Design of yardstick competition and consumer prices

Dijkstra, Pieter; Haan, Marco; Mulder, Machiel

university of groningen / faculty of economics and business

15004-EEF

Design of Yardstick Competition and Consumer Prices: Experimental Evidence

Peter T. Dijkstra
Marco A. Haan
Machiel Mulder

SOM is the research institute of the Faculty of Economics & Business at the University of Groningen. SOM has six programmes:

- Economics, Econometrics and Finance
- Global Economics & Management
- Human Resource Management & Organizational Behaviour
- Innovation & Organization
- Marketing
- Operations Management & Operations Research

Research Institute SOM
Faculty of Economics & Business
University of Groningen

Visiting address:
Nettelbosje 2
9747 AE Groningen
The Netherlands

Postal address:
P.O. Box 800
9700 AV Groningen
The Netherlands

T +31 50 363 7068/3815

www.rug.nl/feb/research

university of groningen / faculty of economics and business

Design of Yardstick Competition and Consumer Prices: Experimental Evidence

Peter T. Dijkstra
Faculty of Economics and Business, Department of Economics, Econometrics and Finance

Marco A. Haan
Faculty of Economics and Business, Department of Economics, Econometrics and Finance

Machiel Mulder
Faculty of Economics and Business, Department of Economics, Econometrics and Finance
& Netherlands Authority for Consumers & Markets

Design of Yardstick Competition and Consumer Prices: Experimental Evidence*

Peter T. Dijkstra† Marco A. Haan‡ Machiel Mulder‡,§

March 20, 2015

Abstract

In this paper we analyze the effect of the design of yardstick competition on consumer prices, by means of a theoretical analysis as well as an economic experiment. We compare four different designs: the uniform yardstick, the unweighted uniform yardstick, the discriminatory yardstick, and the best-practice yardstick. The effect of a specific design on prices depends on two separate mechanisms, one which affects the incentive power to increase productive efficiency and another which affects the risk of collusion. We show theoretically that for the best-practice yardstick these two mechanisms point in the same direction (high prices), which is confirmed by the experiment. The theoretical analysis also shows that the discriminatory yardstick results in lower prices than the unweighted uniform yardstick, which is also confirmed by the economic experiment. The theory, however, does not give a clear answer on the relative performance of the discriminatory versus the uniform yardstick. In the experimental analysis, we find that the advantage of the discriminatory yardstick in terms of giving incentives to improve productive efficiency exceeds the disadvantage of a relatively higher risk of collusion. This conclusion appears to be robust for different degrees of heterogeneity of the industry. Hence the discriminatory yardstick yields the lowest prices for consumers.

JEL Classification Codes: C73, C92, L13, L51.

Keywords: Collusion; Industry Structure; Yardstick Competition; Experiment.

*We are indebted to seminar participants at the University of Groningen (RUG) and the Netherlands Authority for Consumers & Markets (ACM). Financial support of the Netherlands Authority for Consumers & Markets (ACM) is gratefully acknowledged. The authors are fully responsible for the contents of the paper.

†Corresponding author, p.t.dijkstra@rug.nl. Phone: +31 50 363 4001. Fax: +31 50 363 7337. Department of Economics, Econometrics and Finance, University of Groningen, P.O. Box 800, 9700 AV Groningen, The Netherlands.

‡Department of Economics, Econometrics and Finance, University of Groningen, P.O. Box 800, 9700 AV Groningen, The Netherlands.

§Netherlands Authority for Consumers & Markets (ACM), The Hague, The Netherlands.

