The excess burden of tax evasion - An experimental detection-concealment contest*

Ralph-C Bayer† and Matthias Sutter‡

October 29, 2003

Abstract

We present an experimental study on the wasted resources associated with tax evasion. This waste arises from taxpayers and tax authorities, investing costly effort in concealment, respectively detection, of tax evasion. We show that (socially inefficient) efforts depend positively on the prevailing tax rate, but not on the fine which is imposed in case of detected tax evasion. The frequency of evasion increases with tax rates. Additionally, we observe less tax evasion than a model with risk neutral taxpayers predicts. We find evidence that this is rather due to individual moral constraints than due to risk aversion.

JEL-classification code: H26, K42, C91

Keywords: tax evasion, contest, experiment, tax rates, fines

---

*We would like to thank the Center for Experimental Economics at the University of Innsbruck (sponsored by the Raiffeisen-Landesbank Tirol) for financial support.

†Corresponding author. School of Economics, University of Adelaide, North Terrace, SA 5005, Australia, e-mail: ralph.bayer@adelaide.edu.au.

‡Max Planck Institute for Research into Economic Systems and University of Innsbruck. Postal address: Kahlaische Strasse 10, D-07745 Jena, Germany. e-mail: sutter@mpiew-jena.mpg.de

1 Introduction

It is not clear what the welfare implications of tax evasion are. Some authors believe that tax evasion itself constitutes a deadweight loss for society (e.g. Usher, 1986). Some others point out the difficulty to asses welfare effects, since the state of the economy, the efficiency of the prevailing tax system, and social preferences over income distributions are unknown (see Cowell, 1990, chp 7). In any case, tax evasion entails additional social costs in the form of taxpayers investing effort and money in order to conceal tax evasion. These social costs have to be added to the enforcement cost caused by tax the authority's auditing effort when the welfare implications of tax evasion are considered. Hence, a given tax system does not only influence the amount of tax evasion or the size of a country's shadow economy (Schneider and Enste, 2000); it has also immediate consequences for the extent of wastefully invested resources in the concealment-detection contest between taxpayers and tax authority. Tax enforcement and covering measures going along with cheating are costly not only for the individuals involved, but also for a society, since these resources could be used for productive purposes otherwise. Consequently, this cost can be viewed as an extra excess burden of taxation a society has to bear.

In this paper, we are interested in the influence of a tax system on these wastefully invested resources. We present a model of a concealment-detection contest between taxpayer and tax authority. The taxpayer can invest some of his income in order to shelter his evasion behaviour[1] while the tax authority spends resources on detection[2]. The probability that tax evasion is detected decreases with the taxpayer's concealment investment and increases with the authority's detection effort. Allowing for concealment and detection efforts describes the tax-evasion decision more realistically than conventional models where taxpayers have no means of covering their evasion and audit rates are exogenously fixed.[3]

[1] Think, for instance, of a taxpayer spending money or forgoing possible interest payments in order to shelter black money abroad.

[2] Think of hiring more tax administrators to monitor tax reports or of investing in better detection technology, which have been shown empirically to reduce tax evasion (see, for instance, Cebula, 2001).

[3] There are some earlier papers which allow for concealment of tax evasion (like Cremer and Gahvari, 1994) or which acknowledge that investing in income-detection technologies might raise the probability of a successful audit by the tax authority (like in Usher, 1986). However, these papers do not model the interaction between taxpayer and tax authority explicitly and do not focus on the extent of wastefully invested resources in the context of tax evasion. Cremer and Gahvari (1994) rather explore the influence of tax evasion and concealment on the design of an optimal linear income tax; Usher (1986) studies the effects of concealment and detection effort on the marginal costs of public funds.

In our model, we are able to investigate how tax rates and fines influence the resources wastefully invested for detection and concealment. Hence, we can determine the degree of social (in)efficiency of different tax regimes. The less resources are wasted in the contest, the more efficient is the tax-collection and enforcement system. Our theoretical model predicts that efficiency decreases with higher tax rates, while the influence of fines is more complicated to predict.

We test our model predictions in a controlled laboratory experiment. Experimental economics provides an ideal methodological tool to measure the influence of different tax regimes on wastefully invested resources for concealment or detection of tax evasion. Experimentation in the laboratory is defined by controlled manipulation of independent treatments (inducing different tax regimes) and randomized assignment of participants to those treatments. If differences between experimental groups on dependent variables (i.e., concealment and detection effort) can be observed, these differences can be attributed causally to differences in treatments (here: combinations of tax rates and fines). In the field, it is much more problematic to study the efficiency costs of tax rates and fines. (1), it is hard to determine how precisely to measure concealment and detection efforts. On the side of the tax authority it might be feasible to approximate detection costs by the costs for monitoring tax declarations, whereas on the side of the taxpayers it is less clear which kind of expenditures (legal advice, bribes, expenses, forgone gains etc.) should be subsumed under concealment costs. (2), even if there were consensus on how to measure the efficiency costs, data from taxpayers would be very hard to get, because nobody would voluntarily want to reveal expenditures associated with illegal tax evasion. (3), given that one has found a way around problem (2), to study the comparative static effects of different tax regimes would still require to expose taxpayers and tax authorities (randomly) to different tax regimes. This is hardly possible in reality, since because 'real-life experiments' with tax regimes are very costly and/or are legally impossible on grounds of equal treatment of taxpayers.[4] In our experimental design, it is possible to satisfy the needs

[4] Slemrod et al. (2001) report a field experiment in Minnesota on the effects of an increased probability of audit on taxpayer's tax returns. They find that an increased probability of audit has a positive effect on declared tax liability for low- and middle-income taxpayers, but the reverse effect for high-income taxpayers. Even though highly original in their 'experimental' design, one weakness of Slemrod et al. (2001) is the fact that the increased probability of audit was indicated in a letter such that a certain taxpayer "had been selected at random to be part of a study that will increase the number of taxpayers whose 1994 individual income tax returns are closely examined" (p. 463). The authors themselves acknowledge that there is no control on how field participants interpreted this loose information. A similar problem of control in the field is present in a recent study by Wenzel and Taylor (2002) on the effects of tax-reporting schedules on tax returns, where it remains open how different tones in the letters (cooperative vs. deterring) from the Australian Taxation Office to rental property owners were perceived.

(1) through (3) and, hence, we can reliably test the efficiency-cost effects of different tax regimes, i.e. of tax rates and fines.

We find in our experiments that higher tax rates clearly reduce efficiency, whereas higher fines do not have a significant influence on efficiency, i.e. they have no systematic effect on concealment and detection costs. A further finding of our experiment is that subjects do not permanently evade taxes, even though we have set up the design such that tax evasion is a better than fair gamble and, thus, risk neutral taxpayers should evade taxes all the time. Alm et al. (1992) have already put forward that the real puzzle in tax evasion is rather why people do pay taxes than why they try evading them. Like in the real world, we can observe in our experiment a lot of honest taxpayers truthfully revealing their income to the tax authority. A widely used explanation for this puzzle (see e.g. Gordon, 1989, or Myles and Naylor, 1996) is the existence of some psychological cost for cheating. Our model (based on Bayer, 2002) can be extended to account for such costs. In the extension with moral costs, the theoretical model predicts that taxpayers without any scruples always evade while taxpayers with moral constraints are at least sometimes honest. We use this prediction in our laboratory experiment to identify whether moral constraints really play a role in taxpayers' evasion behaviour. We find that the existence of moral costs is a valid explanation for honesty, which fits better to the data than explaining truthful declaration by assuming strong risk aversion.

The remainder of the paper is organized as follows: Section 2 introduces the basic model and derives the main predictions. Section 3 is devoted to our experimental design. Results on the influence of tax rates and fines are presented and discussed in Section 4. Section 5 analyzes individual behaviour more closely and provides some interpretations for behaviour deviating from the model predictions. A brief conclusion is offered in Section 6.

