as low as possible. For this reason we use a linear Cournot duopoly, where only six different integer quantities are admissible. This has the advantage that gross payoffs can easily be communicated to the participants through a simple payoff table. We scale and shift a profit function from a standard linear Cournot game without cost, such that we obtain payoffs that are suitable for the experiments. We use

\[ \Pi_i(q_i, q_{-i}) := [(A - q_i - q_{-i}) q_i + Z] \gamma. \]
Note that we include the shifting factor $Z$ in order to limit the strategy profiles leading to negative profits. With these parameters the Cournot quantity is given by $q^c = A/3$, the perfectly competitive quantity is $q^{pc} = A/2$ and the collusive quantity (i.e. half the monopoly quantity) is $q^{co} = A/4$. We use the following parameters

\[
Z = 2.55 \\
A = 6 \\
\gamma = 100.
\]

In order to allow for enough of a spread and experimental quantities in discrete steps from 1 to 6 we transfer the experimental quantities with

\[
q_i = \frac{q_i^{exp} + 1}{2}.
\]

For the tax and enforcement parameters – tax rate $t$ and the base detection probability $\alpha$ we use

\[
t = .3 \\
\alpha = .15.
\]

The audit rules we test are as follows:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Detection Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>fixed</td>
<td>$\alpha_i = 0.15$</td>
</tr>
<tr>
<td>relative high</td>
<td>$\alpha_i = 0.15 - (d_i - d_{-i})/1000$</td>
</tr>
<tr>
<td>relative low</td>
<td>$\alpha_i = 0.15 - (d_i - d_{-i})/2000$</td>
</tr>
<tr>
<td>jump</td>
<td>$\alpha_i = \begin{cases} 0 &amp; if \ d_i &gt; d_{-i} \ 0.15 &amp; if \ d_i = d_{-i} \ 0.3 &amp; if \ d_i &lt; d_{-i} \end{cases}$</td>
</tr>
</tbody>
</table>

Table 1: Audit rules used in the experiment
Figure 1: Predicted outcomes

Figure 1 graphically shows the equilibrium predictions. Black and grey dashed lines show the best-responses for the quantity choices taking into account the subgame-prefix continuation in the declaration game. Dots show equilibria. The shading in the background indicates the optimal declaration behavior for given quantity choices. Dark grey indicates full evasion, light grey partial evasion, and white stands for truthful declaration.

Under a fixed audit rule theory predicts full evasion and Cournot quantities. Due to the discrete production quantities there are multiple equilibria in the quantity game. However, they all lead to a total quantity of \( Q^* = 6 \), which is the total equilibrium quantity in the underlying continuous Cournot game. The dark shading indicates that for any combination of production quantities firms are predicted to fully evade all tax and declare zero profits.

The first dividend of a relative rule with a high reactivity is very strong. For almost all quantity profiles truthful declaration (the white shading) is the equilibrium. In contrast, the second dividend does not materialize. For quantity pairs that are in the vicinity of best responses the relative rule with a high reactivity implies full declaration, which nullifies the incentive to damage the other firm’s gross profit. Quantity predictions are the same as under a fixed rule. In this treatment the reactivity of the relative rule is geared towards a maximum first dividend, i.e. preventing evasion while keeping the auditing resources used constant.

For a relative rule with a low reactivity, the first dividend is less pronounced, as the incentive to declare truthfully is weaker. We expect for most quantity combinations, that firms declare some but not all of their profit...
The partial evasion in the second stage leaves room for the relative rules externality to increase quantities in equilibrium. There are again multiple equilibria, which are caused by indivisibilities and all lead to a total equilibrium quantity of $Q = 8$. In this treatment the reactivity is geared towards maximizing the second dividend.

The jump rule removes the symmetric equilibrium where both produce the Cournot quantity and adds asymmetric equilibria where the total quantity with $Q = 7$ exceeds the total Cournot output. Theory predicts a second dividend. The first dividend in theory is strong but not as strong as under a relative rule with a high reactivity. Recall that the company with the higher profit will evade, while the firm with the lower profit declares truthfully. Only if both firms were to produce the same quantity, which is not an equilibrium, full compliance would result as an equilibrium continuation. A jump rule in theory is producing sizeable first and second dividends.