1 Introduction

In order to give monopolistic firms incentives to increase their productive efficiency while the realized benefits are passed on to consumers, regulators may apply yardstick competition. In this type of regulation, the (maximum) price for consumers is based on the costs of a group of similar firms (Shleifer, 1985). Experiences with yardstick regulation exist in different countries, such as in the United Kingdom with the water supply and sewerage industry and the electricity networks (Dassler, Parker and Saal, 2006; Jamasb and Pollitt, 2007), in the Netherlands with the energy-distribution grids (Haffner, Delmer and Van Til, 2010), in Spain also with the energy grids (Blázques-Gómez and Grifell-Tatjé, 2011), in Japan with railways (Mizutani, Kozumi and Matsushima, 2009) and in Norway with bus transport services (Dalen and Gomez-Lobo, 2002). In several cases, the introduction of yardstick regulation improved productive efficiency or resulted in lower consumer prices. In other cases, however, the experience appeared to be less successful.

The ultimate price effect of yardstick competition depends on two different mechanisms: the incentives for firms to increase their productive efficiency and the incentives for firms to collude with each other. A yardstick that performs well under the assumption that firms behave non-cooperatively may still backfire if it facilitates collusion. Within a regulatory system of yardstick competition, collusion means that the firms agree, perhaps tacitly, with each other not to reduce costs or to jointly manipulate productivity reports (Tangerås, 2002). While giving incentives to increase efficiency belongs to the key objectives of yardstick competition, the incentives to collude are unintended and related to how yardstick competition is implemented. Both effects have to be analyzed in order to determine the impact of yardstick competition on consumer prices.

The incentive power to raise productive efficiency is higher, the less a firm's regulated price is related to its own costs. If the price is capped on the level of the (average) costs of (all) other firms, this power is maximized, meaning that high-powered incentives are given to that firm to reduce costs. This type of yardstick competition is called discriminatory-yardstick competition, referring to the fact that every firm faces a specific price cap (i.e. the average costs of the other firms). If the maximum price is based on the costs of all firms, the incentive power to increase efficiency depends on the share of a firm's costs in the regulated price. This type of yardstick competition is called uniform yardstick competition, as each firm faces the same price cap. The uniform yardstick can be calculated on the basis of weighted or unweighted average costs. The incentive power is ex ante undetermined when the yardstick is based on the costs of the most efficient firm (the so-called best-practice yardstick), as all less efficient firms face the highest incentive power, while the most efficient firm does not face any incentive to become even more efficient. Hence, it is clear that the impact of yardstick competition on the incentives for firms to increase productive efficiency depends on how the yardstick is determined.

The incentives to reduce costs may, however, be (partly) neutralized if firms also have the incentive to collude with each other, i.e. to make agreements not to reduce costs. The incentives for individual firms to collude depends on a trade-off between the short-run benefits of cheating, versus the long-run opportunity costs of a collapse of the cartel. In an experiment, Potters et al. (2004) find that the incentive to collude with equally sized firms is higher when a discriminatory yardstick is applied compared to a situation with a uniform yardstick. Apparently, the authors conclude, the stronger incentives to collude with a discriminatory yardstick outweigh the higher incentive to raise productive efficiency. Yet, this effect is only shown for equally-sized firms, raising the question whether a more heterogeneous firm-size distribution would give the same result. From Dijkstra, Haan, and Mulder (2014), we know that the incentive to collude in case of a weighted uniform yardstick is related to the industry structure: in more heterogeneous industries, firms appear to collude less than in homogeneous industries.

Hence, in order to determine the ultimate effect of yardstick competition on consumer prices, the trade-off between the incentive power and the incentive to collude has to be assessed for different industry structures. As this trade-off depends on the magnitude of both effects, a theoretical analysis is not sufficient to make the assessment. Therefore, we conduct a laboratory experiment. The objective of this experiment is to determine the optimal design of the yardstick from the perspective of consumers taking into account both the incentives for efficiency improvement and the risk of collusion among the participants of the yardstick competition.

In our experiment we let agents decide upon cost levels while they know that their output prices are set by a regulator using a specific form of yardstick competition. This design of the experiment is similar to Dijkstra et al. (2014). We use a simple model, loosely based on Shleifer (1985), where firms have to exert costly effort to lower their costs. For simplicity, managerial benefits are a concave and quadratic function of a firm's marginal costs. Managers aim to maximize the sum of profits and managerial benefits, and do so in a repeated game.