2 Timing, payoffs, and experimental design

In this section, we explain the timing, information, and payoff structure underlying the experiment. The experimentally implemented structure follows the theoretical model developed in Bayer (2002). We begin with the timing.

2.1 Timing

Timing and information structure within one experimental round are the following:

1. Nature determines the actual income $Y \in \{0, y\}$. The probability that $Y = y$ is earned is given by λ. This probability is common knowledge.
2. The taxpayer observes Y.
3. The taxpayer makes an income declaration $D \in \{0, y\}$ and exerts a concealment effort $E \in \{0, 1, ..., 10\}$.
4. The authority observes the declaration D but not the concealment effort E.
5. The authority chooses a detection effort $A \in \{0, 1, ..., 10\}$.
6. Nature decides whether the actual income is verifiable in court. The verification probability depends on the efforts and is given by $P(A, E)$, which is specified below.
7. Taxpayer and authority are informed about the efforts of the other party and whether a fine is due. Taxpayers receive their ex post net income U and the authority receives the revenue R, respectively.

2.2 Action spaces and payoff structure

In this section we explain the underlying payoff structure for the experiment and comment on the possible actions the subjects can take.

- We restrict the income distribution to two values 0 and y. Consequently, we restrict the possible income declaration to be dichotomous as well:

$$\begin{aligned} Y &= \begin{cases} y & \text{with probability} \quad \lambda \\ 0 & \text{with probaility} \quad 1-\lambda \end{cases} \\ D &\in \{y, 0\} \end{aligned}$$

- In order to keep the experiment simple we only allow for integer values for the efforts. The feasible efforts (A, E) range from 0 to 10.

- Effort costs are linear for both tax authority and taxpayer. One unit of concealment effort costs the taxpayer c^e experimental money units while for the authority the detection cost per effort unit is given by c^a.

- As the verification-probability function we use:
$$P(A, E) = \begin{cases} 1 & \text{if} \quad A, E = 0 \\ \frac{A}{A+E} & \text{else} \end{cases} . \tag{1}$$
This probability function is widely used in the contest literature. Combined with linear detection and concealment costs we achieve that the marginal cost of influencing the verification probability in the favoured direction increases for both the authority and the taxpayer. This seems to be a realistic feature, since authorities and tax evaders should use the cheapest means of detection and concealment respectively, before more expensive measures are taken.

- The tax system is linear and the fine is proportional to the taxes evaded. The potential fine if evasion took place can be expressed as $f \cdot t \cdot y$, where t is the tax rate and f denotes the fine parameter.

Given this underlying structure the expected payoff per round for a taxpayer depending on his declaration behaviour and true income becomes

$$EU(Y = y) := \begin{cases} (1-t)y - c^e \cdot E & \text{for} \quad D = y \\ y - p(A^E, E) \cdot f \cdot t \cdot y - c^e \cdot E & \text{for} \quad D = 0 \end{cases} \tag{2}$$

$$EU(Y = 0) := \begin{cases} -t \cdot y - c^e \cdot E & \text{for} \quad D = y \\ -c^e \cdot E & \text{for} \quad D = 0 \end{cases} \tag{3}$$

where A^E denotes the expected detection effort of the authority.

The expected payoff for the authority ER can be written as

$$ER(A) := \begin{cases} \mu \cdot p(A, E^E) \cdot f \cdot t \cdot y - c^a \cdot A & \text{for} \quad D = 0 \\ t \cdot y - c^a \cdot A & \text{for} \quad D = y \end{cases} , \tag{4}$$

where μ is the belief that the zero declaration comes from a taxpayer who has an actual income of y and E^E denotes the expected concealment effort conditional on tax evasion taking place.

2.3 Experimental design and parametrization

Two persons, called taxpayer and tax authority were paired for 20 rounds.[5] In each round, the tax authority received with a probability $\lambda = 0.8$ an income of $Y = 1000$ Taler. With probability $1 - \lambda$ the income was $Y = 0$. After observing the actual income the taxpayer had to make an income declaration $D \in \{0, 1000\}$. A declaration of 0 given that an income of 1000 was earned constitutes the case of tax evasion. The other action the taxpayer had to take is choosing his concealment effort $E \in \{0, 1, ..., 10\}$, with marginal concealment cost $c^e = 20$. Without knowing the taxpayer's real income Y, the tax authority had to determine its detection effort $A \in \{0, 1, ..., 10\}$, with marginal detection cost $c^a = 40$. The combination of E and A determined the probability that the real income of the taxpayer could be verified by the tax authority (see equation 1). Given this detection probability nature decided, by using random number generated by the experimental software, whether the actual income was verified or not. In case of detected tax evasion, the taxpayer had to pay a fine, which depended on evaded tax ($= 1000 \cdot t$) and a fine parameter f.

We set up four different treatments by exogenously varying tax rates and fines. Tax rates could be either 25% (T_l) or 40% (T_h). Fines were proportional to the evaded tax in case of detected tax evasion, by either adding a surcharge of 25% (F_l) or of 100% (F_h) to the evaded tax. This was implemented by setting the fine parameter $f = 1.25$ and $f = 2$,respectively. The fine - of course - had also to be paid to the tax authority. The taxpayer's payoff per round was calculated by subtracting taxes, the fine if any and concealment costs from the taxpayer's effective income. We chose these treatments to be able to distinguish between different sets of incentives. Table 1 gives the taxpayer's payoffs net of concealment cost for the different treatments given that the income was earned. The entries are to be read as net incomes for [*truthful declaration*; (*successful evasion*, *unsuccessful evasion*)].

	T_l	T_h
F_l	[750; (1000, 687.5)]	[600; (1000, 500)]
F_h	[750; (1000, 500)]	[600; (1000, 200)]

Table 1*: Taxpayer's payoff net of concealment cost if the income was earned*

[5] See the Appendix for a translation of the instructions.

The tax authority earned a base wage of 450 Taler, plus the taxes (if income was declared truthfully) or the fine (if income was concealed, but detected), minus detection costs. At the end of the experiment, 1000 Talers were exchanged for 1.2 Euro. The base wage per round was introduced in order to ensure that the payoffs for authority and taxpayer are not too different. We perceive equitable payoffs as important, since we are not interested in the effects of inequality aversion.

The experiment was run with the help of z-Tree (Fischbacher, 1999) in June 2002 at the University of Innsbruck. For each treatment, we ran two sessions á 20 participants, yielding 20 independent observations (pairs of taxpayer and tax authority) per treatment. Average age of our 160 student participants was 22.7 years, with 59% being female. Two thirds of participants were enrolled in business or economics, most of the others studied law, medicine or psychology. On average, sessions lasted 45 minutes. Average earnings were 12.6 Euro.

3 Predictions of the theoretical model

To start with, we assume risk-neutral subjects. This will give us a benchmark for behaviour and will allow us to draw conclusions about the reasons for deviations from this benchmark.