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Table 2: Predictions

Table 2 summarizes the theoretical predictions of the experimental treatments and compares them to the control treatment. From left to right in the experimental treatments the predicted second dividend (i.e. the welfare gains from the product-market externality) increases. The first dividend, which consists of a higher fraction of reported gross profits $\bar{d}/\bar{\Pi}$ is strongest for the relative rule with high reactivity and declines when moving to a jump rule or to a relative rule with low reactivity.

7 Results

In total 238 subjects participated in these four different treatments. Participants were recruited with ORSEE (Greiner, 2015), and were randomly
distributed over 12 sessions. All sessions were conducted at the Adelaide Laboratory for Experimental Economics. Participants received written instructions and profit tables for the underlying gross profits. Treatments were programmed in z-tree (Fischbacher, 2007). Quantity choices were restricted to natural numbers from one to six. The decision screen for quantities contained a gross profit calculator, where subjects could enter hypothetical quantities for themselves and for their competitor. Once quantity choices were made, participants observed the gross profits and then simultaneously chose the tax declarations. Once again, the screens contained a profit calculator showing participants the tax payments and resulting detection probabilities for hypothetical pairs of tax declarations they could enter. Subjects played 30 periods in a partner matching. The experiment took about 60 minutes and participants earned on average a bit more than 20 Australian Dollars. In what follows we investigate, how well the different rules performed with respect to delivering the two hypothesized dividends.

7.1 The first dividend – reduced tax evasion

According to standard theory we predict that in the control treatment with a fixed detection probability all profits remain undeclared. Similarly, under a relative rule with low reactivity only a very small fraction of the profits (i.e. 7 percent or less) are predicted to be declared. Both, the jump rule and the relative rule with a high reactivity in theory should provide a sizeable first dividend with equilibrium declaration rates of between 84 and 94 percent (jump rule) and fully truthful declaration (relative rule with high reactivity).

Figure 2 depicts the time series of the average fraction of profit declared in the four treatments. As predicted the declared fraction of profits is lowest under a fixed audit rule. All pairwise comparisons with the other treatments are highly significant ($p < 0.01$ for all comparisons, two-sided Mann-Whitney U-test).\(^9\) Also as theory suggests, the relative rule with a high reactivity yields greater compliance than the jump rule ($p < 0.02$, two-sided M-W

\(^9\)The unit of observation for the tests is the declaration fraction of a group of competitors averaged over both group members and all periods.
Figure 2: Fraction of declared profits by treatment
U-test). Surprisingly, the relative rule with a low reactivity, which theory predicts to only generate a tiny first-dividend, does not significantly worse than the relative rule with a high reactivity ($p > 0.21$, two-sided M-W U-test). It even tends to lead to (weakly) significantly higher declaration ratios than the jump rule ($p < 0.08$, two-sided M-W U-test).

**Result 1** The observed declaration ratios for the fixed rule, the relative rule with high reactivity and the jump rule are roughly consistent with those predicted by theory.

**Result 2** The observed declaration ratio for the relative rule with low reactivity is much higher than predicted by theory and does not significantly differ from that of a relative rule with high reactivity.

It is instructive to classify the behavior of participants into the distinct categories of “truthful declaration”, “partial evasion” and “full evasion.” This gives a better idea if the observed average declaration ratios are actually driven by equilibrium logic or not. Under a fixed rule for risk-neutral subjects we predict full evasion. In more than 73 percent of observations this is what happens. A strongly risk-averse subject should choose to declare truthfully as observed in about 14 percent of observations. Partial evasion is never optimal for a large class of risk preferences (like e.g. EUT, rank-dependant EUT, cumulative prospect theory and others). Only in a small number of cases (12.6 percent) we observe such behavior. In the reasonably easy environment of a fixed rule, which rules out any strategic uncertainty in the declaration stage, the behavior is largely consistent with equilibrium play.

We turn to the jump rule now. The reasonably high fraction of subjects that declares truthfully (34 percent) is consistent with the theoretical predictions that non risk-seeking subjects that end up with a lower or equal profit compared to their competitor should declare truthfully. Non risk-seeking subjects that come out ahead from the production stage should evade partially and declare profits to the amount of their competitors gross profit.

