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Veröffentlichungsversion / Published Version
Arbeitspapier / working paper

IHS Working Paper 21
August 2020

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Title

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Empowering consumers to reduce corporate tax avoidance

Theory and Experiments

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Monday, 31 August 2020

Abstract

We analyze corporate tax avoidance in a theoretical model and in a stylized experimental Bertrand setting in which symmetric firms and consumers sell and buy a homogeneous product, when human participants make decisions as firms and consumers. We investigate how market power and information disclosure of firms' tax avoidance behavior impacts corporate tax avoidance and market competition. By imposing a tax rating, corporate tax behavior becomes more transparent, and consumers actively and costly boycott firms that do not pay their taxes. Firms adapt and anticipate consumer boycotts and increase tax payments, and prices. When rating disclosure is voluntary, the positive effect on corporate tax compliance vanishes in large markets.

JEL codes: H26, C92, D78, D82, L15

Keywords: tax avoidance, policy measure, tax rating, transparency, lab experiment

1. Introduction

> *"Tax havens are one of the key engines of the rise in global inequality. As inequality rises, offshore tax evasion is becoming an elite sport".* *Gabriel Zucman on Paradise Papers, The Guardian, Nov 8, 2017*

Multinational companies have been receiving more than usual attention by both national tax authorities and the general public. Since their remarkably low (often close to zero) effective corporate tax payments became public knowledge they have featured prominently in the public (tax policy) debate. The discrepancy of sales in the billions yet corporate tax liabilities in the low thousands attracted the attention of political heavy-weights such as the European Commission, the G8, G20 and many national tax authorities. Also, the OECD acknowledged the substantial economic importance of aggressive tax planning and launched a special program to fight *Base Erosion and Profit Shifting* (BEPS). Clearly, budgetary constraints on the one hand and robust empirical evidence on tax avoidance on the other hand ask governments to coordinate and negotiate to achieve some kind of sustainable agreement with the tax havens around the globe.[1]

Besides heated political discussions and the potential legislative threat of stricter accounting rules, the aggressive tax planning by multinationals has produced up-wind for consumer initiatives who have called for boycotting firms that have been blamed for engaging in aggressive tax avoidance conduct. This paper links these two fronts and explores whether and to what extent empowering consumers by increasing tax transparency might actually work as a complementary policy measure to curb corporate tax avoidance.

Corporate tax avoidance

After the *Paradise Papers*, a poll in UK found that 9 out of 10 people believe that tax avoidance by large companies is morally wrong, even if technically legal. In this paper, we investigate tax avoidance, not evasion. Two quotes colorfully shed light on the distinction of both terms: "When the law draws a line, a case is on one side of it or the other, […] When an act is condemned as evasion, what is meant is that it is on the wrong side of the line ... [Bullen v. Wisconsin (1916)]" (Slemrod and Yitzhaki, 2002, p.1428). And for tax avoidance Fuest et al. (2013, p.19) state: "Profit shifting and tax planning – even if considered as aggressive – are not violations of the law, even if they are in conflict with what was intended." So, although

[1] For a recent review of the evidence on tax avoidance see e.g. Fuest et al. (2013).

avoidance is legal and evasion is not, the differences in practice seem not to be clear-cut, basically by substance making corporate tax avoidance a gray area, and any case brought forward will require interpretation of what is acceptable and what is not. Closing legal tax loopholes is not straight-forward at all, even if the political will to do so would be extraordinary. It is therefore natural to explore complementary mechanism that could help curbing corporate tax avoidance.[2] One such mechanism could be to increase transparency, thereby enabling consumers to make up their minds themselves, and to consider corporate tax avoidance practices as well, when making their consumption choices.

Transparency and consumer (re)actions

Transparency and reputation building

If a product feature is hidden from consumers when making choices (say, a feature defining its quality) market performance is compromised. Since Akerlof (1970), a number of market mechanisms have been proposed to alleviate or eliminate such information problems. One of the earliest mechanisms is the voluntary supply of verifiable information on the product quality. If disclosure costs are negligible and consumers are rational, firms with medium to high quality products will disclose information to differentiate themselves from low quality firms (see Grossman, 1981 and Milgrom, 1981). In contrast to this "unravelling" prediction, the voluntary disclosure of information is at best incomplete in practice (for a recent review see Dranove and Jin, 2010). These information problems get even more severe when consumers do not get to know the product quality after purchase (credence goods, e.g. Dulleck et al., 2011; Huck et al., 2016).

The interaction between market features (transparency, repeated interaction, reputation, competition, strategic choice variables) and market efficiency when informational asymmetries are present has been analyzed empirically and experimentally. Some effects are straightforward, as in Huck et al. (2012), in which the sellers' reputation increases market efficiency in the presence of moral hazard.[3] In others, results are still under dispute, as the effect of competition on efficiency is positive in Huck et al., 2012, and inexistent in Dulleck et

[2] Whereas tax evasion has been studied extensively (Allingham and Sandmo, 1972; experimental account: e.g. Tyran and Feld, 2006, more recently Lefebvre et al., 2015, Dwenger et al., 2016) , only a very thin literature addresses the substantial problem of tax avoidance (Blaufus et al., 2015), i.e. willfully reducing tax liabilities, without breaking the law.

[3] Reputation building modelling has a long tradition in economics (Kreps et al., 1982), and it is mainly based on reciprocal behavior (Bolton et al., 2013).

al. (2011). In others, the effect depends on facilitating factors, as in Huck et al. (2012) where, once competition is in place, transparency has no noticeable effect on efficiency, having a positive effect in less competitive environments.

This literature is relevant to our research because tax compliance behavior can be one component of the quality of a firm's product. If consumers (weakly) positively valued the firms' tax compliance, we would be in the domain of vertical differentiation models. Under these circumstances, transparency on tax compliance behavior should have a positive effect on quality, as already found in Henze et al. (2015); the complementary result is found in Balafoutas et al. (2015), as revealing the willingness to avoid taxes negatively affects the quality of the product.

Implicit in the argument that transparency will increase tax compliance behavior is that consumers are rational and make the correct inferences about the firms withholding information about quality. Recent studies cast some doubts on the inference process that might be responsible for the failure of the unravelling argument in practice (see Jin et al., 2015). Nevertheless, in this paper we assume rational consumers and firms.

Quality labels

If consumers had full information about all products in their choice set, there would be no need for certification, product standards or labels. However, as this assumption is violated in almost every real-life consumption situation, product labels can provide helpful information. That is why a variety of labels has been launched in the recent past. For example, governments have introduced labels to increase consumer awareness and to (successfully) steer consumption. Examples reach from compulsory energy efficiency standards for electric home appliances (Newell and Siikamäki, 2014), energy labels for buildings (Hyland et al., 2013; Kok and Jennen, 2012), food hygiene standards (Vegeris and Smeaton, 2014), to country of origin identification (Peterson and Jolibert, 1995).[4]

Whereas governments typically make labels compulsory, NGOs, lacking this legislative power, typically introduce certification on a voluntary basis. Classic examples include organic or

[4] There is no neutral label: if a label conveyed only irrelevant information there would be no point in introducing that label in the first place. In all other cases there is an expectation that, incorporating the additional information will weakly shift demand in one particular direction. For example, in the case of energy efficient household appliances, people would likely either pick more efficient gadget or they ignore this additional information. However, it is hard to conceive that, ceteris paribus, such information causally would make them buy less energy efficient products.

GMO-free food (Marette et al., 2012), no animal testing for cosmetics, sustainable foresting (FSC) and fishing (MSC), or local agricultural produce. Firms fulfil their corporate social responsibility (CSR) and get certified (e.g., ISO 26000) to label themselves, going voluntarily beyond the minimal legal requirements (McWilliams and Siegel, 2001).

Their efforts usually include fair employment conditions and sustainable environmental standards through which firms can gain reputational benefits such as positive corporate associations and purchase intentions (Groza et al., 2011; Nan and Heo, 2007). However, somewhat interestingly, "CSR scholarship has been largely silent on the issue of the payment of corporate tax" (Dowling, 2013, p.173, see also Christensen and Murphy, 2004). In this article, we do not directly address the issue of whether or not tax avoidance should be part of CSR considerations, but we experimentally test whether and to what extent consumers steer their purchases and engage in consumer boycotts as a response to corporate tax avoidance.

Consumer boycotts

A consumer boycott is considered to be "an attempt by one or more parties to achieve certain objectives by urging individual consumers to refrain from making selected purchases in the marketplace" (Friedman, 1985, p.97). Consumer boycotts can be caused by various dimensions such as factory closings (Klein et al., 2004), factory relocations (Hoffmann and Müller, 2009), sudden increases in retails prices (Engelmann and Tyran, 2005) or the impression of unfair prices in general (Xiao and Houser, 2009). Further established reasons for consumer boycotts include service offshoring (Thelen and Shapiro, 2012), socially immoral behavior of companies (Strong, 1997; Waddock, 2004), corporate wrongdoing in general (Thelen and Shapiro, 2012), or even be related to foreign policy (Chavis and Leslie, 2008).

As consumer boycotts can also be seen as an instrument of 'moral self-expression' (Kozinets and Handelman, 1998) and a way to 'vote by consumption' (Shaw et al., 2006), disagreement with a company's tax conduct could be a valid reason to boycott that firm. Whereas consumers, national firms and multi-national companies all face specific tax duties, only the multi-national enterprises can make use of big-scale tax avoidance schemes by cleverly using tax loopholes that are not accessible (to a comparable extent) by the national taxpayers (both national companies and consumers).[5] In fact, fairness concerns about how the total tax burden should

[5] In this article, we focus on the role of companies and consumers with and without substantial avoidance opportunities, respectively. Hence, we leave investigating the role of purely nationally operating companies for future research.

be split between (multi-national) firms and consumers could be a powerful reason to participate in a consumer boycott of a tax avoiding company. In any case, consumer boycotts are considered to be a relevant factor influencing a company's competitiveness, especially if there are other companies that offer similar products but are not boycotted at the same time (Vorley, 2003). So far, the majority of studies related to consumer boycotts looked at unidirectional effects only. Either the causes and reasons for (un)successful consumer boycotts *or* their effect on companies' strategies was analyzed separately.[6] We close this gap by explicitly investigating the mutual behavioral reactions on both sides of the market, allowing for consumer boycotts and corporate counter-measures in a repeated setting. In our environment, corporate tax compliance has direct and immediate consequences on firms' ability to compete in prices.

Research aim and contribution

Curbing tax avoidance is not straight-forward at all. Even if it was possible to waive the magic wand, it would be very hard to quantitatively define a moral benchmark for excessive tax avoidance, namely because it is *not* illegal to avoid taxes. Put simply, it is not clear how much tax avoidance could be deemed acceptable. That is why we investigate a market-based solution without the need to set a normatively acceptable avoidance level.

Beyond the robust evidence discussed above on the effect of quality labels (introduced by either policy makers, NGOs or even firms themselves) on consumer behavior, it has never been investigated whether disclosing information about corporate tax avoidance could induce behavioral change. In this paper we present experimental evidence on how different levels of transparency, in the form of tax ratings, shape the interaction of consumers and firms in stylized markets in which we vary consumers´ bargaining power.

The closest example of quality labels for firms with reasonably low tax avoidance is the initiative www.fairtaxmark.net. On their website they state "The Fair Tax Mark is the label for good taxpayers. It is for companies and organizations that are proud to pay their fair share of tax."[7] We aim to understand the mechanisms and limitations of certifying tax compliance when

[6] Only Engelmann and Tyran (2005) endogenously analysed both sides of the market simultaneously, but with a very different focus.
[7] http://www.fairtaxmark.net/what-is-it/, accessed 3/3/2016

firms and consumers interact in a market, causally identifying its effectiveness in an incentivized lab experiment.

In summary, we contribute to the thin experimental literature on tax avoidance by conducting a market experiment with varying levels of tax transparency and consumer market power.[8] We include the special case of firms voluntarily choosing their transparency and allow consumers to boycott firms in varying intensities. We answer the following questions: (i) Does tax transparency cause less corporate tax avoidance? (ii) Does the effect of transparency change with market power?

2. Experimental design and hypotheses

In this section, we present our experimental setup before introducing a model based on a vertical differentiation framework in which a firm's tax compliance represents its product quality. Based on this model, we derive hypotheses.