Solving the model for the unique pooling equilibrium (i.e. a pure strategy Perfect Bayesian Equilibrium) gives the following equilibrium strategies and beliefs.[6]

Tax authority:

$$A^* = \begin{cases} \lambda^2 \cdot f \cdot t \cdot y \cdot c^e \cdot \phi & \text{if} \quad D = 0 \\ 0 & \text{if} \quad D = y \end{cases} \tag{5}$$

and

$$\mu^* = \lambda$$

Taxpayer:

$$(D^*, E^*) = \begin{cases} (0,0) & \text{if} \quad Y = 0 \\ (0, \lambda \cdot f \cdot t \cdot y \cdot c^a \cdot \phi) & \text{if} \quad Y = y \end{cases} \tag{6}$$

[6] See Bayer(2002) for a more detailed treatment.

with

$$\phi := \frac{c^a}{(\lambda c^e + c^a)^2}.$$

This set of strategies and beliefs are an equilibrium whenever evasion pays compared to being honest. The condition for profitable evasion is given by

$$f \leq \frac{1}{1 - c^a \phi}. \tag{7}$$

If this condition is violated a taxpayer who earned the income will mix between being honest and evading. The equilibrium evasion probability α^* conditional on having earned the income y and on violating condition 7 is:[7]

$$\alpha^* = \frac{\eta(1-\lambda)\left(\sqrt{f} - \sqrt{f-1}\right)}{\lambda\left((1-\eta)\sqrt{f-1} - \eta\sqrt{f}\right)}$$

where $\eta = c_a/c_e$ is the comparative advantage in concealment over detection. It is possible to show that lower fines increase the probability that an actually earned income is evaded in the case that always evading does not pay.[8] Note, that here equilibrium efforts A^* and E^* decrease if the equilibrium evasion probability α^* decreases. This is driven by the feature that the equilibrium beliefs for evasion μ^* decrease if α^* decreases. In this formulation the tax rate should have no influence on the evasion probability.

We chose the parameters such that evasion, given optimal efforts, always pays for risk neutral taxpayers. Therefore, we might expect that a taxpayer always evades if his income is 1000. In fact the expected declaration should always be 0. The authority's belief to face an evader should be equal to the earnings probability, i.e. $\mu^* = \lambda = 0.8$. Solving for the optimal effort and taking the experiment's discontinuous action space into account gives the following prediction of optimal efforts, as summarized in Table 2:

		treatment(tax/fine)			
optimal effort of	actual/observed action	$T_l F_l$	$T_l F_h$	$T_h F_l$	$T_h F_h$
taxpayer	- evasion	3	5	5	8
tax authority	- declare = 0	1	2	2	3

Table 2: *Optimal efforts for risk-neutrality*

[7] For the derivation see Bayer (2002).

[8] This is true, since $\partial\alpha^*/\partial f < 0$ for $\alpha^* \in [0, 1]$.

With these equilibrium efforts we can calculate the expected efficiency. The expected waste per period is given by

$$W := \lambda c_e E^* + c_a A^*.$$

Then the expected efficiency V in percent is given by one minus the ratio of expected waste to expected income.

$$V := 1 - \frac{W}{\lambda y} \tag{8}$$

This yields the predicted efficiency per treatment stated in Table 3. We see that higher fines should decrease efficiency for given tax rates as higher tax rates for given fines do.

	treatment(tax/fine)			
predicted	$T_l F_l$	$T_l F_h$	$T_h F_l$	$T_h F_h$
efficiency	0.89	0.80	0.80	0.69

Table 3: *Predicted Efficiency per treatment*

4 Results

4.1 Descriptive overview

Table 4 presents some fundamental descriptive data of the experiment. Recall that the actual gross income was determined by a random draw (with 80% probability for gross income $Y = 1000$, and 20% probability for $Y = 0$). Declared income can be either 1000 or zero. If a subject gets $Y = 1000$, but declares zero income, he is classified as evading the tax. The relative frequency of tax evasion ranges from 40% in treatment $T_l F_h$ (with low taxes, but a high fine) to 59% in treatment $T_h F_l$ (with high taxes, but a low fine). Even though it would be optimal for risk-neutral subjects to evade all the time, many subjects mix in their decision between evasion and truthful declaration.[9] The frequency of changing from evading the tax to truthtelling (and the reverse) is summarized in the variable "Degree of switching". The higher the value of the variable, the more often

[9] The discussion of possible reasons for truthful declaration will follow in Section 5.

a subject changes from evasion to non-evasion and reverse within the 20 rounds of the experiment.

The probability of the detection of tax evasion is dependent on the taxpayer's and the tax authority's efforts for concealment and detection. Efforts are summarized in table 6 below. Detected tax evasion leads to fines, which are highest in absolute terms in treatment T_hF_h, and lowest in treatment T_lF_l. Taxpayers' profits are highest in treatment T_lF_l and lowest in treatment T_hF_h, whereas the reverse holds true for tax authorities.

	treatment(tax/fine)			
Averages per treatment ($N = 20$)	T_lF_l	T_lF_h	T_hF_l	T_hF_h
Real income (Y)	16150	14700	15850	16200
Declared income (D)	8800	8850	6250	6950
Absolute frequency of tax evasion	7.35	5.85	9.60	9.25
Relative frequency of tax evasion (given $Y = 1000$)	0.45	0.40	0.59	0.57
Absolute frequency of paying a fine	2.40	2.50	3.60	3.10
Sum of fines	750	1250	1800	2480
Profit taxpayer	12281	10404	9875	9345
Profit tax authority	10424	10329	10508	11144
Degree of switching (if $Y = 1000$)	4.65	5.80	5.30	7.80
Real tax declaration filled out (1 = yes) ($N = 40$)	0.65	0.53	0.65	0.55
Student of economics and business (1 = yes) ($N = 40$)	0.55	0.80	0.63	0.65
Age ($N = 40$)	22.1	22.0	24.3	22.4

Table 4: *Descriptive data*

4.2 Frequency of evasion

Even though the theoretical prediction would be full evasion in any treatment, we find that the frequencies of evasion are well below one hundred percent in all treatments, with averages ranging from 40% in T_lF_h (with low tax rate and high fine) to 59% in T_hF_l. So we can explore how the evasion frequencies vary with tax rates and fines. We find that the relative frequency of tax evasion is lower in treatment T_lF_h than in treatments T_hF_h ($p = 0.048$, Mann-Whitney U-test) and T_hF_l ($p = 0.026$), respectively. However, the difference in evasion frequencies between T_hF_l and T_lF_l is not significant despite of the considerable difference of population means (0.59 to 0.45). In general, the results seem to imply that tax evasion is more prevalent with higher tax rates, but does not systematically depend on the magnitude of the fine.

Result 1 *Higher tax rates tend to lead to more tax evasion, while higher fines reduce tax evasion only if taxes are low.*

	treatment (tax/fine)			
Relative frequency of tax evasion in rounds	T_lF_l	T_lF_h	T_hF_l	T_hF_h
Overall	0.45	0.40	0.59	0.57
Rounds 1-10	0.41	0.40	0.58	0.51
Rounds 11-20	0.50	0.40	0.62	0.63
$N = 20$ per treatment				

Table 5: Frequency of evasion

Table 5 compares the relative frequencies of tax evasion in the first halfe of the experiment with those in the second. With the exception of treatment T_lF_h, tax evasion frequencies rise in the second half, with the increase being significant in treatments T_lF_l ($p = 0.01$, Wilcoxon signed-ranks test) and T_hF_h ($p = 0.003$).

Testing for the degree of switching between evade/not-evade, we find that this is significantly more frequent in treatment T_hF_h than in any other treatment (with $p = 0.004$ vs. T_lF_l, $p = 0.034$ vs. T_lF_h, and $p = 0.012$ vs. T_hF_l, Mann-Whitney U-test), whereas all other three treatments show no significant differences in pairwise comparisons. Interestingly, the degree of switching is not significantly correlated to any measure of effort.