---

10 For an interior declaration to be optimal we would require preferences such that for some but not all $x_1, x_2$ with $x_1 < x_2$ a subject prefers the gamble $(x_1, p; 0, 1 - p)$ over $(x_2, p; 0, 1 - p)$, i.e. the subject violates stochastic dominance.
Figure 3: Fractions of truthful, partially and fully evasive declarations.
The high proportion of subjects (around 50 percent) who evade partially is roughly persistent with this prediction. The 15 percent of subjects who fully evade clearly behave inconsistently with theory. Full evasion in this game is very similar to choosing the monopoly price in a Bertrand duopoly with homogenous goods. It could be caused by attempted collusion. Looking at the behavior of those who enter the declaration stage with less gross profits lends some further support for a reasonable amount of equilibrium logic. About 50 percent of these subject declare truthfully, while only 20 percent do so when coming out on top.

The picture is less clear for the two relative rules. Under the rule with the high reactivity all subjects should report truthfully but only about 51 percent do so. Full evasion or partial evasion (with a very small fraction actually declared) is the equilibrium prediction for the relative rule with low reactivity. With 41.5 percent truthful declarations, declaration behavior seems to be furthest off in this treatment.

While the aggregate declaration behavior in at least three of the treatments looks roughly consistent with the predictions, a look at individual behavior reveals that there is little crisp and precise equilibrium play. In order to decide if there is at least an underlying tendency of behavior qualitatively following equilibrium logic we perform random-effect interval regressions. Our main relationship of interest is how declarations depend on the own and the competitor’s gross profit. This is instructive, since the comparative statics of equilibrium declarations with respect to the gross profits are quite distinct across the treatments. Moreover, this analysis can clarify, if the observed deviations are driven by participants violating equilibrium logic in the declaration subgames or if the differences are caused by off-equilibrium play already in the declaration stage.

For the jump treatment the theoretical impact of the gross profits differs depending on the whether a firm has a higher or lower gross profit than the competitor. Hence, we interact the own and the competitors gross profits with a dummy, which indicates that a firm is ahead. The use of interval regressions is necessary, because declarations are by design censored at zero from below and at the gross profit from above. Table 3 reports the regres-
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* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Interval regressions for declarations by treatment
sions and marginal effects. The regression coefficients are to be understood as influencing an underlying uncensored variable that reflects the propensity to declare income. The marginal effects \(dx/dy\) reported in the table is the averaged estimated impact of the dependent variable on actual declarations (i.e. its linear impact on the declarations conditional on them being uncensored).

Recall that in the fixed treatment in equilibrium everybody should evade fully, which means that declarations should be independent of the own and also the competitor’s gross profit. This is exactly what we observe. In the relative high treatment equilibrium prescribes truthful declaration, which indicates that only the own gross profit should matter for the declaration. This is what the regression tells us. The estimated influence of the own gross profit both on the latent variable and the expected uncensored declaration is smaller than unity and therefore smaller in magnitude than prescribed by equilibrium. This is not surprising, as not all subjects follow the equilibrium. As predicted by theory, the impact of the own gross profit is not significantly different when ahead or behind in terms of gross profit.

In the jump treatment equilibrium predicts that the declaration should be equal to the own gross profit as long as the profit of the competitor is greater. Once a company’s gross profit surpasses that of the competitor the declaration should equal the profit of the competitor. The regression shows that at least qualitatively behavior follows this logic. Declarations are positively influenced only by the own gross profits if behind and by the competitor’s profit if in front. While the size of the coefficient and the marginal effects are way lower than what crisp equilibrium play would imply, the regression shows that a significant amount of subjects followed the logic implied by the equilibrium.

In the first three treatments there is some evidence for observed behavior qualitatively following equilibrium logic. In the fourth treatment with a relative rule of low reactivity this cannot be said. As already indicated by the extraordinary high level of declarations, behavior does not seem to follow equilibrium logic. Recall that under a relative rule, as long as no corner solution is hit, equilibrium declarations increase with both the own
and the competitor’s gross profit. The marginal impact of the own profit is stronger than that of the profit of the competitor. Moreover, the reaction of declarations to gross profits in equilibrium does not depend on being ahead or behind. We find that for subjects with lower profits only the competitor’s profit matters for declarations. For subjects with higher profits both gross profits matter. While the impact of the own profit is positive as expected, strangely the competitor’s profit enters negatively. This is difficult to explain. Ceteris paribus subjects become more aggressive if the competitor is closely behind. This is hard to reconcile with any logic based on standard preferences. Declarations are strategic complements in this treatment. Subjects with standard preferences would have to (wrongly) conjecture that a competitor with a lower gross profit declares the less the smaller the gap between the gross profits is. The only potential explanation we could come up with goes as follows. A subject who comes out of the production stage ahead in profit wants to stay in front after the tax declaration. If there is strategic uncertainty over the declaration of the other player, then a narrowing gap between gross profits under strategic uncertainty reduces the likelihood to come out on top after the tax declaration (as long as nobody is caught). So a subject, who values staying in front, is willing to take more risk with the aim to increase the likelihood of staying in front, which can be achieved by evading more aggressively.