2.1 Experimental design and procedures

We implement a price competition market with 2 firms producing the same homogeneous product. Consumers, either 2 or 4 depending on the treatment, can buy up to 5 units each. Participants interact for 20 periods, firms share the same technology with constant marginal cost (30 Experimental Currency Units, ECU), and consumers always value each unit 100 ECU. Any exchange at a price between 30 and 100 generates a positive profit to both parties, and by design prices always remain in the interval $[0, 100]$.[9] Consumers were not informed about firms' production costs and firms did not know about consumers' valuations.

Exchanges are charged with a transaction fee of 10 ECU for both parties, but only firms can avoid paying these fees.[10] The avoidance technology is linear and modest, for firms: avoiding the transaction fee generates a cost to firms of 1 ECU. Corporate tax avoidance generates a negative externality to other agents, as any transaction fee avoided by a firm is charged to the other firm and consumers, weighted by their market participation (the number of units bought

[8] In line with Engelmann and Tyran (2005), Kritikos and Bolle (2004), Purchase (2004) and Sen et al. (2001) we think of the action of boycotting a company similar to the provision of a public good by the group of upset consumers. We therefore consider varying the number of consumers as an interesting treatment dimension as coordination and free-riding problems will increase with the number of consumers.

[9] Choosing 30 rather than 0 for the constant unit cost was a deliberate decision to avoid a natural focal point 50 of equally splitting the surplus.

[10] In the experiment, we deliberately avoided using a taxation context; instead we used the label "exchange fee" for this transaction charge.

or sold by each consumer or firm). While firms can individually cheat on fees, consumers always pay theirs (plus a fraction of any taxes avoided by firms).

Our factorial design consists of six between-subjects treatments in which we manipulate two conditions: (i) market size, measured by the number of consumers (either 2 or 4), and (ii) tax transparency, defined by the provision of information about firms' individual compliance (no information, mandatory or voluntary disclosure of tax ratings).

Table 1. Experimental design

		Tax transparency		
		No	Mandatory	Voluntary
Market size	Small	NO22 (17)	MAN22 (9)	VOL22 (9)
	Large	NO24 (7)	MAN24 (11)	VOL24 (11)

Note: Table 1 displays the 2x3 factorial design, where each treatment abbreviation, which refers to the tax transparency regime, is accompanied by a number, either 22 or 24, that indicates a treatment with two or four consumers, respectively (all treatments have 2 firms). The number of independent observations per treatment (markets) appears in parentheses.

The sequence of decisions is straightforward. In Stage 1, firms choose prices. In Stage 2, consumers buy from one or both firms (with a limit of 5 units per consumer). In stage 3, firms receive information about their sales, and the price and market share of their rival, and decide how many units to 'withdraw' –if any– from tax payments. In treatments VOL22 and VOL24, firms also decide on whether they want to voluntarily disclose their tax compliance.[11] At the end of each round, agents received information about their payoffs in a table including all previous periods.

The payoffs of firm f charging price p_f, selling q_f units and declaring t_f units were

$$\pi_f = \underbrace{(p_f - 30)q_f}_{net\ revenues} - \underbrace{10t_f}_{own\ taxes} - \underbrace{(q_f - t_f)}_{\substack{avoidance \\ cost}} - \underbrace{10t_f \frac{Q - T}{Q + T}}_{burden\ shifting}$$

where $Q = \sum_f q_f$ is the total units sold in the market and $T = \sum_f t_f$ is the total number of units declared.

The payoffs of consumer c buying q_{cf} units from firm f were

[11] If firms declare all their sales, they pay exactly the same amount of tax per unit sold as consumers pay per unit bought (i.e. full tax compliance would result in an equal split of the tax burden).

$$\pi_c = \underbrace{\sum_{f\in\{1,2\}} (100 - p_f) q_{cf}}_{net\ revenues} - \underbrace{10 q_c}_{own\ taxes} - \underbrace{10 q_c \frac{Q - T}{Q + T}}_{burden\ shifting}$$

where $q_c = \sum_f q_{cf}$ is the total units bought by consumer c in the market.

In our design, taxes have to be paid. If a firm avoid paying taxes in full, it shifts the tax burden to other participants (consumers and the other firm). Tax avoidance is not only inefficient (because of the positive avoidance cost), but it also creates a negative externality to dutiful agents. Our design is related to Balafoutas et al. (2015) and closely related to Bartling and Weber (2015) in which firms sell products that may induce a negative externality. In our transparency treatments, firms may make consumers aware of which firm is generating the externality, thereby empowering them to buy more units from the honest firm, and to boycott the avoider.

Our design is simple but rich, and reasonably realistic. As firms compete by setting prices, we open to the door to a trade-off between compliance and prices. Compliant firms face higher costs and consumers may have to pay higher prices to punish the firm avoiding taxes. Consumers may choose to partially reward (buying some units at a lower price from the avoider) and firms may decide to partially comply and pay a fraction of their taxes (competing with the other firm in the level of tax compliance). In both transparency treatments MAN and VOL, information about firms' compliance follows a tax rating, based on a simple step-function (see Table 2):

Table 2. Tax rating system

Rating	Relative proportion of taxes paid
0 - extremely low	0%
1 - very low	(0%, 20%]
2 – low	(20%, 40%]
3 – moderate	(40%, 60%]
4 – high	(60%, 80%]
5 - very high	(80%, 100%]

In total 314 university students participated in the experiments and were recruited using the standard lab procedures of CBESS (University of East Anglia) and ESSEXLab (University of Essex). The average session lasted 70 minutes and the averages payoff was £11.57 (min £0, max £30.1). On arrival, participants were randomly assigned to groups of four and six in treatments with two and four consumers, respectively. They were informed that groups would

not change until the end of the experiment. Each session lasted 20 rounds. Instructions included numeric examples to facilitate understanding and were read aloud. All participants had to pass a comprehension test. The full set of instructions is enclosed as Appendix A.

Tax compliance as a source of value to consumers

As in every static 3-stage game played by subjects, firms pay taxes in the very last stage, backward induction predicts that firms will withdraw all units sold in stage 3, consumers will therefore buy from the low-price firm in stage 2 and competition will drive prices to competitive levels in stage 1. Given that this is the single prediction for the one-shot game, the prediction for the finite repetition of the game coincides with it.

Null Hypothesis. *Tax avoidance, consumer inaction and competitive pricing will survive the introduction of tax transparency. This prediction holds for any market size.*

If tax transparency is to have a bite is because consumers value it, either because they care for their consequences in terms of material payoffs or because they intrinsically value firm paying taxes, e.g. contributing their share. Kreps et al. (1982) already show that players may build a reputation in a finite repeated game, yielding different equilibrium outcomes conditional on incomplete information on player's types.[12] We find reputation building interesting because a prominent feature in our experimental design is that firms may choose to disclose their behavior e.g. whether to build a reputation. Because we pragmatically aim to understand the effect of reputation building on consumer boycotts and tax compliance, in our model we consider an additional stage 0 in which firms can make public announcements committing to a certain quality in stage 3 or may avoid them and let consumers make demand decisions based on "expected quality" derived from the reputation of firms. In the latter case, we assume that the non-disclosing firm provides the quality expected by consumers; this consistency requirement between a reputation parameter r and the quality decision by a non-disclosing firm makes reputation credible in our static model.[13] Note that the addition of stage 0 matches the timing of the model to the timing of decisions in the experiment, in which firms make three subsequent decisions in a row: quality –i.e. taxes- and disclosure in round t and prices in round t+1, followed by consumers making demand decisions in round t+1.

[12] In the early 80's, they were simply named irrational types. After the behavioral revolution in Economics, they might be called social preference players (see for example in Anderhub et al., 2002).

[13] The case of no possibility of public announcements corresponds to the no ratings treatment. When public announcements are mandatory, we will be describing the treatment with mandatory ratings. Finally, voluntary ratings correspond to the case of voluntary public announcements.

In the theoretical model, there is a single consumer who can buy one unit of a good (with value $v \geq 0$) in a price competition market with two firms, costless production and where tax compliance of a firm, $s \in [0,1]$ represents the quality of the product. Tax compliance is valued by the consumer, whose utility function is $u(p, s) = v + \alpha s - p$, where α is the parameter capturing the taste for quality and $p \geq 0$ is the selling price, with $\alpha > \varepsilon > 0$, where ε is the constant marginal cost of providing quality.[14] When tax compliance is not disclosed, the reputation of a non-disclosing firm is captured by a parameter $r > 0$ and the consumer randomly assigns a quality distributed uniformly in the interval $[0, r]$ and makes the demand decisions based on it.[15]

Can this model yield insightful intuitions for our experimental sessions or are we simplifying matters in excess? We argue that the model provides some interesting intuitions. First, the model opens the door to consumer's boycotts, as instances in which the consumer buys from the high (instead of the low) price firm. The rationale is that because the low price firm is offering low quality, the consumer might find it more valuable to buy from the compliant firm, being ready to pay a higher price. Second, the model allows studying the effect of the market size even if it features only one consumer. In the experiment, withdrawn taxes impose a negative externality to other market participants, being the share of the externality borne by an individual consumer inversely dependent on the market size (i.e. the number of consumers). This implies that the extra price a consumer is willing to pay for buying from a fully tax compliant firm is decreasing in the market size. In the model, the parameter α of the taste of quality captures this trade-off between price and quality.[16]

[14] We depart from the particular payoff functions used in the experiment because we are interested in consumer boycotts and tax transparency in general settings (in the field for example), well beyond the specificities of our experimental sessions.

[15] An alternative explanation for the parameter r is that it captures some behavioral features of the consumer: for example, complexity issues associated to the inference process, as in Gabaix and Laibson (2006) and Scitovsky (1950), or inattention by a part of consumers (Reis, 2006). Recently, Jin et al. (2015) offer strong evidence in a series of lab experiments on voluntary disclosure that the failure of the unravelling principle is due to a fundamental failure in consumer inferences when sellers withhold information on quality. If r comes from a non-perfectly rational behavior by consumers, then we might assume that firms would take fully advantage of it and would offer quality 0 when withholding in stage 0. Proposition 3 below would hold in any case.

[16] In an experimental session with N consumers, an individual consumer would be indifferent between (i) buying one unit of product at price p from a firm not-paying taxes, with payoffs (100-p)-10-10/N, and (ii) buying one unit of product at price p+10/N from a firm paying full taxes, with payoffs (100-p-10/N)-10. As we see, the trade-off between price and quality is decreasing in the market size. This computation refers to the case that the rival firm will not declare any sold units and all consumers are symmetric, i.e. all are buying the same number of units. However, the negative relation between the number of consumers and the trade-off between price and tax behavior holds for the general case.

The following three propositions collect the main predictions from the model for each of the three tax transparency regimes that we consider in the experimental design. The other design variable, market size, is linked to the parameter α of the taste of quality. So, for each transparency regime (proposition), we highlight the effect on the results of changing the value of the parameter α. Proofs are collected in Appendix B.

Proposition 1. No Tax Transparency. *There will be no boycotts as the consumer will always buy from the low-price firm. For all values of α, in equilibrium prices will be competitive and no firm will be paying taxes.*

Proposition 2. Mandatory Tax Transparency. *There will be maximum differentiation in equilibrium, with one firm building reputation (full tax compliance), charging non-competitive prices and earning positive profits, and one bad reputation firm paying no taxes at all, pricing competitively and earning nothing. The consumer will buy from the compliant firm, so in equilibrium we will observe boycotts. This result holds for all values of the parameter α.*

Proposition 3. Voluntary Tax Transparency. *If quality provision is too costly, both firms withholding quality and providing the expected quality is a subgame perfect Nash equilibrium outcome. Otherwise, one firm will withhold while the other will disclose and pay taxes in full, as in the case of mandatory tax transparency. The quality cost threshold between these two cases is increasing in the taste for quality α.*

The first two propositions are well-known consequences of the two main ingredients of the model: vertical differentiation and private information. For all values of the parameters, including the parameter α of the taste of quality, the model offers one equilibrium outcome: if quality cannot be signaled, no quality will be offered in equilibrium. When a credible way to signal quality exists, private information will be revealed (either implicitly or explicitly) and tax differentiation will happen in equilibrium. These predictions depart form the null hypothesis in that they give a positive role to tax transparency: the reason being that the "unravelling result" is extremely powerful.