4.3 Concealment and detection efforts

Aggregate data Table 6 shows average effort levels of taxpayers and tax authorities.[10] In the upper part of Table 6 we report the predicted optimal effort, which is based

[10] Regarding effort levels in the first and second half of the experiment, there is no significant increase or decrease in effort levels from rounds 1-10 to rounds 11-20.

on permanent evasion. The lower part shows the actual data on average effort in case of taxpayers evading the tax, respectively in case a tax authority notices a taxpayer's declaration of zero.[11]

		treatment(tax/fine)			
Predicted optimal effort		T_lF_l	T_lF_h	T_hF_l	T_hF_h
- evasion	taxpayer	3	5	5	8
- declare = 0	authority	1	2	2	3
Actual effort					
avg. effort - evasion	taxpayer	4.91	6.49	7.82	7.95
avg. effort - declare = 0	authority	2.83	4.11	4.82	5.61

Table 6: *Effort levels per round*

We find that the effort levels in our experiment are much higher than the theory predicts. Apart from the taxpayers' evasion efforts in treatment T_hF_h, the levels are even above the prediction for evasion with probability one. Recall that the efforts should decrease with lower evasion probabilities. Given the empirical evasion probabilities (see Table 5) the empirical efforts are excessively high.[12] However, more important is testing for treatment differences in effort levels in case of evasion (or presumed evasion from the perspective of the tax authority). Again, there is a general treatment effect ($p = 0.001$, Kruskal-Wallis test). In particular, efforts of taxpayers in case of evasion are lower in T_lF_l than in any other treatment ($p < 0.05$ for any pairwise comparison, Mann-Whitney U-test) and lower in T_lF_h than in T_hF_h ($p = 0.037$) or T_hF_l ($p = 0.048$). Concerning tax authorities' efforts, they are significantly lower in T_lF_l than in all other treatments ($p < 0.05$ in any pairwise comparison, Mann-Whitney U-test). Furthermore, authorities' efforts are lower in T_lF_h than in T_hF_h ($p < 0.01$).

[11] In rounds 1-10, 39 (out of 80) tax payers choose at least one time a positive effort level although they do not evade the tax (either by declaring full income $Y = 1000$ or by declaring zero income if $Y = 0$). In rounds 11-20, only 16 tax payers do the same. The decline in covering without tax evasion is clearly signifant ($p < 0.01$, χ^2-test). Whereas choosing a positive effort in case of zero real income might be considered as strategically motivated (in order to make it harder for the tax authority to detect tax evasion), positive effort in case of declaring full income has to be considered as irrational or as a mistake. Actually, 35% of participants commit such a mistake at least once, 12% of participants more than twice.

[12] We explore the reasons for this behaviour in Section 5.

Summarizing these results we can say that for given fine parameters the efforts of taxpayers and authorities are significantly higher if tax rates are high. However, checking the impact of fines for given tax rates, we find again that the relationship is not that clear. Higher fines only lead to more effort if tax rates are low, too.

Result 2 *Higher tax rates ceteris paribus lead to higher effort levels, while fines have no unequivocal influence.*

Individual data In the following we examine detection and concealment efforts on the individual level. We start by presenting the distribution of efforts, separately for taxpayers and tax authorities, in our four different treatments. Afterwards, we are going to explore the relation between taxpayers' and authorities' efforts.

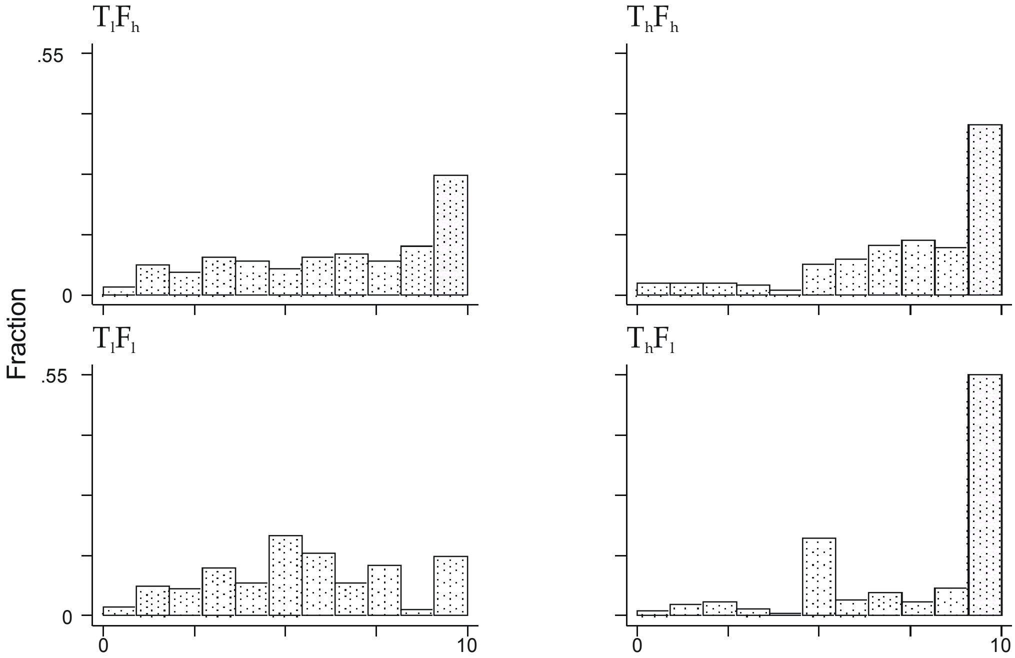

Figure 1: *Taxpayers' efforts if evasion took place*

Figure 1 shows the frequency distribution of concealment efforts if tax evasion took place. We see that the distributions differ considerably between treatments. For high tax rates (see the right hand side of Figure 1) the relative frequency of high concealment efforts is greater than under low tax rates.[13]

[13]For a statistical analysis of differences in means see the previous subsection.

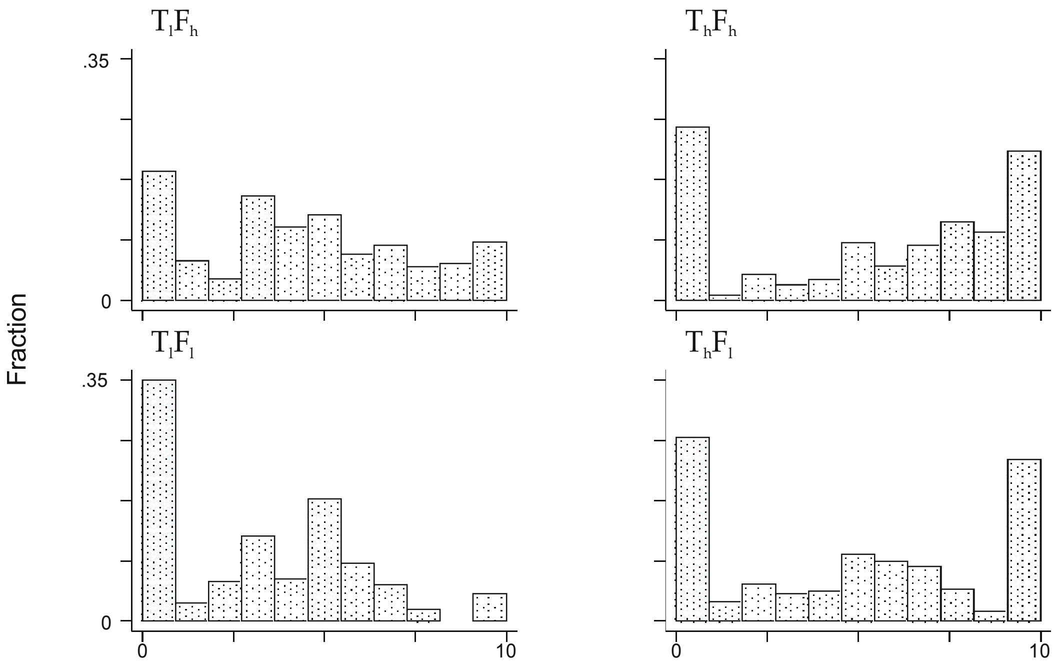

Figure 2: *Authorities' efforts for zero-declarations*

In Figure 2 we plot the relative frequencies of detection efforts if the authority observed a zero declaration. It is evident that under high taxes the relative frequency of very high detection efforts (such as 10) is greater than under low taxes. Furthermore we see that exerting no effort or a very high effort seem to be focal points under the high tax-rate treatments (right hand side of Figure 2). Examining the individual data we find that some authorities mix between efforts of 0 and 10. Such a behaviour is observed with real-world tax authorities (random full-scale audits), while our model does not predict any mixing.