In summary, our initial results are confirmed by the regression analysis. In three treatments (fixed, jump and relative rule with high reactivity) we find patterns that show that actual play follows equilibrium logic. In the remaining treatment with a relative rule with low reactivity declaration behavior is difficult to reconcile with equilibrium logic.

7.1.1 Effectiveness of audits

One very unappealing property of many enforcement rules under commitment is that audits in equilibrium only target the innocent. This, e.g., is the case with the jump rule. Recall that the firm with lower gross profit declares truthfully in equilibrium while the other firm declares just enough not to
be audited at all. So all tax inspectors show up at the firm that reports truthfully. It is questionable if such a policy is sustainable in reality. A tax authority that never uncovers fraud is not likely to survive. Similarly, a tax authority that knows that it will never find any fraud has no real incentive to audit thoroughly. Here we will briefly report and discuss how effective the different audit rules are at detecting hidden profits in our experiments.

An interesting measure to look at is the expected fraction of evaded profits that is discovered. By design, under the fixed rule this expected fraction is equal to $\alpha = 0.15$. In equilibrium, this fraction is not defined for the relative rule with high reactivity, since no evasion should ever occur. For the jump rule in equilibrium all inspectors show up at the innocent firm. So we expect the fraction discovered non-reported profits to be zero. In the relative low treatment the equilibrium expected detection ratio is very close to the ratio in the fixed treatment. It is either exactly 0.15 if the symmetric equilibrium is played or slightly below (0.149) for the two asymmetric equilibria. In summary, theory predicts that the auditing rules that are designed to put larger scrutiny on the suspicious fail to do so. The reason is the adjustment of behavior of the firms in the light of the incentives the audit rules provide.

Empirically, the picture is quite different. Recall, that we observe qualitative evidence of equilibrium logic influencing declaration behavior in most treatments. However, we do not see crisp equilibrium play and the quantitative reaction to changes in profits is much lower than equilibrium predicts, and declaration behavior is quite noisy. This gives rise to the possibility that the rules that are designed to scrutinize the suspicious are also better at actually catching the guilty than a fixed rule. On the left in Table 4 we calculate the fraction of discovered evaded profits predicted by theory and contrast it with what we observe in our experiments. And in fact, the relative rules do better than the fixed rule.

Ranksum tests on the independent observations (i.e. the recovery fraction in a group over the whole game) confirm that all three alternative rules recover a higher fraction than the 15 percent under a fixed rule ($p < 0.001$, 0.001,
two-sided). Moreover, the relative high treatment uncovers significantly more than the jump rule \((p < 0.05\), two-sided).

An alternative statistic to capture the effectiveness of auditing is the average probability that the firm that evades more is audited.\(^{11}\) The theoretical and actual probabilities are shown on the right in the Table above. Again the three relative alternatives to the fixed rule achieve higher values than theory predicts and also do better than the fixed rule. The order across treatments obtained using the expected recovered profit is preserved under this alternative measure.

Result 3 The relative rules perform better, compared to both the theoretical prediction and to the fixed rule, at targeting the guilty. The relative rule with high reactivity tends to perform best.

### 7.2 The second dividend - increased output

Theory predicts a second dividend in the jump and in the relative low treatments. For the second dividend to exist and arise as predicted by theory, subjects are required to declare profits according to equilibrium and to take the influence of their production on their and the competitor’s declaration into account. The findings on the former for the two treatments are mixed. While there is some evidence that qualitatively subjects follow the logic of the jump rule, the data suggests that subjects do not follow the equilibrium logic under a relative rule with modest reactivity. Still, Figure 4 reveals that

\(^{11}\)Putting the total audit probability (i.e. 0.3) on the firm that evades more, maximizes the expected recovered hidden profits.
Figure 4: Average quantities in the treatments

in both of these treatments a second dividend exists, as average quantities are above the Cournot level of three units, while they are around three in the other two treatments as predicted by theory.