Finally, when tax transparency is voluntary, the equilibrium outcome depends on how costly quality provision is. The non-disclosure of quality is very attractive to firms for several reasons: first, it is a cost-saving strategy (because a non-disclosing firm will end up producing the average expected quality $r/2$ rather than full tax compliance as differentiation strategy requires); second, reputation r provides a non-disclosing firm with market power; third, it alleviates competitive pressure out of the equilibrium path. In a model of product differentiation, revenues depend on the relative qualities, but cost depends on absolute value of the quality. Hence, both firms choosing the same strategy, "committing to high values of

quality" is very costly to each firm, because the final product becomes very homogeneous, driving prices down. This problem is got round by both firms choosing the same strategy "withholding"; because the chances of ending up providing roughly the same quality level are small (recall that consumers randomly attach one quality to each firm) and therefore price competition is less fierce.[17]

These elements are so powerful that they may change the very strategic nature of market competition: both firms following a non-disclosure strategy is an equilibrium outcome if the cost of providing high quality is large enough; otherwise choosing the differentiation strategy (i.e. committing to providing the highest quality) is still the best response to a non-disclosing firm. Interestingly, the cost threshold increases with the taste for quality. Because the larger the market size, the lower the taste for quality, it follows that mutual withholding is more likely to happen if the market size is large.

Note that the withholding decision requires some strategic use of disclosure by firms because they will need to build a reputation *r* that requires withholding and not providing the lowest quality in a consistent manner. We will look for evidence of the strategic use of the disclosure by firms when analyzing the experimental data. We end this section by stating our main hypotheses.

Hypothesis 1. *Tax transparency will reduce the level of tax avoidance.*

Hypothesis 2. *Tax transparency will trigger boycotting behavior on less compliant firms*

Hypothesis 3. *Compulsory tax transparency will be as successful in improving tax compliance in small as in large markets.*

Hypothesis 4 *Voluntary tax transparency will (not) be as successful as compulsory transparency in improving tax compliance in small (large) market sizes*.

[17] This is reminiscent of the strategic use of obfuscation by firms, as in Chioveanu and Zhou (2013).

3. Experimental results

We first examine aggregate descriptive statistics and then proceed to the analysis of behavioral determinants. Finally, we analyze the welfare implications of the ratings.

Aggregate behavior

Table 3 displays the main aggregated results of the experiment for prices, tax compliance, disclosure and payoffs to firms and consumers.

Table 3. Overview of aggregated results.

Treatment	Posted prices	Units withdrawn [%]	Disclosure rate [%]	Payoff per traded unit	
				Firms	Consumers
Small markets (2 firms and 2 consumers)					
No ratings **NO22**	49.3	68.9%	-	13.7	39.3
	(21.7)	(40.6)		(22.3)	(21.1)
Mandatory **MAN22**	49.1	47.7%	-	10.4	41.3
	(22.9)	(42.4)		(22.4)	(22.5)
Voluntary **VOL22**	62.9	52.1%	70.8%	25.6	26.6
	(19.2)	(41.8)	(45.5)	(18.6)	(17.3)
Large markets (2 firms and 4 consumers)					
No ratings **NO24**	57.7	72.4%	-	23.4	30.2
	(18.6)	(41.0)		(18.9)	(16.5)
Mandatory **MAN24**	46.5	52.3%	-	9.4	44.6
	(21.9)	(42.4)		(20.7)	(17.3)
Voluntary **VOL24**	50.8	69.3%	40%	15.9	35.9
	(16.8)	(40.1)	(49)	(17.2)	(16.5)

Note: means; standard deviations in parentheses

The data clearly reject the null hypothesis that tax transparency has no effect on market competition. Without ratings, firms largely avoid paying taxes (avoidance rate is around 70% in both small and large markets), but ratings make firms to withdraw less units, in line with Hypothesis 1.

The effect of tax ratings on competition is asymmetric between compulsory vs voluntary, in line with Hypotheses 3 and 4. In small markets, tax avoidance goes from 68.9% (NO22) to 47.7% and 52.1% in MAN22 and VOL22, respectively.[18] In large markets, tax avoidance drops similarly when mandatory: from 72.4% (NO24) to 52.3% in MAN24, but not when voluntary,

[18] Wilcoxon: both p=0.028. The difference between MAN22 and VOL22 is not significant (Wilcoxon: p=0.412); unless otherwise stated, all non-parametric tests are one-sided –as we have directional predictions from the theory model- and conducted on group level averages, to cope with the non-independent observations on group level.

as tax avoidance rate goes up to 69.3% in VOL24.[19] Disclosure in large markets is significantly less frequent (Wilcoxon, p<0.001).

Regarding the pricing dynamics, while we cannot reject the hypothesis of equal pricing behavior across market sizes for the treatment without ratings (Wilcoxon, p=0.325) and with mandatory ratings (p=0.470), we find a significant decrease in price when ratings are voluntary from small to large markets (p=0.044). This last result is driven by an increase in prices from mandatory to voluntary in small markets (p-value=0.038), an increase that does not occur in large markets (p-value=0.178). Finally, the introduction of ratings is detrimental to firms –in the sense that it lowers their profits per unit sold- in all but one treatment: small markets with voluntary ratings. In this case, the increase of tax compliance behavior is accompanied by an increase in the market price that drives firms' profits up.

In the next section our analysis will follow the sequence of decisions considered in the theoretical model, starting with tax avoidance.

Avoidance

Table 4 displays the distribution of tax avoidance, with a firm being the unit of observation at a given period, and the percentage of taxes not paid by the firm in that period.

Table 4. Distribution of tax avoidance by treatment

	0%	[1% - 50%]	[50% - 99%]	100%
Small markets				
No ratings **NO22**	35%	11%	9%	44%
Mandatory **MAN22**	42%	16%	15%	27%
Voluntary **VOL22**	34%	17%	17%	33%
All	37%	15%	14%	35%
Large markets				
No ratings **NO24**	23%	4%	13%	60%
Mandatory **MAN24**	30%	19%	20%	31%
Voluntary **VOL24**	18%	15%	12%	55%
All	24%	13%	15%	49%

We highlight the two corner cases (0% -full tax compliance- and 100% -full tax avoidance) as these concentrate more than two thirds of all observations. Table 4 also documents the upward shift in avoidance when firms compete in large markets: While in small markets the average proportion of firms not avoiding at all (0%) or in full (100%) is very similar (37% and 35%,

[19] Wilcoxon tests: NO24 vs. MAN24: p=0.047, NO24 vs. VOL24: p=0.22 and MAN24 vs. VOL24: p=0.07.

respectively), in large markets fewer firms refrain from full avoidance and many more firms avoid taxes in full (24% and 49%, respectively).

A regression analysis confirms that tax avoidance is on average 14.9% lower when ratings are available (as in MAN or VOL treatments) than in treatments with no disclosure (NO treatments). This effect is mainly driven by a 20.5% reduction in treatments with mandatory ratings (MAN), significantly stronger than the 9.3% reduction when voluntary (VOL), as the first two columns in Table 5 document (Wald: p<0.001).

Table 5. Level of tax avoidance across treatments

	All markets		Small markets	Large markets
Period	0.0145***	0.0145***	0.0129***	0.0162***
	(0.00120)	(0.00115)	(0.00155)	(0.00159)
Ratings	-0.149***			
	(0.0131)			
Mandatory ratings		-0.205***	-0.222***	-0.200***
		(0.0151)	(0.0216)	(0.0172)
Voluntary ratings		-0.0933***	-0.182***	-0.0303
		(0.0140)	(0.0256)	(0.0208)
Constant	0.557***	0.557***	0.568***	0.553***
	(0.0176)	(0.0145)	(0.0209)	(0.0258)
Observations	2319	2319	1188	1131
Log. Likelihood	-647.7	-646.6	-388.0	-248.4
Chi-squared	309.4	329.3	162.0	271.2

Note: This table contains coefficients of linear regressions with random intercepts of subjects nested in groups; 100 bootstrapping repetitions. *Ratings* is a dummy variable that takes value 1 in treatments with ratings and 0 otherwise. Levels of significance: * p<0.1, ** p<0.05, *** p<0.01.

While mandatory ratings reduce tax avoidance equally well in both market sizes (22.2 and 20.0 percentage points in markets with 2 and 4 consumers, respectively), voluntary ratings have a similar effect only in small markets (18.2 p.p.), rendering the effect insignificant in large ones (3 p.p., see models 3 and 4 in Table 5). Consistently, the reduction of tax avoidance in small markets is not significantly different when imposed or when voluntary (Wald: p=0.118), but the same comparison is highly significant in markets with 4 consumers (Wald: p<0.001).

Result 1. **Avoidance**. *Tax ratings significantly reduce tax avoidance. This effect is stronger for mandatory ratings. The reduction in tax avoidance caused by voluntary ratings vanishes in large markets.*

Disclosure

We now focus on treatments in which ratings were voluntary and analyze disclosure behavior conditional on avoidance level. Table 6 displays the disclosure rate by market size for the two extreme ratings (which amount to two thirds of the observations, see Table 4 above) and pool all the intermediate ratings in one category named "intermediate".

Table 6. Disclosure rate conditional on rating by market size

	Market size	
Tax Compliance	Small	Large
Extremely low (0)	41%	21%
Intermediate (1-4)	82%	62%
Very high (5)	90%	68%

Firms are less likely to disclose the tax ratings in large vs small markets, for all levels of compliance, including the very high rating. Table 6 is consistent with the strategic use of disclosure in large markets, where firms provide high quality but do not disclose it, but not in small markets, where firms truthfully reveal their quality by using the rule "disclose unless it is the lowest quality". While in large markets, intermediate and high ratings are disclosed two thirds of the times, in small markets the percentage goes up to almost full disclosure (nearly 90%).

Result 2. Disclosure. *The likelihood of firms to disclose the tax rating (i) depends negatively on tax avoidance and (ii) decreases in market size. There is evidence of strategic use of the disclosing decision in large but not in small markets.*

Pricing

We already have shown that average posted prices in all treatments are well above the (constant) marginal cost $c = 30$ (see Table 3, Wilcoxon, p-value<0.001 in all treatments). For the treatments without ratings (NO22 and NO24), this result is consistent with the standard results in the experimental literature of the rejection of the Bertrand prediction, as found for example in Dufwenberg and Gneezy (2000) or in Fatas et al. (2014). For the treatments with mandatory ratings, the experimental results are consistent with the theoretical prediction of firms using the ratings to differentiate their products, strategy that allow them to set prices above the competitive level.

Table 7. Posted prices across treatments

	All markets		Small markets	Large markets
Period	0.238***	0.238***	0.238***	0.237***
	(0.0500)	(0.0500)	(0.0663)	(0.0759)
Ratings	0.191			
	(3.846)			
Mandatory ratings		-4.110	-0.234	-11.24*
		(4.391)	(6.291)	(5.825)
Voluntary ratings		4.492	13.56**	-6.883
		(4.391)	(6.291)	(5.825)
Constant	49.26***	49.26***	46.80***	55.23***
	(3.086)	(3.007)	(3.766)	(4.623)
Observations	2560	2560	1400	1160
Log. Likelihood	-10657.5	-10655.8	-5808.6	-4840.4
Chi-squared	22.68	26.20	18.27	13.51

Note: This table contains coefficients of linear regressions with random intercepts of subjects nested in groups; 100 bootstrapping repetitions. *Ratings* is a dummy variable that takes value 1 in treatments with ratings and 0 otherwise. Levels of significance: * p<0.1, ** p<0.05, *** p<0.01.

A regression analysis considering all market sizes and rating conditions show no significant effect of ratings on posted prices (see Table 7). But this is because there is a composition effect with respect to the size of the market. Once the regression is split by market size, we observe that for small markets, posted prices are significantly larger when ratings are voluntary (at a 5% level of significance), while for large markets, there is a mild decrease of posted prices (at a 10% level of significance) when ratings are mandatory relative to the treatment without ratings.

Result 3. Pricing dynamics. *Pricing dynamics keep prices above competitive pricing. We find a positive increase in posted prices in small markets with voluntary ratings.*

Consumer behavior

The only source of surplus in our experiment was trade, and consumers were free to buy up to five units from any of the two firms. At the cost of not trading, consumers could boycott *firms* by buying the high price product. To minimize the possibility of counting simple mistakes for an active and intentional act of boycott, we use a strong definition of boycotts: in any round, we define *boycott* when a consumer buys the majority of the demand from the high price firm. Table 8 displays boycott rates averaged across all rounds and consumers by treatment.