Next, we examine the relation between taxpayers' and authorities' efforts. Does an increased effort of one of the parties lead to an escalation of efforts or does one of the actors eventually back down? In the aggregate, our data suggest that escalation is the more likely event, since the average efforts are highly correlated within pairs (with correlation coefficient $r = 0.7$; $p < 0.01$; $N = 80$). This means that high efforts of the tax authority are typically countered by high efforts of the taxpayer and vice versa. However, this result is driven by the low tax-treatments only. Figures 3 to 6 show the frequency of effort combinations of taxpayers and tax authorities (with single round data as the basis) separately for our four treatments. The correlation of both parties' efforts is only significantly positive in our low-tax-treatments T_lF_l (Figure 3, $r = 0.64$; $p < 0.01$) and T_lF_h

(Figure 5, $r = 0.54$; $p = 0.017$). In both high-tax-treatments, the two most frequent effort combinations (E, A) are (10,0) and (10,10). This can be interpreted as the taxpayer's intention of strategic teaching[14], which - if failing - leads to a tough contest with (10,10), or - if successful - to no auditing at all (10,0). However, no tax evader was actually able to induce the tax authority to back down completely over a large number of rounds by high evasion efforts. The attempt of strategic teaching usually led to an escalation of efforts instead. This may partly explain our excessively high effort levels.

Result 3 *Efforts of authority and taxpayer are correlated for low taxes, while high taxes lead to tax authorities mixing between very high and low efforts.*

Figure 7 indicates the relative frequencies of tax authorities' effort choices for honest zero-declarations of taxpayers. It is interesting to note that in treatment $T_l F_l$ authorities choose zero effort in more than one third of cases. This is an indication that they are relatively good in anticipating the truthfulness of the taxpayer's declaration. On the contrary, in treatment $T_h F_h$ the modal category of detection efforts is 9 or 10.

Furthermore, it is evident that tax authorities over the course of the experiment tried to punish notorious cheats by exerting high efforts in order to raise the detection probability. As a consequence, the partial correlation between evasion frequency and efforts of the authority is $r = 0.47$ ($p < 0.01$), controlling for the efforts of the taxpayers in order to eliminate the escalation effect described above.

Result 4 *High evasion frequencies induce high efforts by the tax authority.*

4.4 Efficiency and tax revenue

We turn to the analysis of the efficiency levels in different treatments. Efficiency here refers to the amount of income that is not wasted in the detection-concealment contest.

[14] Camerer et al. (2002) coined the terminology "strategic teaching" in a learning context.