Non-parametric tests confirm that the median of the average production quantities of a pair of competitors is greater than the cournot quantity in the jump and relative low treatments (binomial test, one-sided, \( p < 0.005 \) both treatments) and not different in the other two treatments (binomial test, two-sided, \( p > 0.99 \) both treatments). Further testing if the second dividend differs between the jump treatment and relative low treatment reveals that this is not the case (Mann-Whitney U-test, two-sided, \( p > 0.94 \).) Theory predicted a greater dividend under the relative rule with low reactivity though. In terms of the size of the dividend, we cannot reject the null hypothesis that the jump rule delivers a median dividend of the predicted size (i.e. \( q \in [3, 3.5] \), binomial test, one-sided, \( p > 0.99 \)). In contrast, we can reject the null hypothesis that the relative rule with low reactivity delivers
Result 4 As predicted by theory, the jump and relative rule with low reactivity deliver a second dividend, while the other rules do not.

Result 5 The size of the dividend does not differ across the jump and relative low treatments and is consistent with theory for the jump but lower for the relative low treatment.

The observation, that quantities do not differ across the jump and relative low treatments together with the observation that declaration behavior in the relative low treatment is inconsistent with equilibrium logic raises the suspicion that the observed efficiency gains have been produced through a mechanism different to the theoretically predicted. In order to investigate this, we look at actual play in the different treatments. Figure 5 shows the frequencies of different quantity combinations chosen in the different treatments. The size of the circles is proportional to the relative frequency with which a certain quantity combination has been chosen. The darker filled circles represent the collusive outcome (i.e. both firms produce two units) and the lighter filled circles are quantity combinations consistent with equilibrium in a given treatment.

It is obvious that play does not systematically follow the equilibrium logic. In the two treatments, where the Cournot quantity (i.e. six units in
total) is the equilibrium, the modal play is collusion. The remaining play is spread across the whole spectrum. The resulting average quantities are close to equilibrium; but actual play is not governed by equilibrium logic. In the two treatments, where the equilibrium predicts higher quantities, the modal play is Cournot. As the remaining mass of play is again distributed across the whole spectrum of quantities, we end up with average quantities above Cournot. Summarizing yields the following results.

**Result 6** The second dividend observed in the jump and relative low treatments stems from a shift away from collusive behavior rather than from equilibrium logic.

We conjecture that the underlying mechanism is as follows. While subjects were not able to figure out equilibrium play in the jump and relative high treatment, they at least realized that having a higher gross profit than the competitor is of advantage for the declaration stage. Recall that in a symmetric Cournot duopoly with non-increasing marginal cost, the firm producing more ends up with a higher gross profit. This incentive to produce more than the opponent was sufficient to break collusion and therefore delivered the second dividend. This is consistent with the somewhat weird declaration behavior in the relative rule treatment with low reactivity.

### 7.3 Testing the conjectured mechanism

Up to this point we have only limited evidence for our conjecture that the increase in quantities is driven by subjects insight that having a higher gross profit than the competitor is of advantage in the declaration game. There is clearly no such advantage under a fixed rule due to the independence. Similarly, for the subjects that are declaring truthfully under the relative rule with high reactivity due to the strong incentives there is no advantage to be had from having a higher payoff than the competitors.

In what follows we are reporting the results from additional experiments, which we designed to test this hypothesis. Our idea is as follows. Suppose, it were possible to perform a manipulation, which gives participants deciding on production a psychological incentive to come out with a higher gross
profit than the competitor. Further imagine that adding this psychological incentive keeps the material incentives unchanged. Adding such a manipulation to the four treatments would give rise to a nice test. If our conjecture is correct, then adding this psychological incentive to the two treatments where we do not observe a second dividend (i.e. fixed and relative high), will lead to a switch away from collusive behavior, resulting in a similar distribution of outcomes, as in the treatments with a jump rule and with the relative rule with low reactivity. In other words, if the relative rules yield a second dividend, since subjects recognize that a having a higher gross profit than the competitor is beneficial, then adding a psychological incentive to treatments where there are no financial incentives for higher gross profits should result in behaviour similar to that in treatments with the financial incentive.