Table 8. Boycotting behavior

	Market size	
Ratings	Small	Large
No ratings	3.68%	6.43%
Mandatory	10.28%	9.20%
Voluntary	11.94%	10.45%

Our definition of boycott does not require ratings to exist, as the only reference point is the minimum posted price. Without ratings, consumers may still boycott and reward a consistently moderate pricing behavior.[20] The data from treatments NO22 and NO24 show that there is a positive fraction of instances in which consumers bought more units from the high price firm. When ratings are in place, our definition of boycott additionally captures tax based reciprocal behavior between consumers and firms.[21] Arguably, ratings may trigger an exchange of better quality and higher prices between agents. In our experiment, this is exactly what we observe. Relative to the baseline without ratings, and for any market size, ratings generate significantly more boycotts, substantial in size.[22] Thus, consumers systematically refuse to buy from the cheaper firm at a personal monetary cost. Notably, we find no significant difference between mandatory and voluntary, nor across market size.

Result 4. Boycotts. *Relative to the baseline, (i) there is an increase in consumer boycotts when ratings are in place, and (ii) there is no significant effect of market size on boycotts.*

At the aggregate level, the experimental results show that (i) ratings help to reduce tax avoidance in all but one treatment (large markets when the disclosure of the ratings is voluntary), and that (ii) the increase of tax compliance comes with an increase in the selling price in only one treatment (small markets when the disclosure of ratings is voluntary).

Behavioral drivers

We now take a closer look to the individual behavior of consumers and firms. The key element to the impact of ratings on competitive market condition is that consumers value them. Accordingly, we start by examining consumer purchasing behavior, i.e. demand equations for

[20] A consumer who buys from a firm posting the current higher price but who has decreased the price in a number of consecutive periods.
[21] Conditional behavior has been recurrently documented in markets (Fatas and Mañez, 2007, and Fatas et al, 2013) and other experimental settings (Croson et al 2005, 2015, Fatas et al, 2020).
[22] Wilcoxon tests: NO22 vs MAN22: p=0.061 and NO22 vs VOL22: p=0.005. MAN22 vs. VOL22: p=0.2973.

small (table 9) and large (table 10) market sizes.[23] Basic microeconomics demands (i) negative own-price and positive cross-price effect, and (ii) the latter being smaller in size in absolute value.[24] In all market conditions, the estimated demand equations meet these two basic requirements, showing that consumers in our experiment behave in an economic rational way along the pricing dimension.[25]

Table 9: Market demand for small market size

Variable: Demand (t)	No ratings	Mandatory Ratings		Voluntary ratings		
Period	0.0246	0.0144	0.0152	0.00635	-0.00146	-0.00372
	(0.0185)	(0.0220)	(0.0231)	(0.0190)	(0.0199)	(0.0197)
Own Price (t)	-0.112***	-0.0922***	-0.0895***	-0.076***	-0.094***	-0.095***
	(0.00772)	(0.00840)	(0.00851)	(0.00705)	(0.00768)	(0.00747)
Other Price (t)	0.0892***	0.0757***	0.0726***	0.0444***	0.0582***	0.0599***
	(0.00772)	(0.00840)	(0.00851)	(0.00705)	(0.00768)	(0.00747)
Own Rating (t-1)			0.125*			
			(0.0699)			
Other Rating (t-1)			-0.119*			
			(0.0699)			
Own rating disclosed (t-1)					0.0330	
					(0.269)	
Other rating disclosed (t-1)					0.101	
					(0.269)	
Disclosed Own rating=5 (t-1)						0.611**
						(0.258)
Disclosed Other rating=5 (t-1)						-0.848***
						(0.258)
Constant	5.424***	4.868***	4.863***	6.264***	6.509***	6.700***
	(0.498)	(0.448)	(0.530)	(0.553)	(0.621)	(0.598)
Observations	680	360	342	360	342	342
Log. likelihood	-1686.4	-824.5	-771.7	-782.6	-732.0	-723.9
Chi-squared	246.6	131.9	137.9	122.5	156.5	180.6

Note: This table contains coefficients of linear regressions with standard errors (in parentheses) controlling for non-independence of observations on subjects nested in groups (mixed multi-level models). Firms who sell nothing by definition would not get a tax rating in that period. To avoid missing values, we assign the same firm's rating from the latest period available. *Rating=5* is a dummy variable that takes value 1 when the disclosed rating of a firm is 5 and 0 if the rating is disclosed, but less than 5. Allowing for missing values does qualitatively not change the results. Levels of significance: * p<0.1, ** p<0.05, *** p<0.01

In treatments where the disclosure of ratings is mandatory (MAN22 and MAN24), we include *own rating* and *other rating* as independent variables, to account for the reaction of consumers

[23] On average, consumers allocate their demand as follows: in small markets: (low price firm: 7.23; high price firm 2.44); in large markets: (low price firm: 13.25; high price firm: 5.44)

[24] Comparison of the own and cross price effects across market size show that for large markets the estimates double in size relative to small market condition. But taking into account that the demand for large market size doubles the demand for small market size (20 units and 10 units in large and small market conditions respectively), the associated elasticities are of similar size.

[25] The variable period is not systematically significant, consistent with a stationary behavior of consumers. The constant gets close half of the market size (5 in small markets and 10 in large markets), meaning that, absent any other variable, consumers naturally split their demand between the two firms. Equal splitting is (5, 5) and (10, 10) in small and large market sizes respectively.

to the taxes paid by a firm in round *t-1*, before making buying decision in period *t*. The first important observation is that in both mandatory treatments, price elasticities are highly significant and of similar size to the 'No ratings' estimates. The nature of price competition in the market does not change when the quality dimension is imposed from the outset.[26] Second, the *own rating* estimate is positive and significant (at the 10% level in small markets and 1% in large markets), implying that consumers demand more from a firm the better its tax paying behavior. Third, demand of a firm depends negatively on the rating of the other firm (the variable *other rating*). This is indicative of what might be called a *quality trap*: all other things equal, an increase in the own rating increases one's own demand, encouraging the use of better ratings by firms, but the positive effect on demand of an increase in the rating of a firm is offset by the negative effect of the increase in the rating of the other firm. At the end of the day, both firms are providing better quality without enjoying any net gain in quantity demanded.

Result 5. Quality trap. *When ratings are imposed, the mutual provision of better qualities by firms does not carry over higher quantity demanded*

From a behavioral point of view, firms have a hard time competing in multiple (two) dimensions. In the differentiating equilibrium, one firm provides the highest quality (and makes positive profits), while the other makes no profits at all, making her tempation to deviate salient. A race for larger qualities makes both firms not to differentiate in the quality dimension, while facing a tough competition in the price dimension.

[26] Appendix C contains an econometric analysis to test the differences of the own-price and cross-price elasticities across the different treatments. As per the comparison of the "no rating" vs "mandatory ratings", there are no significant differences of the own-price elasticity for both market sizes, no significant difference of the cross-price elasticity for large market price and a mild difference of the cross-price elasticity (significant at 10% level) for the small market size.

Table 10: Market demand for large market size

Variable: Demand (t)	No ratings	Mandatory ratings		Voluntary ratings		
Period	0.0416	0.0876**	0.103***	0.0623*	0.0486	0.0572
	(0.0405)	(0.0341)	(0.0374)	(0.0327)	(0.0358)	(0.0356)
Own Price (t)	-0.208***	-0.179***	-0.185***	-0.217***	-0.222***	-0.224***
	(0.0169)	(0.0106)	(0.0104)	(0.0137)	(0.0143)	(0.0146)
Other Price (t)	0.145***	0.133***	0.135***	0.187***	0.192***	0.192***
	(0.0169)	(0.0106)	(0.0104)	(0.0137)	(0.0143)	(0.0146)
Own Rating (t-1)			0.562***			
			(0.0993)			
Other Rating (t-1)			-0.359***			
			(0.0993)			
Own rating disclosed (t-1)					0.182	
					(0.414)	
Other rating disclosed (t-1)					-0.742*	
					(0.414)	
Disclosed Own rating=5 (t-1)						0.317
						(0.515)
Disclosed Other rating=5 (t-1)						-0.0883
						(0.515)
Constant	11.99***	9.883***	9.435***	9.896***	10.26***	10.01***
	(1.238)	(0.681)	(0.691)	(0.773)	(0.851)	(0.857)
Observations	280	440	418	440	418	418
Log. likelihood	-788.0	-1251.7	-1168.3	-1231.0	-1167.9	-1169.1
Chi-squared	172.2	333.2	408.5	294.2	282.4	280.5

Note: This table contains coefficients of linear regressions with standard errors (in parentheses) controlling for non-independence of observations on subjects nested in groups (mixed multi-level models). Firms who sell nothing by definition would not get a tax rating in that period. To avoid missing values, we assign the same firm's rating from the latest period available. Rating=5 is a dummy variable that takes value 1 when the disclosed rating of a firm is 5 and 0 if the rating is disclosed, but less than 5. Allowing for missing values does qualitatively not change the results. Levels of significance: * p<0.1, ** p<0.05, *** p<0.01

Finally, when ratings are voluntary, we include the disclosure decision as an independent binary variable, using two different formulations: (i) disclosure alone and (ii) disclosure of top ratings. First, voluntary ratings have an impact on the nature of price competition. In small markets, it softens price competition (own-price and cross-price estimates significantly decrease in absolute value in comparison to treatments MAN and NO at a 1% level). In large markets, price competition is fiercer (own-price and cross-price estimates increase in absolute terms from MAN to VOL treatments at a 1% level). This points to the existence, in small markets but not in large markets, of a premium to firms –in the price dimension- when disclosing the quality is a voluntary choice for compliant firms. We call it the *endogeneity premium*. Second, the quality trap in terms of quantity demanded is only observed in small markets (consistent with consumers asking for the disclosure of top ratings). For large markets, rather than a trap, we find the opposite effect, as a negative externality is documented: any attempt of increasing one's own ratings does not affect one's own demand but rather decreases the demand of the other firm.

Why does an endogeneity premium exist? Why do we observe a different effect of ratings on demand in small and large markets? We start by ruling out that the differential endogeneity premium is related to some "irrational" disclosing decisions by firms in large markets. We do so by estimating the likelihood of disclosing tax ratings across different market sizes.

Table 11: Likelihood of disclosing the tax rating by market size

Variable	Small markets		Large markets		All markets	
Period	0.00248	0.00929*	-0.017***	-0.0115**	-0.00112	-0.00118
	(0.00435)	(0.00490)	(0.00533)	(0.00538)	(0.00403)	(0.00403)
Full compliance (t)	0.281***		0.269***			
	(0.0877)		(0.0905)			
Avoidance level (t)		-0.472***		-0.558***	-0.594***	-0.566***
		(0.118)		(0.108)	(0.0709)	(0.0980)
Large market					-0.350**	-0.316*
					(0.166)	(0.186)
Avoidance level (t) x large market						-0.0533
						(0.131)
Observations	341	341	433	433	774	774
Log. Likelihood	-164.83	-151.51	-196.94	-181.45	-338.18	-338.10
Chi-squared	16.40	40.16	22.65	50.91	89.53	89.85

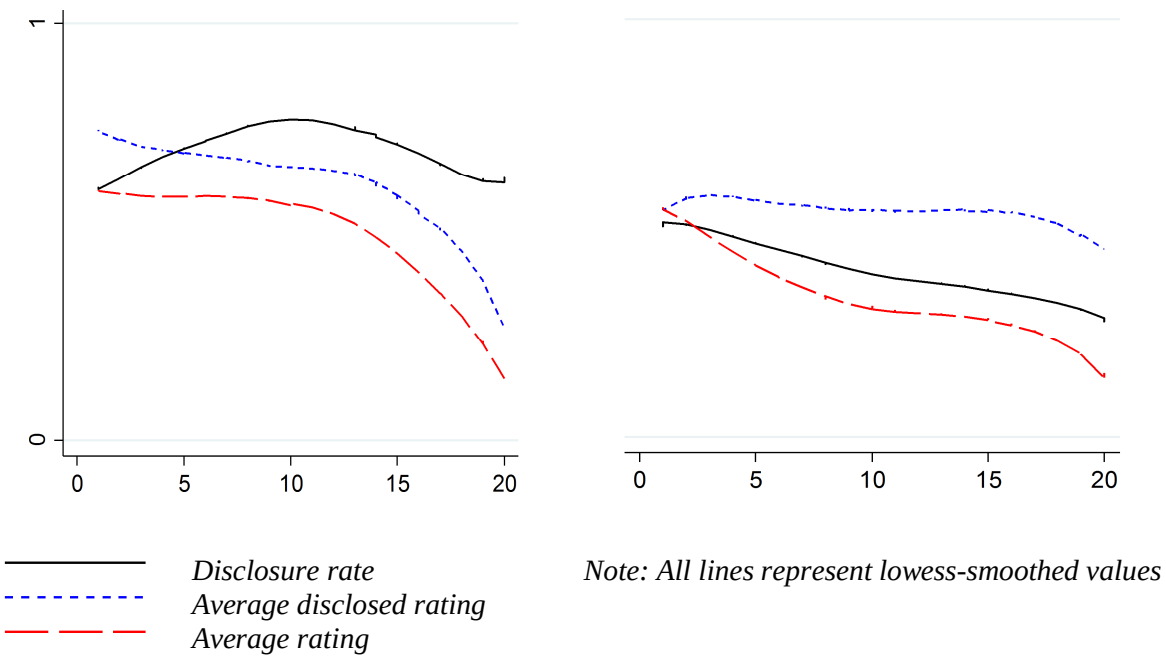
Note: This table contains marginal effects of Probit regressions with random intercepts of subjects nested in groups. *Full compliance* takes the value of 1 if the firm paid the taxes of all their units and 0 otherwise. *Large market* takes a value of one in treatments with four consumers and zero otherwise. *Avoidance level* $\in [0,1]$ represents the proportion of a firm's sales no taxes were paid for. Levels of significance: * p<0.1, ** p<0.05, *** p<0.01.