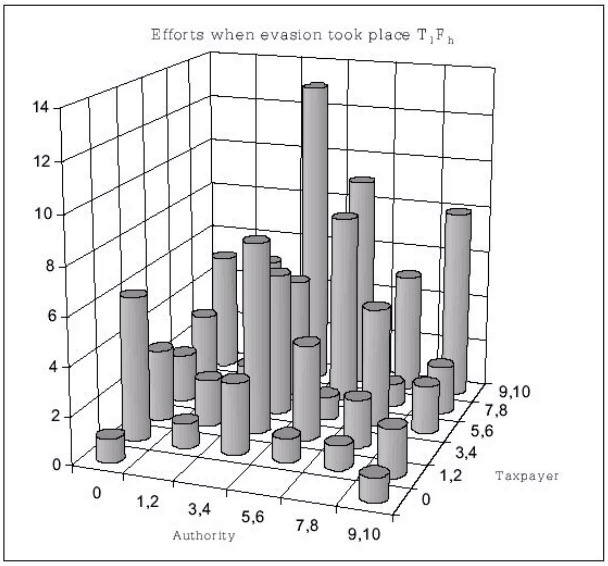

Figure 3: *Effort combinations for treatment* $T_l F_h$

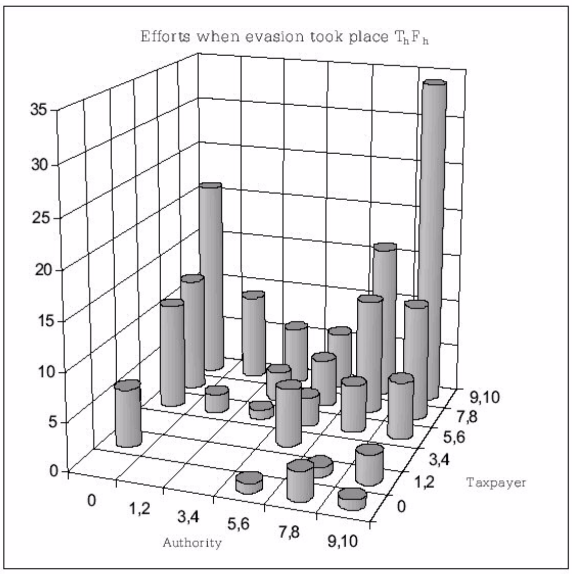

Figure 4: *Effort combinations for treatment* $T_h F_h$

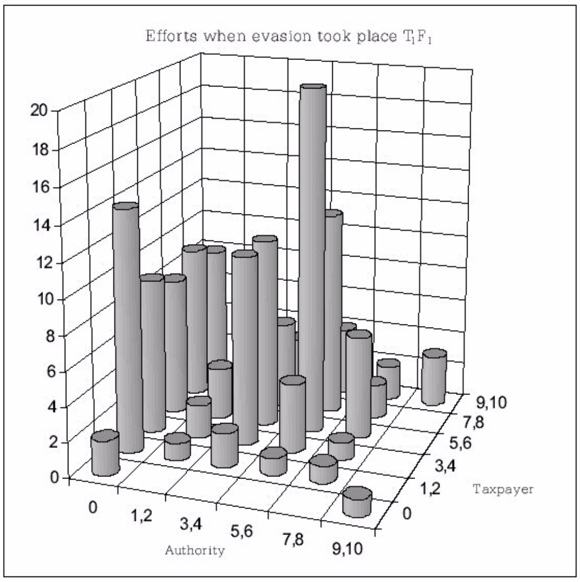

Figure 5: *Effort combinations for the treatment T_lF_l*

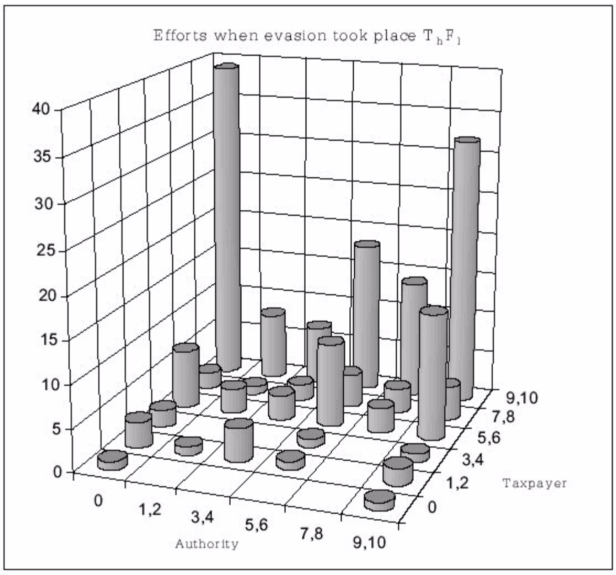

Figure 6: *Effort combinations for treatment T_hF_l*

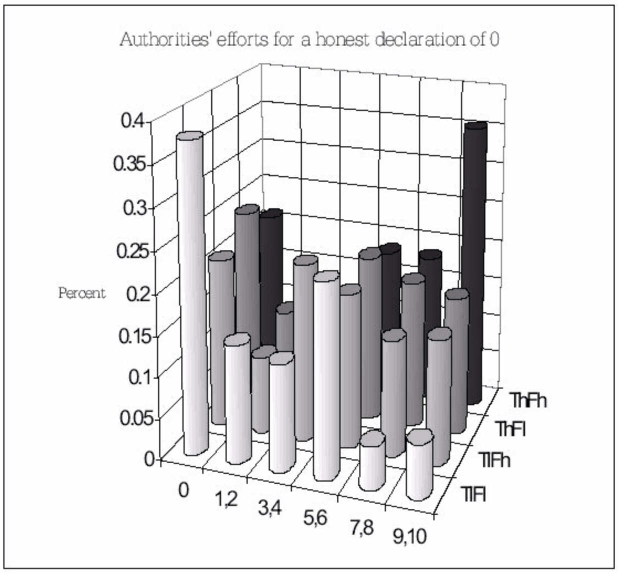

Figure 7: *Authorities' efforts for truthfull zero-declarations*

We calculated an efficiency measure for every pair of subjects. This measure gives the percentage of income created in a relationship that is not invested into wasteful detection and concealment. Figure 8 shows the efficiency distributions for the different treatments. While in the low-tax low-fine treatment (T_lF_l) about 40 percent of pairs achieved more than 90 percent efficiency, not a single pair was able to sustain such a high efficiency level in the high-tax high-fine treatment (T_hF_h). A Kruskal-Wallis test confirms that there is a treatment effect with respect to efficiency ($p < 0.01$, $df = 3$, $N = 80$). Table 7 below shows the average efficiency levels as well as the predicted ones.

Treatment	T_lF_l	T_lF_h	T_hF_l	T_hF_h
Actual efficiency	84.9	79.8	71.8	70.9
Predicted efficiency	89.0	80.0	80.0	69.0

Table 7: *Efficiency by treatment*

Moreover, testing for pairwise differences with a Mann-Whitney U-test shows that low taxes lead to higher efficiency. Efficiency is higher with low taxes than with high taxes, both under low fines ($p < 0.01$) and under high fines ($p = 0.028$). The influence of fines for a given tax rate is not significant. This is in line with our result that the fines do not

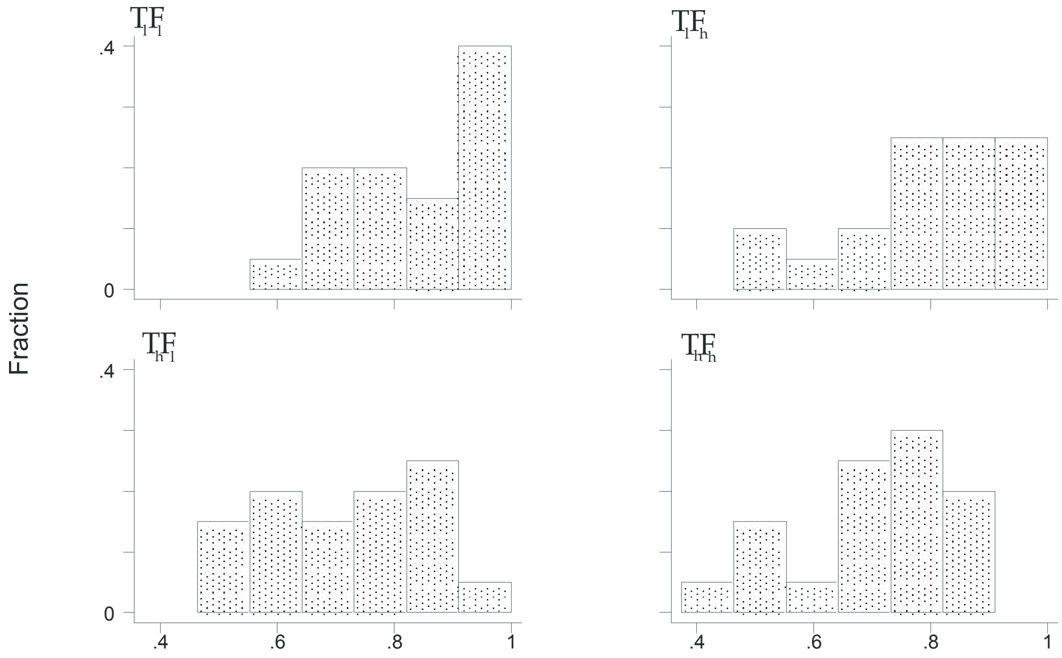

Figure 8: *Efficiency of pairs per treatment*

have a large influence on tax-evasion frequencies. However, if both taxes and fines are high then efficiency is considerably lower than in the case where fines and taxes are low ($p < 0.01$).

Result 5 *Higher tax rates lead to lower efficiency, while the influence of fines is not significant.*

It is interesting to check whether the sacrifice of some efficiency by increasing tax rates at least induces a higher revenue for the government. The surprising answer is that this is not necessarily true if one takes the enforcement effort into account.

Revenue (total for all rounds)	treatment(tax/fine)			
	T_lF_l	T_lF_h	T_hF_l	T_hF_h
Tax revenue	2200	2212.5	2500	2780
Taxes recovered by audits	600	625	1440	1240
Fines	750	1250	1800	2480
− Enforcement Cost	−1126	−1758.5	−3232	−3356
Total net revenue	2424	2329	2508	3144
Net revenue in percent of income	15.0	15.8	15.8	19.4

Table 8: *Average revenues by treatment*

Table 8 above summarizes the average revenue (summed over all 20 rounds) by treatments. Higher tax rates lead to higher tax revenues, higher taxes recovered by audits, and higher revenues from fines. However, if the enforcment cost (effort cost of the authority) is deducted then the differences in total net revenue are small. In fact, pairwise Mann-Whitney U-tests indicate that there are no statistically significant differences in total net revenues among treatments. Higher taxes tend only to increase net revenue - if at all - when they are backed up by high fines.

Result 6 *Higher taxes do not lead to a significantly higher net revenue if enforcement costs are deducted.*

4.5 The effects of detected tax evasion

In this section, we are going to examine taxpayers' and tax authorities' future play after tax evasion was detected. In principle, the detection of tax evasion in round t can have two different effects on the taxpayer's side. Either the taxpayer switches to truthfully reporting the full income in the next round ehen he has income $Y = 1000$, or the taxpayer sticks to evading taxes by declaring zero income, but increases his concealment effort. The tax authority can react to detected tax evasion by changing the detection effort in the next round when the taxpayer declares zero income.

In total, tax evasion was detected and a fine had to be paid in 232 out of 641 cases of tax evasion (see also Table 1 for the absolute frequency of paying a fine in our different treatments). Table 9 summarizes taxpayers' and tax authorities' reactions to detection in round t. The first row indicates the average frequency of truthful declaration in the next round (with $Y = 1000$). Note that switching to truthful declaration is most probable in our treatments with high fines, and least probable with low fines. Given low tax rates, the influence of the fine's size is significant. High fines lead to a considerably higher frequency of full declaration than low fines ($p < 0.05$; one-sided Mann-Whitney U-test). With high tax rates, the difference is not statistically significant.

Relative frequency of	T_lF_l	T_lF_h	T_hF_l	T_hF_h
- truthful declaration$^{*,+}$	0.40	0.73	0.46	0.55
- increasing concealment effort$^{*,\#}$	0.69	0.72	0.77	0.56
- increasing detection effort$^{*,\sim}$	0.26	0.17	0.13	0.15

Notes

* averages are taken across subjects with a given treatment.

$^+$ data refer to the next round with $Y = 1000$.

$^\#$ data refer to the next round with $Y = 1000$ and $D = 0$.

$^\sim$ data refer to the next round with $D = 0$.

Table 9: *Reaction to detection in round t*

If taxpayers continue to evade taxes in round $t + 1$ (or the next round with $Y = 1000$) after detection in round t, their concealment effort increases, on average, in about two thirds of the cases. The increase in concealment effort is significantly different from a random draw ($p < 0.05$, binomial test) for all treatments, except T_hF_h.