We turn to the literature on the psychology of performing for a team in a competitive situation to find a manipulation that generates the desired psychological incentives. In a seminal paper Williams et al. (1989) show that swimmers perform better in relays than in individual races if their team mates observe their performance. Heuzé and Brunel (2003) find in an experimental study that this performance enhancing effect is linked to the perceived likelihood of the team winning. In Cooper and Sutter (2018) a questionnaire that elicits many different traits and emotions of individuals that were assigned different roles in teams confirms that subjects feel highly responsible for the payoff of their team members and feel pressure to do well for their team mates. Finally, Hüffmeier and Hertel (2011) show that inter-team competition and the degree of being able to influence the outcome are critical for higher effort. Together, these studies show that put in a competitive environment, as a member of a team that observes the actions increases the competitiveness of a person.

In our additional treatments we evoke this competitive effect on quantity choices by having different subjects making the quantity (CEO) and tax-declaration decisions (CFO). Financial incentives are kept identical to the original treatments, and an additional 244 participants took part.\textsuperscript{12} Now the

\textsuperscript{12}We achieve this by sharing the net profit equally between CEO and CFO and doubling the rate we exchange experimental currency for Australian Dollars.
CEOs of the two firms simultaneously choose quantities. The CFOs then see the actions and gross profits taken by their CEOs and make a tax declaration. Like in a relay of swimmers, the CEO hands a lead over or deficit to the gross profit of the competitor to the own CFO. The psychological pressure to do well in terms of gross profit and the will to give the CFO a higher gross profit than the competitor now provide the additional psychological incentive to break collaborative outcomes.

For brevity, we will restrict the discussion of the results from these additional treatments to their effect on the distribution of quantity outcomes and on collusion in particular.\textsuperscript{13} Figure 6 shows the distribution of quantity combinations with the use of bubble plots. It immediately becomes clear that the distributions obtained in the four distributive treatments are all very similar to the two original treatments (jump and relative low) that achieved a second dividend. The distributions for the fixed and relative high treatment change dramatically, once the additional psychological incentive to compete is introduced via distributed decision making. A considerable mass shifts away from collusive outcomes (dark shaded) to more competitive outcomes.

The visual impression is confirmed by a rigorous test. We counted the number of collusive outcomes for each market across the 30 rounds and regressed them on treatment dummies. Given the count data structure we use a Poisson regression. We have quite a few markets, where the firms never colluded, leading to our data being zero-inflated. Hence, we employ the zero-inflated version of a Poisson regression with treatment dummies as predictors for certain zeros.\textsuperscript{14}

As expected from the plot, we see that there is no significant difference with respect to the occurrences of the collusive outcome between the individual fixed and individual relative high treatments. These were the treatments

\textsuperscript{13} The declaration behavior in the distributed treatment is qualitatively similar to that in the corresponding individual treatments.

\textsuperscript{14} As a robustness check we also ran a zero inflated negative binomial regression, which yields qualitatively equivalent results.
Figure 6: Quantity outcomes in all treatments

were we did not observe the second dividend (as predicted by theory). As hypothesized, introducing distributed decision making reduces the occurrence of collusive outcomes in these two treatments significantly. Furthermore, in the treatments, where we already observe reduced counts of collusive outcomes, adding the psychological incentive for achieving a larger gross profit than the competitor either increases (jump, $p < 0.01$) or does not significantly change (relative low, $p > 0.7$) the occurrence of collusion.

**Result 7** Additional treatments that provide a psychological incentive to achieve a higher gross profit than the competitor, provide evidence that the second dividend is driven by the insight that having a higher gross profit than the competitor is beneficial for tax declaration.
## Count of collusive outcomes in a group

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### Predictors for certain zeros

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*p < 0.1, **p < 0.05, ***p < 0.01

Table 5: Zero-inflated Poisson regression in counts of collusive outcomes in a group

### 7.4 Distribution of surplus

In what follows we compare the total surplus under the different rules and its distribution across consumers, firms and government. Production decisions determine the total surplus. Tax declarations determine the distribution of surplus between net profits and tax revenue. Consumer surplus is a residual.