Table 11 shows that disclosure decisions follow a rational procedure regardless of the market size: the main result can be summarized as "disclosing bad news is never a good idea". We find that (i) firms are 28.1% and 26.9% more likely to disclose a rating of 5 in small and large markets, respectively, and that (ii) firms are also 47.2% and 55.8% less likely to disclose their ratings, if they did not pay taxes at all, in small and large markets. We can only find one difference across market sizes: firms in large markets are around 30% less likely to disclose their tax rating than firms in small markets; but the interaction term with avoidance level although negative is not statistically significant from zero.

It seems that disclosing less in large markets vs small markets is a "rational" strategic decision of firms. Figure 1 displays a dynamic view of average disclosure and average ratings.

Figure 1. Disclosure behavior of firms over time with voluntary ratings

Small markets (VOL22) *Large markets (VOL24)*



Average ratings (long-dashed red line) start at the same level at period 1 in both market sizes, but quickly diverge and decline in large markets, in sharp contrast with the flat trend in small markets (before a common end-game effect). There is also a similar and differential behavior regarding disclosure rates (solid black line): starting around 50% in both cases, they do not decline over time in small markets (with a peak of 75% around period 10), while in large markets they steadily decline over time. Despite the different behavior in average rating and disclosing behavior across market sizes, the evolution of the average disclosed rating is strikingly similar. In small markets, the average disclosed rating (short-dashed blue line) is quite flat around 60% until the last 5 periods where an end-game effect happens, while in large markets is flat at around the same level as in the small markets.

We find this pattern consistent with firms making a strategic use of disclosure in large markets. In small markets, average rating and average disclosed rating follow parallel paths, indicative of firms following the truthful disclosing behavior described above.[27] In large markets, ratings and disclosed ratings evolve in a divergent way, consistent with the existence of the *endogeneity premium* in small markets (but not in large markets) when disclosure is a choice. Interestingly, we present in Table 12 evidence that truthfully revealing the quality rather than

[27] The constant vertical gap is explained by firms disclosing all but the lowest rating (as shown in Table 6).

making a strategic use of the disclosing decision is what consumers value when the disclosing decision is a choice.

Table 12: Likelihood that a firm sold more units than the other firm in treatments with ratings by market size

	Mandatory ratings		Voluntary ratings			
Variable: Market share higher (t)	Small markets	Large markets	Small markets		Large markets	
Lower price (t)	0.555***	0.939***	0.654***	0.673***	0.799***	0.805***
	(0.0663)	(0.0732)	(0.0627)	(0.0632)	(0.0681)	(0.0678)
Higher rating (t-1)	0.158**	0.215***				
	(0.0669)	(0.0703)				
Only discloser (t-1)			-0.0016		0.0670	
			(0.0812)		(0.0837)	
Only discloser after both disclosed (t-1)				0.240**		0.0877
				(0.121)		(0.173)
Observations	342	418	342	342	418	418
Log Likelihood	-186.1	-168.5	-174.6	-172.6	-194.6	-194.8
Chi-squared	72.25	158.1	108.3	110.6	138.0	138.0

Note: This table contains marginal effects of Probit regressions with random intercepts of subjects nested in groups. *Lower price* takes the value of 1 if a firm's price is lower than the other firm's price and 0 otherwise. *Higher rating* takes the value of 1 if the firm's rating was higher than the other firm's rating and 0 otherwise. *Only discloser* takes the value of 1 if the firm disclosed its rating, but the other firm did not and 0 otherwise. *Only discloser after both disclosed* takes the value of 1 if both firms disclosed their rating in t-1, and the firm disclosed its rating in t, but the other firm did not (in t), and 0 otherwise. Levels of significance: * p<0.1, ** p<0.05, *** p<0.01.

Table 12 display econometric estimations of the likelihood that a firm sells more than the rival using the two different strategic variables: pricing and rating. Being the only discloser in the market never confers an advantage in terms of market share; rather, it is consistently keeping on disclosing the rating, captured by the variable "being the only discloser after both disclosing in the previous period" which lets firms enjoy a market share above 50%.[28]

We finally investigate whether firms can take advantage of the existence of the *endogeneity premium* in small markets with voluntary ratings, which takes the form of smaller own price elastic demands and more differentiated product, to exert market power and increase prices.

[28] Table C1 in Appendix C shows that this advantage also implies larger profits.

Table 13: Probability of price increase in (t) by market size and rating treatment

Variable: Price increase in t vs t-1	Mandatory ratings		Voluntary ratings	
	Small markets	Large markets	Small markets	Large markets
Period	-0.017**	-0.014***	-0.086*	-0.012***
	(0.00466)	(0.00421)	(0.0046)	(0.004)
Incr. own rating t-1 vs t-2	0.0687	0.0650		
	(0.0536)	(0.0547)		
Incr. own hyp. rating t-1 vs t-2			0.108*	-0.0069
			(0.0558)	(0.0564)
Observations	360	440	360	440
Log Likelihood	-233.28	-287.6	-231.7	-291.6
Chi-squared	17.52	15.11	9.36	9.01

Note: This table contains marginal effects of Probit regressions with random intercepts of subjects nested in groups. Hypothetical ratings: Firms who did not sell a single unit in t would result in a missing observation of the rating in t. To avoid missing values, we used a hypothetical instead of the actual rating replacing NAs with the same firm's rating in t-1. Levels of significance: * p<0.1, ** p<0.05, *** p<0.01.

Table 13 presents the outcome of our econometric analysis across market sizes. The dependent variable is the probability of a firm increasing her posted prices and we investigate the role of two covariates: the variable *period* and a dummy variable on whether a firm increased their quality. The econometric results show that only in VOL22 firms significantly increased prices following an increase of ratings. This closes the circle.

Result 6. Endogeneity premium. *When ratings are voluntary, consumers reward the truthful disclosing behavior by firms by letting them enjoy larger market power.*

Welfare analysis

In Table 14 we compare profits across different market sizes using as a normalized dependent variable the payoffs obtained per unit by consumers and firms. As independent variables, we include period and treatment dummies. Because the selling price determines how the surplus from trade is allocated between consumers and sellers, Table 14 simply reflects the zero-sum nature of the payoffs per traded unit: what is good for the consumer has to be at the expense of the firm's welfare. In small markets, the endogeneity premium is reflected in the large estimate of dummy variable *voluntary ratings*, absolute value of 13, and significant at the 10% level for both consumer and firm payoffs. In large markets, the quality trap is observed in the highly significant coefficient (at the 1% level) of the variable *mandatory ratings* in the model estimating consumer payoff per unit traded. In small markets, the coefficient is not significantly different from zero.

Table 14: Payoffs per unit traded

Variable	Consumers			Firms		
	Small market	Large market	Both	Small market	Large market	Both
Period	-0.438***	-0.529***	-0.495***	0.403***	0.419***	0.411***
	(0.0565)	(0.0455)	(0.0355)	(0.0684)	(0.0754)	(0.0508)
Mandatory ratings	1.863	15.32***	1.862	-1.895	-13.61**	-1.895
	(6.899)	(5.375)	(5.963)	(6.628)	(5.729)	(5.911)
Voluntary ratings	-12.98*	6.631	-12.95**	12.92*	-7.442	12.92**
	(6.899)	(5.375)	(5.964)	(6.625)	(5.728)	(5.907)
Large market size			-9.802			10.50
			(6.471)			(6.431)
Mandatory ratings x Large market size			13.47			-11.69
			(9.162)			(9.096)
Voluntary ratings x Large market size			19.60**			-20.37**
			(9.162)			(9.093)
Constant	43.62***	34.81***	44.23***	8.534**	18.84***	8.427**
	(4.102)	(4.229)	(3.528)	(3.968)	(4.547)	(3.524)
Observations	1347	2254	3601	1188	1131	2319
Log. Likelihood	-5330.1	-8956.0	-14291.3	-4872.2	-4696.2	-9574.1
Chi-squared	64.54	143.8	205.9	39.69	36.55	75.58

Note: This table contains coefficients of linear regressions with random intercepts of subjects nested in groups. Levels of significance: * p<0.1, ** p<0.05, *** p<0.01.

Result 7. *When ratings are imposed from the outset, there is a quality trap that hurts firms. The endogeneity premium in small markets, but not in large markets, makes firms be better off.*

4. Discussion and conclusion

This paper studies a symmetric experimental environment in which firms produce an homogeneous good competing in prices, and demand is decided by consumers. Once prices and demand are set, firms may avoid paying taxes and consumers do not. Tax avoidance by a firm is borne by the other participants in the market, and the negative externality leads consumers to boycott tax avoidance firms, in a complex setting in which the interaction of prices, demand, corporate tax avoidance and disclosure becomes complex. In our experiment, consumers may learn about corporate tax compliance. When this information is not available to consumers, corporate tax avoidance rates skyrocket to 70%, in line with the evidence of large corporations managing to effectively pay an extremely low tax rate. When tax avoidance is made public, we observe that the behavior of firms dramatically changes. When in some experimental sessions a tax rating system that truthfully reveals to all participants firms' compliance, firms choose to reliably inform consumers of the "quality" of the product they sell, as a proxy for their social corporate responsibility.

Our experiment is related to the influential experimental paper on credence goods by Dulleck et al (2011), analyzing two institutional features -liability and verifiability- and two market features -competition and reputation. In this paper, firms were allowed to produce any quality and consumers maximized welfare when firms offered the highest quality. Also, because the tax rating truthfully revealed quality to market participants our design imposed verifiability. While Dulleck et al (2011) find no effect of verifiability in the absence of liability, we actually find a strong effect of the tax ratings on firm behavior, as avoidance rates went down from 70% to 50%.

The rationale for this is simple. As long as consumers consider compliance as a signal of the product quality, a tax rating converts price competition into a vertically differentiated environment (under the assumption that paying their taxes is universally accepted). In our model, product differentiation, with one firm and only one providing high quality at non-competitive prices, is the equilibrium outcome, an increase in tax compliance is predicted, and it is observed in the experimental data. We do not get product differentiation in the experimental sessions (see Table C2 in Appendix C). Rather, firms do engage in a quality trap that push them to offer competitive prices while providing high quality, in line with Huck et al (2016), when analyzing markets for experience goods in which firms could build reputation for quality, and consumers only focused on one dimension: price. In our setting, the causal path is different. The low quality-low price firm enjoys no profits, with behavioral incentives to push quality up and becoming the high-quality firm. Once there is no effective product differentiation, a price war leads prices down.