Interestingly, tax authorities react strikingly different to detection in round t. The next time a taxpayer declares zero income ($D = 0$) after detection in round t, detection effort is increased in less than 20% of cases, on average. The decrease in detection effort is significantly different from a random draw ($p < 0.05$, binomial test) for all treatments.[15]

Hence, whereas taxpayers who continue to evade taxes increase their concealment effort in order to reduce the probability of being caught cheating on taxes, tax authorities reduce their detection effort in more than 80% of cases when they face a zero income-declaration the next time. This might be due to tax authorities expecting taxpayers to switch to truthful declaration of income after suffering a fine from detected tax evasion in round t.

Result 7 *After being caught taxpayers switch to honesty more often if fines are high. Taxpayers who still evade tend to increase the concealment effort, while tax authorities do not anticipate this and consequently reduce their detection effort.*

[15] Applying a Wilcoxon-signed ranks test to the relative frequency of increasing concealment effort, respectively detection effort, within a given pair of taxpayer and tax authority, we can confirm that taxpayers increase their effort significantly more often than tax authorities ($p < 0.05$ for any treatment separately, two-sided test).

5 Why do people pay taxes?

In this section we explore briefly why in the experiment taxpayers did not always evade taxes even though this would have been profitable. Since it was not the main purpose of our experiment to address this question there may be many different possible explanations our experimental design cannot discriminate between. So this section gives some ex-post interpretations, which, although plausible, should be further examined by experiments tailored to discriminate between those and possible alternative explanations.

There are two main reasons why people would choose not to evade even if the evasion is a better than fair gamble: risk aversion and moral constraints. Recall that a taxpayer should always evades if his utility from being honest is smaller than the expected equilibrium utility from evasion. To be willing to mix between truthful declaration and evasion the following has to hold, where (C1) is for expected utility theory and (C2) is for expected value maximization with moral constraints, which cause some moral cost K in case of evasion.[16]

$$U(Y_h) = [1 - p(A^*, E^*)]\, U(\overline{Y}) + p(A^*, E^*) U(\underline{Y}) \tag{C1}$$

$$Y_h = [1 - p(A^*, E^*)] \left[\overline{Y} - K\right] + p(A^*, E^*) \left[\underline{Y} - K\right] \tag{C2}$$

Here Y_h is the net income for truthful declaration, $\overline{Y}$ the gross income for successful evasion, and $\underline{Y}$ gives the payoff if evasion is detected. We see that for (C1) under risk aversion ($U' > 0$ and $U'' < 0$) the expected payoff for evasion has to be greater than the certain net income after truthful declaration. This directly follows from Jensens' Inequality. The same is true for the moral constraint condition (C2). There the expected payoff from evading has to exceed the certainty equivalent by the moral cost K. If we now compare the payoffs in the experiment with the certainty equivalent we find out that on average the taxpayers earned less than they would have if they would have declared always truthfully. This is also confirmed by a statistical test. The payoffs for the taxpayers are significantly smaller than the net income after truthful declaration ($p = 0.03$, one-sided Wilcoxon-Test, $N = 80$).[17] Consequently, both hypotheses alone cannot explain

[16] A hybrid equilibrium where the taxpayer mixes between truthful revelation and evasion if he earned the income requires that the taxpayer is indifferent between evasion and non-evasion in that case.

[17] We calculated and used the difference between actual payoff and hypothetical honesty payoff for every taxpayer over the 20 rounds for the statistical test.

that taxpayers were sometimes honest. On the contrary, this finding even suggests that taxpayers were risk-loving. This immediately becomes plausible if one takes the framing of the situation into account. Taxpayers earn an income and then have to pay taxes. If taxpayers use their gross income as a reference point the tax liability is perceived as a loss. According to Prospect Theory (Kahneman and Tversky, 1979) people are loss-averse. A further indication for loss-aversion are the high efforts in the experiment (compared to efforts predicted under risk-neutrality). It is possible to show that loss-aversion tends to increase efforts.[18]

If taxpayers are loss-averse, it still remains to be explained why they frequently truthfully reported their income. The reason why that may have been the case becomes clearer if we look at some subjects showing the rather radical behaviour of always truthfully reporting the income. In the experiment 7.5 percent of the taxpayers always reported their gross income correctly. There is no utility function (not even extreme risk-aversion) that can explain this behaviour. For an explanation we come back to moral constraints. If we allow for moral constraints, i.e. an additional psychological cost K of non-compliance, the behaviour becomes explainable. Then the honest taxpayers did choose to truthfully reveal their income because they had very high scruples.[19]

So a combination of loss-aversion and scruples is a plausible explanation for the behaviour of taxpayers. Their behaviour, however, might be highly influenced by the tax authorities' detection efforts. In the low tax treatment the authorities' behaviour is roughly consistent with the prediction of our model. The fact that in the high tax treatments tax authorities frequently switch from very high to very low detection efforts and vice versa is a bit puzzling. Our tentative explanation would be that the perceived intentions play a role. A higher tax widens the payoff spread for the authority between tax compliance and evasion. Therefore the perceived intention of an evader as perceived by the authority should be worse under higher tax rates. So if people react to bad intentions with punishment (see Charness and Rabin, 2002 or Falk et al., 2003) then the high efforts could be explained by the attempt to punish the taxpayer. These high efforts, though, are very expensive, such that a subject only wants to punish if it is certain enough that the opponent cheated.[20]

[18] Proofs for some utility functions can be obtained from the authors.

[19] Note that anticipation of a very high detection effort by the authority or reputation-building was not the reason for taxpayers being truthful. The tax authorities who faced zero-declarations of permanently honest taxpayers frequently anticipated this and repeatedly chose a detection effort of zero. So a one-off evasion would have been very profitable in monetary terms.

[20] The tax authority's mixing between very high and very low efforts alternatively can be the result of overconfidence with respect to the guess whether the taxpayer cheated or not, leading to beliefs close to 0 or 1. It is not clear however, why this should happen under high tax rates only.

6 Conclusion

Tax evasion is a prevailing phenomenon in most countries. Besides having a negative effect of cutting the state's budgetary scope, tax evasion may entail an excess burden by inducing both taxpayers and tax authorities alike to invest unproductively and waste resources in order to conceal, respectively detect, tax evasion. Bayer (2002) has shown that higher tax rates lead, ceteris paribus, to an increase in the amount of wastefully invested resources. This theoretical hypothesis is confirmed in our experiment. On the contrary, fines have been found not to have a significant influence on the inefficiencies created by the tax collection and enforcement system. Hence, tax rates, but not fines, are the driving force for a tax regime's excess burden.

Tax rates also play a prominent role in influencing the scope of tax evasion. Our experiment shows that tax rates tend to have a signficantly positive influence on tax evasion. Fines, however, failed to significantly influence tax-evasion behaviour. A better deterrent proved to be the experience of being caught when fines are high. A majority of tax cheats turned to honest taxpayers after having been caught provided that the fines are high. Low fines, however, do not have this catharsis effect due to painful experience. This suggests that fines and audit effort are rather complements than substitutes for tax enforcement.

As more convictions of tax cheats are an expensive mean for reducing tax evasion, since this increases enforcement costs, one might want to consider alternative measures. In our experiment lower taxes proved to be a very good alternative. Lower taxes reduced tax evasion and inefficiencies without leading to a significant drop in net revenue. High taxes only tended to increase the net revenue - though not significantly in a statistical sense - if in addition high fines applied. This finding gives another rationale for keeping tax rates low, additionally to the well known disincentive effects of high tax rates.