Figure 7 shows the average total surplus and its distribution for the different treatments.\(^{15}\) As a benchmark one could think of the equilibrium in a world without tax evasion. Firms produce Cournot quantities and pay their taxes. Under such a scenario the total surplus of 2110 units would be divided into a consumer surplus of 800 an after-tax profit of 917 and a tax revenue of 393. Note that the relative rule with a high reactivity produces a distribu-

\(^{15}\)Profits that are confiscated when tax evasion is found out are added to the government revenue.
tion that is relatively similar to this benchmark. Under a fixed rule the total surplus is slightly higher and the widespread evasion causes increased after-tax profits, while the government revenue is considerably lower and mainly consists of confiscated profits for found-out tax evasion.

The jump rule and the relative rule with low reactivity produce virtually the same increased total surplus, as they both yield very similar average quantities. However, the unexpectedly high profit declarations in the relative low treatment imply that the potential problem of low revenue does not occur. The total tax revenue is even closer to the benchmark than with the jump rule. From a policy standpoint a relative rule with low reactivity is preferred. This is due to the slightly better performance in the revenue department. A further advantage of the continuous relative rule is that it is a bit more forgiving in a realistic environment where firms differ with respect to production technology and therefore size. Suppose, we are in an environment with a large and a small firm, where ceteris paribus the large firm has a higher profit in a Cournot equilibrium. Then a jump rule that does not adjust for the difference, will in equilibrium always give an advantage to the larger firm. In equilibrium, all the cost associated with audits fall to
smaller firm, which reports truthfully.\textsuperscript{16}

8 Conclusion

Theory suggests that audit rules that condition the thoroughness of a profit-tax audit on all tax returns in an oligopolistic industry, can distort production decisions. If appropriately designed these rules yield a theoretical double dividend by reducing tax evasion and increasing competitiveness at the same time. In this paper we investigated if the hypothesized dividends are plausible to occur in reality by conducting laboratory tests. Laboratory tests are not without their problems but are in our view the best methodology for the question at hand. Given that an independent real-world observation for our purpose is a whole industry, for a field experiment randomizing the audit rules across many otherwise similar industries would be required. This is highly impractical. Instead we construct minimum working examples and test if the underlying theoretical mechanism is understood and followed by intelligent people.

We find that relative rules deliver the dividends in magnitudes similar to the theoretical predictions. However, there are some notable deviations from equilibrium play. A smooth relative rule that reacts with modest changes in detection probabilities if declarations diverge, delivers a much higher first dividend than predicted by theory. We conclude that it might not be necessary to introduce a rule as aggressive as theory requires in order to incentivize firms to cheat less. This is good news, since very aggressive relative rules might wipe out the second dividend. The relative rule with high reactivity, in theory, incentivizes truthful declarations but removes the incentives to increase quantities beyond the Cournot Nash equilibrium. Our experiments confirm this theoretical prediction.

We also test an alternative rule that renders tax declarations a rank-order tournament, where the firm with a lower declaration gets hit by a heavy audit while the firm with the higher declaration is not audited at all. Theory

\textsuperscript{16}It is possible that deviations from equilibrium in reality mitigate this problem though.
predicts that such a rule delivers on both fronts, i.e. reduces tax evasion and yields higher than Cournot quantities. Unfortunately, theory also predicts that only truthfully reporting firms are audited. This is quite problematic, since it is hard to keep up enforcement if nobody is ever caught cheating. In our experiments this rule (which we called jump-rule) performed well. It produced a modes first dividend and a sizeable second dividend. Noise and systematic deviations from equilibrium play countered the theoretical prediction that the rule only targets the innocent. In contrast to theory the jump rule was considerably better at recovering undeclared profit than the fixed rule we implemented in the control treatment.

In terms of over-all performance we favour a smooth relative rule with a modest reactivity. It delivers virtually the same total surplus as the jump rule but at the same time yields a much higher tax revenue. We believe that such a rule is worth considering in reality. In the past, some academics and practitioners were concerned about relative rules having the damaging side-effect of fostering collusion. Our experiments were able to remove this concern. Rather than promoting collusion the relative rule (and the jump rule) were able to significantly reduce collusion. In fact, there is evidence that the second dividend delivered by the low-reaction relative and jump rule actually resulted from an incentive to breaking collusion rather than from the involved equilibrium logic proposed by theory.

References


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