We run experimental sessions with two and four consumers and we always found a positive impact of mandatory ratings on tax compliance of firms. However, a different story comes with respect to whether firms have incentives to disclose their private information on their own. We run several sessions where the disclosure of tax rating was voluntary. When the number of consumers was small enough, we did find again a positive effect of ratings on quality, and the same underlying unravelling effect: firms make heavy use of the option to disclose their tax rating. There is no quality trap, as price competition is not fierce. Why? Our behavioral explanation is that consumers give firms an endogeneity premium, allowing firms to exert some market power in the price dimension when choosing to voluntarily disclose. Consequently, cross-price elasticities are smaller and prices, and profits, go up.

The effect is dependent on the market size. In large markets, firms do not consistently disclose but make a strategic use of disclosure, sometimes choosing to hide good ratings. Quality is a (hidden) attribute of the product, strictly speaking not a credence good. The quality of a traded product has an impact on the welfare of all participants, because avoided taxes are levied by the rest of participants, as a private good provided by all other participants. The larger the number of buyers, the lower the externality effect, and the less a consumer should worry about firms paying taxes. The quality dimension loses importance and we are effectively back to a world without ratings.

As for the policy implications of the research, the mandatory disclosure of seller's information regarding the tax compliance rate is an effective tool to reduce corporate tax avoidance, but it is expected to face strong opposition by the business lobby as consumers do not allow an increase in market prices that may imply larger profits to firms. In our setting, the only instance in which consumers reward disclosing firms with larger prices happens when tax ratings are voluntary, not surviving large market sizes. As the size of markets with big corporations is typically large, the only road ahead could be to make the public bad nature of tax avoidance more salient. Unpaid taxes does not imply larger tax rates to sustain the same welfare state, but a smaller welfare state.

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Acknowledgements

We gratefully acknowledge financial support by the ESRC Centre for Competition Policy, the ESRC Network for Integrated Behavioural Science and the Austrian Science Fund (FWF) under project I2027-G16. Furthermore, we thank participants of IMEBESS Oxford 2014, ESA Prague 2014, and participants of research seminars at the University of East Anglia, Florida State University and the Vienna Center for Experimental Economics for their helpful comments and suggestions.

APPENDIX A. EXPERIMENTAL INSTRUCTIONS

In the following we provide instructions for the treatments NO22, MAN22 and VOL22.

No Rating (NO22)

Instructions

Welcome to today's experiment on decision-making. The session will begin shortly. Before we start, we ask you to turn off your mobile phone and other devices completely. Please refrain from talking to other participants during the experiment. If you have a question at any point in the experiment, please raise your hand. In this experiment, you will repeatedly make decisions. By doing this you can earn money. How much you will earn depends on your decisions and on the decisions of other participants. Your decisions will be absolutely anonymous, i.e. your identity will neither be revealed to your co-participants nor to the experimenters at any time during or after the experiment.

At the beginning of the experiment, you will be matched with three other participants to form a group of four. We will call each group a 'market'. Each market consists of two firms (firm 1 and firm 2) and two consumers (consumer 1 and consumer 2). At the beginning of the experiment, you will be randomly assigned to either the role of a firm or the role of a consumer. You have a 50% probability of becoming a firm or a consumer. The composition of each market and your role (being a consumer or a firm) will not change throughout the experiment. Markets are independent in that what happens in the other markets will not affect your market in any way.

Firms and consumers interact in each market for 20 rounds. Firms produce and sell an identical product and consumers buy and enjoy products in the following way:

a) Firms choose prices. For each unit they sell, firms may make a profit. The unit profit is the difference between the selling price and the production costs. Production costs are the same for both firms and will only be known by them, and will be the same for the 20 rounds of the experiment.
b) Consumers observe the prices chosen by firms and buy products. For each unit they buy, consumers may make a profit. The unit profit is the difference between the consumption value of the product they buy and the price they pay for it. Consumption values are the same for both consumers and will only be known by them, and will stay the same for the 20 rounds of the experiment.

Depending on your role, you will be informed about your production costs (if you are a firm) or about your consumption value (if you are a consumer).

The logic of the experiment is simple. Each round, firms choose prices first, from 0 to 100 Experimental Currency Units (ECU). Consumers, upon observing the prices of both firms, make shopping decisions, buying up to 5 units from any of the two firms (up to a total of 10 units per market).

At the VOL of each round, exchange fees will be collected in each market. The exchange fees for the entire market will be 20 ECU per exchanged unit. So, if a total of 10 units were exchanged in a market in total, fees for this market will be 200 ECU that round.

The distribution of fees among consumers and firms is computed using the following mechanism. First, each firm decides how many units it wants to withdraw from the distribution of exchange fees. The cost of withdrawing one unit is 1 ECU. The exchange fee corresponding to any withdrawn units will be covered by the consumers (they cannot withdraw units from the fees computation) and the other firm (if it does not withdraw all its units).

Second, the market fees will be distributed proportionally to the units not withdrawn from the computation. Note that if a firm withdraws as many units as it has sold, this firm will pay no exchange fees at all. We give you three examples now.

Example 1	Units sold/bought	Market fees	Units withdrawn	Units computed	Share	Individual fees	
Firm 1	5	20 x 10 ECU = 200 ECU	5	5-5=0	0/15	200 ECU x (0/15) =	0 ECU
Firm 2	5		0	5-0=5	5/15	200 ECU x (5/15) =	66.7 ECU
Consumer 1	5		-	5	5/15	200 ECU x (5/15) =	66.7 ECU
Consumer 2	5		-	5	5/15	200 ECU x (5/15) =	66.7 ECU
Total	20		5	15			200 ECU

Example 2	Units sold/bought	Market fees	Units withdrawn	Units computed	Share	Individual fees	
Firm 1	5	10 x 10 ECU = 100 ECU	5	5-5=0	0/5	100 ECU x (0/5) =	0 ECU
Firm 2	0		0	0	0/5	100 ECU x (0/5) =	0 ECU
Consumer 1	5		-	5	5/5	100 ECU x (5/5) =	100 ECU
Consumer 2	0		-	0	0/5	100 ECU x (0/5) =	0 ECU
Total	10		5	5			100 ECU

Example 3	Units sold/bought	Market fees	Units withdrawn	Units computed	Share	Individual fees	
Firm 1	10	20 x 10 ECU = 200 ECU	4	10-4=6	6/16	200 ECU x (6/16) =	75 ECU
Firm 2	0		0	0	0/16	200 ECU x (0/16) =	0 ECU
Consumer 1	5		-	5	5/16	200 ECU x (5/16) =	62.5 ECU
Consumer 2	5		-	5	5/16	200 ECU x (5/16) =	62.5 ECU
Total	20		4	16			200 ECU

No one will be informed about the units withdrawn by firms, although you will be informed about the total exchange fees that you pay. These fees will be deducted from your preliminary profits.

At the VOL of each round you will be informed about the prices and market shares of firms in your market and about your earnings in that round. You will also learn about the outcomes of previous rounds. You will never know the earnings of the other members of your group. At the VOL of the experiment, the earnings of all rounds will be summed up and converted into pounds at a rate of 250 ECU = 1 pound.

Exogenous Rating (MAN22)

Instructions

Welcome to today's experiment on decision-making. The session will begin shortly. Before we start, we ask you to turn off your mobile phone and other devices completely. Please refrain from talking to other participants during the experiment. If you have a question at any point in the experiment, please raise your hand. In this experiment, you will repeatedly make decisions. By doing this you can earn money. How much you will earn depends on your decisions and on the decisions of other participants. Your decisions will be absolutely anonymous, i.e. your identity will neither be revealed to your co-participants nor to the experimenters at any time during or after the experiment.

At the beginning of the experiment, you will be matched with three other participants to form a group of four. We will call each group a 'market'. Each market consists of two firms (firm 1 and firm 2) and two consumers (consumer 1 and consumer 2). At the beginning of the experiment, you will be randomly assigned to either the role of a firm or the role of a consumer. You have a 50% probability of becoming a firm or a consumer. The composition of each market and your role (being a consumer or a firm) will not change throughout the experiment. Markets are independent in that what happens in the other markets will not affect your market in any way.

Firms and consumers interact in each market for 20 rounds. Firms produce and sell an identical product and consumers buy and enjoy products in the following way:

a) Firms choose prices. For each unit they sell, firms may make a profit. The unit profit is the difference between the selling price and the production costs. Production costs are the same for both firms and will only be known by them, and will be the same for the 20 rounds of the experiment.
b) Consumers observe the prices chosen by firms and buy products. For each unit they buy, consumers may make a profit. The unit profit is the difference between the consumption value of the product they buy and the price they pay for it. Consumption values are the same for both consumers and will only be known by them, and will stay the same for the 20 rounds of the experiment.

Depending on your role, you will be informed about your production costs (if you are a firm) or about your consumption value (if you are a consumer).

The logic of the experiment is simple. Each round, firms choose prices first, from 0 to 100 Experimental Currency Units (ECU). Consumers, upon observing the prices of both firms, make shopping decisions, buying up to 5 units from any of the two firms (up to a total of 10 units per market).

At the VOL of each round, exchange fees will be collected in each market. The exchange fees for the entire market will be 20 ECU per exchanged unit. So, if a total of 10 units were exchanged in a market in total, fees for this market will be 200 ECU that round.

The distribution of fees among consumers and firms is computed using the following mechanism. First, each firm decides how many units it wants to withdraw from the distribution of exchange fees. The cost of withdrawing one unit is 1 ECU. The exchange fee corresponding to any withdrawn units will be covered by the consumers (they cannot withdraw units from the fees computation) and the other firm (if it does not withdraw all its units).

Second, the market fees will be distributed proportionally to the units not withdrawn from the computation. Note that if a firm withdraws as many units as it has sold, this firm will pay no exchange fees at all. We give you three examples now.

Example 1	Units sold/bought	Market fees	Units withdrawn	Units computed	Share	Individual fees		Rating
Firm 1	5	20 x 10 ECU =	5	5-5=0	0/15	200 ECU x (0/15) =	0 ECU	0: extremely low
Firm 2	5	200 ECU	0	5-0=5	5/15	200 ECU x (5/15) =	66.7 ECU	5: very high

Consumer 1	5		-	5	5/15	200 ECU x (5/15) =	66.7 ECU	-
Consumer 2	5		-	5	5/15	200 ECU x (5/15) =	66.7 ECU	-
Total	20		5	15			200 ECU	

Example 2	Units sold/bought	Market fees	Units withdrawn	Units computed	Share	Individual fees		
Firm 1	5		5	5-5=0	0/5	100 ECU x (0/5) =	0 ECU	0: extremely low
Firm 2	0	10 x 10 ECU = 100 ECU	0	0	0/5	100 ECU x (0/5) =	0 ECU	no sales
Consumer 1	5		-	5	5/5	100 ECU x (5/5) =	100 ECU	-
Consumer 2	0		-	0	0/5	100 ECU x (0/5) =	0 ECU	-
Total	10		5	5			100 ECU	

Example 3	Units sold/bought	Market fees	Units withdrawn	Units computed	Share	Individual fees		
Firm 1	10		4	10-4=6	6/16	200 ECU x (6/16) =	75 ECU	3: moderate
Firm 2	0	20 x 10 ECU = 200 ECU	0	0	0/16	200 ECU x (0/16) =	0 ECU	no sales
Consumer 1	5		-	5	5/16	200 ECU x (5/16) =	62.5 ECU	-
Consumer 2	5		-	5	5/16	200 ECU x (5/16) =	62.5 ECU	-
Total	20		4	16			200 ECU	

The individual fees will be deducted from your preliminary profits. Consumers and Firms will know the fees they pay and they will get information about the fees paid by each firm with a rating. The rating reflects the proportion of the exchange fees a firm actually paid, relative to the exchange fee it paid if it decided not to withdraw any units (i.e. its maximum exchange fee). The rating can take the value of 0 (Extremely low, the firm pays 0% of the maximum), 1 (Very low, the firm pays between 1 and 20%), 2 (Low, between 21 and 40%), 3 (Moderate, between 41 to 60%), 4 (High, from 61 to 80%), and 5 (Very high, if the firms pays at least 81% of the maximum). Consumers and firms will know the ratings of firms of previous rounds when they make new price and shopping decisions, respectively.