The relatively high frequency of taxpayers' truthfully reporting their income can be accounted for in a model which assumes moral constraints or scruples on the side of taxpayers. Such moral constraints may provide an effective deterrent to tax evasion. The perception of the tax system to be fair, government spending to be efficient and politicians to be men of integrity has been shown to reduce tax evasion (Pommerehne and Weck-Hannemann, 1996). The underlying reason for this finding might be that these perceptions foster positive attitudes toward the state and taxation which become behaviourally relevant by increasing tax-evasion scruples and, thus, reducing tax evasion.

References

[1] Alm, J.,McClelland, G. H., Schulze, W. D. (1992), Why do people pay taxes? *Journal of Public Economics* **48(1)**: 21-38

[2] Bayer, R.-C. (2002), A contest with the taxman - The impact of tax rates on tax evasion and wastefully invested resources. Mimeo, London School of Economics.

[3] Camerer, C. F.; Teck-Hua H.; Chong, J.-K. (2002), Sophisticated experience-weighted attraction learning and strategic teaching in repeated games. *Journal of Economic Theory* **104**: 137-188.

[4] Cebula, R. J. (2001), Impact of income-detection technology and other factors on aggregate income tax evasion: The case of the United States. *Banca Nazionale del Lavoro Quarterly Review* **54**: 401-415.

[5] Charness, G.; Rabin, M. (2002), Understanding social preferences with simple tests. *Quaterly Journal of Economics* **117**: 817-868.

[6] Cowell, F. A. (1990), Cheating the government - The economics of evasion, MIT Press, Cambridge, London.

[7] Cremer, H., Gahvari, F. (1994), Tax evasion, concealment and the optimal linear income tax. *Scandinavian Journal of Economics* **96**: 219-239.

[8] Falk, A.; Fehr, E.; Fischbacher, U. (2003), On the nature of fair behavior, *Economic Inquiry* **41**: 20-26.

[9] Fischbacher, U. (1999), Z-tree: Zurich toolbox for readymade economic experiments, Working paper No. 21, Institute for Empirical Research in Economics, University of Zurich.

[10] Gordon, J. P. F. (1989), Individual morality and reputation costs as deterrents to tax evasion, *European Economic Review* **33:** 797-805.

[11] Kahneman, D., Tversky, A. (1979), Prospect theory: An analysis of decision under risk, *Econometrica* **47**(2): 263-291

[12] Myles, G. D., Naylor, R. A. (1996), A model of tax evasion with group conformity and social status, *European Journal of Political Economy* **12:** 49-66.

[13] Pommerehne, W. W., Weck-Hannemann, H. (1996), Tax Rates, Tax Administration and Income Tax Evasion in Switzerland. *Public Choice* **88**: 161-170.

[14] Schneider, F., Enste, D. H. (2000), Shadow economies: Size, causes, and consequences. *Journal of Economic Literature* **38**: 77-114.

[15] Slemrod, J., Blumenthal, M., Christian, C. (2001), Taxpayer response to an increased probability of audit: evidence from a controlled experiment in Minnesota. *Journal of Public Economics* **79**: 455-483.

[16] Usher, D. (1986), Tax evasion and the marginal cost of public funds. *Economic Inquiry* **24**: 563-586.

[17] Wenzel, M., Taylor, N. (2002), An experimental evaluation of tax-reporting schedules: A case of evidence-based tax administration. Australian National University, Working Paper.

Appendix - Experimental instructions

Instructions (originally in German)

We provide the instructions for the T_hF_h-treatment. In treatments with the low tax rate (T_lF_x) the tax rate was set at 25% instead. In treatments with the low fine (T_xF_l), the fine consisted of the evaded tax plus an additional payment of one quarter of the evaded tax.

Welcome to the experiment!

We kindly ask you not to talk to other participants until the end of the experiment.

In this experiment, there are two different roles, *taxpayer* and *tax authority*. The experimental currency is denoted as Taler. The exchange rate is set at

1000 Taler = 1.2 Euro.

One taxpayer and one tax authority will be paired for the whole experiment, i.e. there are fixed pairs. The experiment consists of 21 identical rounds. The first one of these will be a trial round which will not be paid.

A. Sequence of events in each round

At the start of each round there is a random draw on the taxpayer's income in this round. With a probability of 80% the taxpayer receives 1000 Talers as income. With a probability of 20% the taxpayer's income is zero.

The *taxpayer* gets informed about his income (either 0 or 1000 Taler) and has to decide whether or not to *declare* his income to the tax authority (either 0 or 1000 Taler). Furthermore, the taxpayer has to decide on a *concealment effort* (ranging from 0 to 10 points). Positive concealment effort causes costs, which will be specified below. The higher the chosen concealment effort, the less likely it becomes that the tax authority will be able to verify the taxpayer's real income.

The *tax authority* learns about the taxpayer's declared income. Note that the tax authority gets no information about the real income of the taxpayer, nor about the taxpayer's concealment effort. The tax authority has to choose a *detection effort* (ranging from 0 to 10 points). Positive detection effort is costly. The higher the chosen detection effort, the more likely the tax authority will be able to verify the taxpayer's real income.

The combination of concealment effort and detection effort determines the probability of verifying the taxpayer's real income, as will be explained in detail below. Given this probability, a random draw will determine whether the taxpayer's real income will be verified or not.

After each round both the taxpayer and the tax authority will be informed about the taxpayer's concealment effort and the tax authority's detection effort, as well as whether the real income could be verified by the tax authority.

B. Payoffs per round

1. Taxpayer's payoff

payoff = real income - taxes - potential fine - costs of concealment effort

- Taxes: Declared income * tax rate: The tax rate equals 40%.
- Fine: The taxpayer has to pay a fine in case he/she has declared zero income although real income is 1000 Talers, *and* if the tax authority was able to verify the real income. The fine consists of the evaded tax (= real income * tax rate = 400 Taler) plus an additional payment of equal size (= 400 Taler). Hence, the potential fine amounts in total to 800 Taler.
- Costs of concealment effort:

Concealment effort (points)	0	1	2	3	4	5	6	7	8	9	10
Costs (in Taler)	0	20	40	60	80	100	120	140	160	180	200

2. Tax authority's payoff

payoff = basic wage + taxes + potential fine - costs of detection effort

- Basic wage: 450 Taler
- Taxes: Declared income * Tax rate (40%)
- Fine: If the real income is verified and the taxpayer declared less than his/her real income, the tax authority receives the fine of 800 Taler (for the composition of the fine see above).
- Costs of detection effort:

Detection effort (points)	0	1	2	3	4	5	6	7	8	9	10
Costs (in Taler)	0	40	80	120	160	200	240	280	320	360	400

C. The probability of detection

The following table shows, how the combination of concealment effort and detection effort determines the probability of verifying the real income. Figures in the table denote percentages.

		Detection effort										
	Points	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Concealment effort	*0*	100	100	100	100	100	100	100	100	100	100	100
	1	0	50	67	75	80	83	86	88	89	90	91
	2	0	33	50	60	67	71	75	78	80	82	83
	3	0	25	40	50	57	63	67	70	73	75	77
	4	0	20	33	43	50	56	60	64	67	69	71
	5	0	17	29	38	44	50	55	58	62	64	67
	6	0	14	25	33	40	45	50	54	57	60	63
	7	0	13	22	30	36	42	46	50	53	56	59
	8	0	11	20	27	33	38	43	47	50	53	56
	9	0	10	18	25	31	36	40	44	47	50	53
	10	0	9	17	23	29	33	38	41	44	47	50

Example: If the tax authority chooses a detection effort of 7 points and the taxpayer a concealment effort of 2 points, then the detection probability is 78%. Imagine an urn with 100 balls, numbered consecutively from 1 to 100. If in a random draw a ball with a number from 1 to 78 is drawn, then the real income is verified and known to the tax authority. If a ball with a number from 79 to 100 is drawn, the taxpayer's real income remains concealed.