At the VOL of each round you will be informed about the prices, market shares and ratings of firms in your market and about your earnings in that round. You will also learn about the outcomes of previous rounds. You will never know the earnings of the other members of your group. At the VOL of the experiment, the earnings of all rounds will be summed up and converted into pounds at a rate of 250 ECU = 1 pound.

Endogenous Rating (VOL22)

Instructions

Welcome to today's experiment on decision-making. The session will begin shortly. Before we start, we ask you to turn off your mobile phone and other devices completely. Please refrain from talking to other participants during the experiment. If you have a question at any point in the experiment, please raise your hand. In this experiment, you will repeatedly make decisions. By doing this you can earn money. How much you will earn depends on your decisions and on the decisions of other participants. Your decisions will be absolutely anonymous, i.e. your identity will neither be revealed to your co-participants nor to the experimenters at any time during or after the experiment.

At the beginning of the experiment, you will be matched with three other participants to form a group of four. We will call each group a 'market'. Each market consists of two firms (firm 1 and firm 2) and two consumers (consumer 1 and consumer 2). At the beginning of the experiment, you will be randomly assigned to either the role of a firm or the role of a consumer. You have a 50% probability of becoming a firm or a consumer. The composition of each market and your role (being a consumer or a firm) will not change throughout the experiment. Markets are independent in that what happens in the other markets will not affect your market in any way.

Firms and consumers interact in each market for 20 rounds. Firms produce and sell an identical product and consumers buy and enjoy products in the following way:

a) Firms choose prices. For each unit they sell, firms may make a profit. The unit profit is the difference between the selling price and the production costs. Production costs are the same for both firms and will only be known by them, and will be the same for the 20 rounds of the experiment.
b) Consumers observe the prices chosen by firms and buy products. For each unit they buy, consumers may make a profit. The unit profit is the difference between the consumption value of the product they buy and the price they pay for it. Consumption values are the same for both consumers and will only be known by them, and will stay the same for the 20 rounds of the experiment.

Depending on your role, you will be informed about your production costs (if you are a firm) or about your consumption value (if you are a consumer).

The logic of the experiment is simple. Each round, firms choose prices first, from 0 to 100 Experimental Currency Units (ECU). Consumers, upon observing the prices of both firms, make shopping decisions, buying up to 5 units from any of the two firms (up to a total of 10 units per market).

At the VOL of each round, exchange fees will be collected in each market. The exchange fees for the entire market will be 20 ECU per exchanged unit. So, if a total of 10 units were exchanged in a market in total, fees for this market will be 200 ECU that round.

The distribution of fees among consumers and firms is computed using the following mechanism. First, each firm decides how many units it wants to withdraw from the distribution of exchange fees. The cost of withdrawing one unit is 1 ECU. The exchange fee corresponding to any withdrawn units will be covered by the consumers (they cannot withdraw units from the fees computation) and the other firm (if it does not withdraw all its units).

Second, the market fees will be distributed proportionally to the units not withdrawn from the computation. Note that if a firm withdraws as many units as it has sold, this firm will pay no exchange fees at all. We give you three examples now.

Example 1	Units sold/bought	Market fees	Units withdrawn	Units computed	Share	Individual fees		Disclose Rating?	Displayed Rating
Firm 1	5		5	5-5=0	0/15	200 ECU x (0/15) =	0 ECU	D	0: extremely low
Firm 2	5	20 x 10 ECU =	0	5-0=5	5/15	200 ECU x (5/15) =	66.7 ECU	D	5: very high
Consumer 1	5	200 ECU	-	5	5/15	200 ECU x (5/15) =	66.7 ECU	-	-
Consumer 2	5		-	5	5/15	200 ECU x (5/15) =	66.7 ECU	-	-
Total	20		5	15			200 ECU		

Example 2	Units sold/bought	Market fees	Units withdrawn	Units computed	Share	Individual fees			
Firm 1	5	10 x 10 ECU = 100 ECU	5	5-5=0	0/5	100 ECU x (0/5) =	0 ECU	D	0: extremely low
Firm 2	0		0	0	0/5	100 ECU x (0/5) =	0 ECU	-	no sales
Consumer 1	5		-	5	5/5	100 ECU x (5/5) =	100 ECU	-	-
Consumer 2	0		-	0	0/5	100 ECU x (0/5) =	0 ECU	-	-
Total	10		5	5			100 ECU		

Example 3	Units sold/bought	Market fees	Units withdrawn	Units computed	Share	Individual fees			
Firm 1	6	20 x 10 ECU = 200 ECU	4	6-4=2	2/12	200 ECU x (2/12) =	33.3 ECU	D	2: low
Firm 2	4		4	4-4=0	0/12	200 ECU x (0/12) =	0 ECU	ND	not disclosed
Consumer 1	5		-	5	5/12	200 ECU x (5/12) =	83.3 ECU	-	-
Consumer 2	5		-	5	5/12	200 ECU x (5/12) =	83.3 ECU	-	-
Total	20		8	12			200 ECU		

The individual fees will be deducted from your preliminary profits. Consumers and Firms will know the fees they pay. Each firm may also choose to voluntarily disclose a rating regarding its payment of fees. The rating reflects the proportion of the exchange fees a firm actually paid, relative to the exchange fee it paid if it decided not to withdraw any units (i.e. its maximum exchange fee). The rating can take the value of 0 (Extremely low, the firm pays 0% of the maximum), 1 (Very low, the firm pays between 1 and 20%), 2 (Low, between 21 and 40%), 3 (Moderate, between 41 to 60%), 4 (High, from 61 to 80%), and 5 (Very high, if the firms pays at least 81% of the maximum). Consumers and firms will know the ratings of firms of previous rounds, if disclosed, when they make new price and shopping decisions, respectively.

At the VOL of each round you will be informed about the prices, market shares and ratings of firms in your market and about your earnings in that round. You will also learn about the outcomes of previous rounds. You will never know the earnings of the other members of your group. At the VOL of the experiment, the earnings of all rounds will be summed up and converted into pounds at a rate of 250 ECU = 1 pound.

APPENDIX B. THEORETICAL PREDICTIONS

Proof of Proposition 1: Tax opacity corresponds to the case where firms are not allowed to make quality announcements in Stage 0. We use backward induction. Firms will choose $s = 0$ in stage 3 (because quality is costly), the consumer will buy from the low-price firm in stage 2 and competitive pricing will be the equilibrium outcome in stage 1.

Proof of Proposition 2. This corresponds to the case in which in stage 0, firms are obliged to make a binding announcement about the quality they will provide in stage 3. We proceed by backward induction. In stage 2, the consumer will be buying the high price product if the price differential is smaller than a proportion of the tax compliance differential, where the proportionality constant is given by the taste parameter α, $p_H - p_L \leq \alpha(s_H - s_L)$. In Stage 1, price competition will drive the less tax compliant firm to set competitive prices while the high quality firm will charge $p_H^* = \alpha(s_H - s_L)$. Given that profits of the high-quality firm, $\pi(s_H, s_L) = \alpha(s_H - s_L) - \varepsilon s_H = (\alpha - \varepsilon)s_H - \alpha s_L$, are increasing in his own tax compliance behavior, the equilibrium in Stage 0 implies maximum differentiation, $s_H = 1, s_L = 0$, with profits $\pi(s_H, s_L) = \alpha - \varepsilon$ and $\pi(s_L, s_H) = 0$. There is also an inefficient mixed strategy equilibrium.[29] In the mixed strategy equilibrium, firms randomize between not paying and paying full taxes; the probability that a firm does not pay taxes is inversely related to the taste for quality, $p^* = \varepsilon/\alpha$.

Proof of Proposition 3. This is the case in which making binding announcements at stage 0 about future tax compliance is a strategic decision by firms. The strategy set in stage 0 is now $(ND, 0, \ldots, 1)$ where ND stands for "Do Not Disclose", and the remaining strategies should be read "make a public commitment to a fraction s of the taxes". The model is solved using backward induction arguments. We will show that there exist values of the quality cost such that both firms withholding is a subgame perfect Nash equilibrium.

<u>Stage 3</u>. *Purchasing Subgames.* A subgame in this stage is characterized by a pair of prices (p_1, p_2) and a pair of qualities (s_1, s_2). The consumer will buy from firm 1 if $\alpha s_1 - p_1 \geq \alpha s_2 - p_2$, that is, if $p_1 \leq p_2 + \alpha(s_1 - s_2)$, where s_k is either the observed quality or the realized quality of firm k, for $k = 1, 2$.

[29] The mixed strategy Nash equilibrium is inefficient because expected profits are null in equilibrium – as compared to a pure strategy equilibrium where the high quality firm receives positive profits.

Stage 2: *Pricing subgames*. A subgame in this stage is characterized by a pair of quality decisions, one for each firm, and firms choose prices simultaneous and unilaterally. Because at this stage the cost εs of providing quality s are sunk –i.e. the quality decisions have been already taken in stage 1- quality costs do not affect the optimal choice of prices; i.e. optimal prices will come from revenue R maximization in this stage. There are three types of subgames.

2.1 Both firms disclose. Without loss of generality, assume that $s_1 > s_2$. The best response of firm i comes from the revenue maximization problem. The optimal response is to undercut prices until they reach the floor $p = 0$. Hence, the best response is $p_i^{BR}\left(p_j\right) = max\left\{p_j + \alpha\left(s_j - s_i\right), 0\right\}$, and because we are assuming that $s_1 > s_2$, we get the equilibrium prices $p_1^* = \alpha(s_1 - s_2)$ and $p_2^* = 0$ with revenues $R_1^* = \alpha(s_1 - s_2) - \varepsilon s_1 = s_1(\alpha - \varepsilon) - \alpha s_2$ and $R_2^* = 0$

2.2 No firm discloses. When a firm does not disclose, the consumer will assign a random quality σ independently and uniformly distributed in the interval $[0, r]$ to its product. If no firm discloses the quality, given the pair of prices (p_1, p_2), the probability that the consumer will end up buying from firm i is $Prob\left(\sigma_i \geq \sigma_j + \frac{p_i - p_j}{\alpha}\right)$. This probability is

$$Prob\left(\sigma_i \geq \sigma_j + \frac{p_i - p_j}{\alpha}\right) = \int_{\sigma_j=0}^{r} \int_{\sigma_i=\sigma_j+\frac{p_i-p_j}{\alpha}}^{r} f(\sigma_i)\, f(\sigma_j) d\sigma_i d\sigma_j$$

where

$$\int_{\sigma_i=\sigma_j+\frac{p_i-p_j}{\alpha}}^{r} f(\sigma_i)\, d\sigma_i = \frac{1}{r}\left(r - \left(\sigma_j + \frac{p_i - p_j}{\alpha}\right)\right)$$

The, the probability that the consumer will end up buying from firm is is

$$Prob\left(\sigma_i \geq \sigma_j + \frac{p_i - p_j}{\alpha}\right) = \frac{1}{r}\int_{\sigma_j=0}^{r} \left(r - \left(\sigma_j + \frac{p_i - p_j}{\alpha}\right)\right) f(\sigma_j) d\sigma_j$$

$$= \frac{1}{r}\int_{\sigma_j=0}^{r} \left(r - \frac{p_i - p_j}{\alpha}\right) f(\sigma_j) d\sigma_j - \frac{1}{r}\int_{\sigma_j=0}^{r} \sigma_j f(\sigma_j) d\sigma_j = \frac{r - \frac{p_i - p_j}{\alpha}}{r} - \frac{1}{2}$$

$$= \frac{1}{2} - \frac{p_i - p_j}{\alpha r}$$

The best response function for firm i comes from the revenue maximization problem

$$\max_{p_i} R_i = p_i \times \left(\frac{1}{2} - \frac{p_i - p_j}{\alpha r}\right)$$

The first order condition is

$$\frac{dR_i}{dp_i} = \frac{1}{2} - \frac{p_i - p_j}{\alpha r} - \frac{p_i}{\alpha r} = 0$$

The best response is therefore

$$p_i^{BR}\left(p_j\right) = \frac{\alpha r}{4} + \frac{1}{2} p_j$$

Imposing symmetry, $p_i = p_j = p^*$, we obtain the Nash equilibrium price is $p^* = \frac{\alpha r}{2}$, with equilibrium revenues $R^* = \frac{\alpha r}{4}$.

<u>*2.3 Only one firm discloses*</u>. Without loss of generality, let us assume that firm 2 does not disclose (i.e. chooses strategy ND). Let us start analyzing the best response function for the firm disclosing the quality in Stage 1 that faces firm 2 with price p_2 and undisclosed quality σ_2. The probability that the consumer will end up buying from firm 1 is the probability that the realization of the quality level for firm 2 σ_2 is not high enough, that is, $Prob\left(\sigma_2 \leq s_1 + \frac{p_2 - p_1}{\alpha}\right)$. The best response of firm 1 comes from the solution to the following maximization problem

$$\max_{p_1} R_1 = p_1 \times Prob\left(\sigma_2 \leq s_1 + \frac{p_2 - p_1}{\alpha}\right)$$

Note that the higher the price p_1, the lower the chances that the consumer will buy from firm 1. This implies that the optimal price p_1^* will never be higher that the price $\overline{p}_1$ for which the probability of selling is 0, and will never be lower than the price $\widehat{p}_1$ for which the probability of selling is 1. We now compute these two critical values as follows

$$s_1 + \frac{p_2 - \overline{p}_1}{\alpha} = 0 \rightarrow \overline{p}_1 = \alpha s_1 + p_2$$

$$s_1 + \frac{p_2 - \overline{p}_1}{\alpha} = 1 \rightarrow \widehat{p}_1 = \alpha s_1 + p_2 - \alpha r$$

Once we know these boundaries, we compute the interior solution p_1^I to the optimization problem. The first order condition is

$$\frac{dR_1}{dp_1} = s_1 + \frac{p_2 - p_1^I}{\alpha} - \frac{p_1^I}{\alpha} = 0 \rightarrow p_1^I = \frac{\alpha s_1 + p_2}{2} = \frac{\overline{p}_1}{2}$$

For all values of r, s_1 and p_2 we have that $p_1^I < \overline{p}_1$ and that $p_1^I \geq \widehat{p}_1$ for $\alpha s_1 + p_2 \leq 2\alpha r$. Hence, the optimal choice for firm 1 is

$$p_1^{BR}(p_2) = \begin{cases} \frac{1}{2}(\alpha s_1 + p_2) & if\ \alpha s_1 + p_2 \leq 2\alpha r \\ \alpha s_1 + p_2 - \alpha r & if\ \alpha s_1 + p_2 > 2\alpha r \end{cases}$$

And notice that the slope of the best response function is positive, $\frac{dp_1^*}{dp_2} > 0$, meaning that prices are strategic complements.

We next analyze the optimal behavior for the firm not disclosing the quality. The best response of firm 2 comes from the solution to the following maximization problem

$$\max_{p_2} R_2 = p_2 \times Prob\left(\sigma_2 > s_1 + \frac{p_2 - p_1}{\alpha}\right)$$

Because the probability of selling decreases with p_2, it follows that as before, two boundary prices are relevant. The first one is when the probability of selling is 0. This happens at price $\overline{p}_2$ such that

$$s_1 + \frac{\overline{p}_2 - p_1}{\alpha} = r \rightarrow \overline{p}_2 = \alpha r + p_1 - \alpha s_1$$

And the second one is then the probability of selling is already 1. This happens at price $\widehat{p}_2$ such that

$$s_1 + \frac{\widehat{p}_2 - p_1}{\alpha} = 0 \rightarrow \widehat{p}_2 = p_1 - \alpha s_1$$

The interior solution p_2^I solves the following maximization problem

$$\max_{p_2} R_2 = p_2 \times \left(r - s_1 - \frac{p_2 - p_1}{\alpha}\right) \times \frac{1}{r}$$

The first order condition is

$$\frac{dR_2}{dp_2} = r - s_1 - \frac{p_2^I - p_1}{\alpha} - \frac{p_2^I}{\alpha} = 0 \rightarrow p_2^I = \frac{\alpha r + p_1 - \alpha s_1}{2} = \frac{\overline{p}_2}{2}$$

As before, we obtain that the interior solution is always smaller than the upper threshold and that it is above the lower threshold when $p_1 - \alpha s_1 \leq \alpha r$. So, the optimal choice for firm 2 is

$$p_2^{BR}(p_1) = \begin{cases} max\left\{0, \dfrac{\alpha r + p_1 - \alpha s_1}{2}\right\} & if\ p_1 - \alpha s_1 \leq \alpha r \\ p_1 - \alpha s_1 & if\ p_1 - \alpha s_1 > \alpha r \end{cases}$$

Two questions are in order. First, prices are strategic complements, as $\frac{dp_2^*}{dp_1} > 0$. And second, we have included the *max* operator when $p_1 - \alpha s_1 \leq \alpha r$. This is because there are combinations of price and quality that comply with the restriction but imply a negative price. This happens when $p_1 - \alpha s_1 < -\alpha r$. For these cases, regardless of how small firm 2 sets her price, she will never stand a chance of selling to the consumer.

We next analyze the Nash equilibrium structure of this class of subgames. Recall that these subgames are characterized by a tuple (s_1, α, r). The undercutting nature of the best responses begs the question of when the non-disclosing firm will reach the price floor $p_2 = 0$ in equilibrium. The best response of firm 1 to $p_2 = 0$ depends on whether $\alpha s_1 + p_2 \lesseqgtr 2\alpha r$. We consider each case separately.

Case (i): $s_1 \geq 2r$. Firm 1's best response to $p_2 = 0$ is $p_1^{BR}(0) = \alpha s_1 - \alpha r$. Then, it follows that $p_1^{BR}(0) - \alpha s_1 = \alpha s_1 - \alpha r - \alpha s_1 = -\alpha r < 0$, implying that the best response for firm 2 is $p_2^{BR}(p_1) = max\left\{0, \frac{\alpha r + \alpha s_1 - \alpha r - \alpha s_1}{2}\right\} = 0$. Therefore, $p_1^* = \alpha s_1 - \alpha r > 0$ and $p_2^* = 0$ are the Nash equilibrium prices.

Case (ii): $s_1 \leq 2r$. Firm 1's best response to $p_2 = 0$ is $p_1^{BR}(0) = \frac{\alpha s_1}{2}$. Then, it follows that $p_1^{BR}(0) - \alpha s_1 = \frac{\alpha s_1}{2} - \alpha s_1 < 0$, implying that the best response for firm 2 is $p_2^{BR}(p_1) = max\left\{0, \frac{\alpha r + \frac{\alpha s_1}{2} - \alpha s_1}{2}\right\} = \frac{2\alpha r - \alpha s_1}{4} > 0$. So, $p_1^* > 0$ and $p_2^* = 0$ are not equilibrium prices.

This analysis shows that for a given subgame (s_1, α, r), when r is smaller than $\hat{r} = \frac{s_1}{2}$, firm 2 will charge a price $p_2^* = 0$ and firm 1 will charge price $p_1^* = \alpha s_1 - \alpha r$ and will sell with probability 1 in equilibrium. However, when r is above the threshold $\hat{r} = \frac{s_1}{2}$, both firms will charge a positive price and both firms have a positive probability of selling to the customer.

<u>Stage 1</u>: *Quality disclosure subgames*. We finally arrive at the stage in which qualities are announced. Here, the game is defined by the pair (α, r). We next show that there are conditions

under which no disclosure by neither firm constitutes a Subgame perfect Nash equilibrium of the game. Let us assume that firm 2 does not disclose any quality. Which is the best response of firm 1? If she decides not to disclose, then her revenues will be $R^* = \frac{\alpha r}{4}$ and she will bear the cost of producing the expected quality $r/2$. Hence, her profits will be $\pi^*(ND, ND) = \frac{\alpha r}{4} - \varepsilon \times \frac{r}{2}$. An alternative is commit to quality s, with associated cost $\varepsilon \times s$. Which are the revenues from such an alternative? The easier way is to focus on values of the parameter r lower than ½, so we are in the case where firm 1, by setting price $\alpha s_1 - \alpha r$ can assure that firm 2 will stand no chance of selling to the customer. The profits to firm 1 are therefore $\pi^*(s_1, ND) = \alpha s_1 - \alpha r - \varepsilon \times s_1 = s_1(\alpha - \varepsilon) - \alpha r$. Because these profits are increasing in the quality level, it follows that firm 1 will choose the highest quality $s_1 = 1$. Hence, the associated profits will be $\pi^*(1, ND) = \alpha - \varepsilon - \alpha r = \alpha(1 - r) - \varepsilon$. Then, it follows that $\pi^*(ND, ND) - \pi^*(1, ND) = 2(2 - r)\varepsilon - (4 - 5r)\alpha$, and there exists a value $\hat{\varepsilon}$ of the cost parameter above which firm 1 will prefer to withhold. This threshold is $\hat{\varepsilon} = \frac{4-5r}{4-2r}\alpha$, and it increases with the parameter α. Qed

Appendix C. Additional econometric analysis

Table 12: Likelihood that firm made higher profits than the other firm in treatments with ratings by market size

	Mandatory ratings		Voluntary ratings			
Variable: Get (t)	Small markets	Large markets	Small markets		Large markets	
Lower price (t)	0.0406	-0.0288	0.211***	0.222***	0.254***	0.256***
	(0.0613)	(0.0495)	(0.0552)	(0.0560)	(0.0534)	(0.0536)
Higher rating (t-1)	-0.0777	0.0348				
	(0.0721)	(0.0544)				
Only discloser (t-1)			0.208		-0.0286	
			(0.308)		(0.0692)	
Only discloser after both disclosed (t-1)				0.201*		0.148
				(0.114)		(0.148)
Observations	342	418	342	342	418	418
Log Likelihood	-224.61	-289.35	-228.14	-228.14	-276.22	-275.80
Chi-squared	1.74	0.76	17.42	17.42	22.83	23.49

Note: This table contains marginal effects of Probit regressions with random intercepts of subjects nested in groups. *Lower price* takes the value of 1 if a firm's price is lower than the other firm's price and 0 otherwise. *Higher rating* takes the value of 1 if the firm's rating was higher than the other firm's rating and 0 otherwise. *Only discloser* takes the value of 1 if the firm disclosed its rating, but the other firm did not and 0 otherwise. *Only discloser after both disclosed* takes the value of 1 if both firms disclosed their rating in t-1, and the firm disclosed its rating in t, but the other firm did not (in t), and 0 otherwise. Levels of significance: * p<0.1, ** p<0.05, *** p<0.01.

Table C.2. Rating coordination and prices, by market size and rating scheme

Mandatory ratings

	Small markets		Large markets	
Ratings	Occurrence	Prices	Occurrence	Prices
(Low, Low)	25.18%	48.37	33.82%	39.27
(High, High)	39.57%	57.06	33.33%	54.72
(One High, One Low)	35.25%	37.79 43.70	32.84%	43.35 46.20

Notes: Separated by treatments these tables contain the number of observations of feasible rating combinations as well as average posted prices (t) for such combinations of ratings in t-1. *Low* and *High* ratings contain observations of ratings $\in \{0,1,2\}$ and $\{3,4,5\}$, respectively. ND stands for non-disclosed.

Voluntary ratings

	Small markets		Large markets	
Ratings	Occurrence	Prices	Occurrence	Prices
(Low, Low)	5.59%	57.14	9.39%	47.34
(High, High)	19.25%	56.26	7.51%	57.27
(One High, One Low)	27.33%	72.29 70.09	5.63%	46.59 50.45
(ND, ND)	13.66%	58.79	42.25%	50.02
(One Low, One ND)	9.94%	58.31 66.31	10.33%	49.38 46.81
(One High, One ND)	24.22%	68.49 61.31	24.88%	54.89 56.51

These tables display the distribution of the rating combinations and the average posted prices by market size and treatment. In treatments where ratings are mandatory, game theory predicts two asymmetric Nash equilibria, with one firm offering high quality and the other specialising in low quality product. Hence, firms face a severe coordination problem, as only the firm offering the high quality product will get positive profits. Data reveal that this competitive environment is tough: Most of the times firms fail to coordinate and either both offer low or high ratings simultaneously: firms exhibit a (Low, Low) or (High, High) profiles two thirds of the times.

However, when firms are given the chance of selecting in how many dimensions they want to compete, we observe better coordination of firms on the equilibria for both market sizes. In small markets, VOL22, in 51% of occasions firms coordinate on the asymmetric equilibria (High, Low) or (High, ND), while in large markets, firms coordinate on the symmetric equilibrium (ND, ND) in 40% of the occasions and the asymmetric combination (High, ND) in 25%.