First, assuming a heterogeneous industry structure consisting of 2 firms, we analyze the impact of different definitions of the yardstick on the price for consumers. The yardsticks analyzed are the discriminatory, weighted uniform, unweighted uniform and best-practice. In each case we analyze which cost decisions firms make, to what extent they collude and what the ultimate price for consumers is. We find that the price for consumers is highest for a best-practice yardstick, while a discriminatory yardstick yields prices that are lower (i.e. closer to the social optimum) than an unweighted uniform yardstick.

Next, we zoom in on two particular yardsticks: the (weighted) uniform and the discriminatory yardstick. These two yardsticks are most often used in practice, while theory does not provide a clear prediction in terms of their market performance. We find that overall, i.e. taking into account a number of different industry structures, the discriminatory yardstick results in the most efficient consumer prices. From this we conclude that the discriminatory yardstick is the preferred yardstick in order to raise productive efficiency of monopolistic firms and to pass on these benefits to consumers.

In a companion paper (Dijkstra et al., 2014) we use a similar set-up to study the effect of industry structure on regulated prices with a (weighted) uniform yardstick. Therefore, parts of the description of the theoretical model and the experimental set-up in this paper closely follow that in our companion paper. The structure of this paper is as follows. Section 2 describes our theoretical model. The experimental design is presented in Section 3. Section 4 discusses the result of our experiment with 4 yardsticks, while Section 5 discusses the comparison between the discriminatory and (weighted) uniform yardsticks. Section 6 concludes.

2 The Model

2.1 Setup

We consider the following model. There are n firms that play an infinitely repeated game. Each firm acts as a local monopolist. For simplicity, we assume that firm i faces demand that is completely inelastic and exogenously given by mass $\alpha_i \in (0,1)$. We normalize total demand, so $\sum_{i=1}^{n} \alpha_i = 1$. For ease of exposition, we will refer to α_i as the market share of firm i. In each round, firm i decides on its constant marginal cost c_i for that round. Firm i's profits then equal $\pi_i(c_i, \mathbf{c}_{-i}) = \left(p_i^y(c_i, \mathbf{c}_{-i}) - c_i\right)\alpha_i$, with p_i^y the price that firm i can set under yardstick y, and the vector $\mathbf{c}_{-i}$ consists of the cost levels chosen by the other firms. We assume that the manager of firm i maximizes $u_i = \pi_i(c_i, \mathbf{c}_{-i}) + R_i(c_i)$, with R_i a managerial benefit that is non-negative and concave: $R_i \geq 0$, $R_i'' < 0$, and $R_i(0) = 0$. Note that this specification is equivalent to Shleifer (1985), where managers invest in a cost-reducing technology.[1] For simplicity, we use the following quadratic specification:

$$R(c_i) = \left(-ac_i^2 + bc_i\right)\alpha_i, \tag{1}$$

where $a, b \in \mathbb{R}^+$ are parameters and $c_i \in [0, b/a]$. Throughout, we assume that a and b are such that all expressions that we derive are well defined. The assumption that

[1] In Shleifer (1985), firms invest $R(c)$ in a cost-reducing technology that lowers marginal cost by c. With downward sloping demand, the monopolist cannot fully capture the social welfare generated by lower costs. Hence it will underinvest from a welfare perspective. This is no longer true, however, if demand is inelastic. In that case, the monopolist does capture the entire surplus and hence there is no underinvestment. For experimental simplicity, we do assume inelastic demand. We therefore use a slightly different set-up. We effectively assume that the manager of the firm has to exert some costly effort to lower costs. The discrepancy between the private and social optimum is then caused by the fact that the manager's costly effort is not taken into account when maximizing social welfare. This allows us to generate the same theoretical prediction (that firms underinvest), but in a simpler set-up. Note that our interpretation closely follows Potters et al. (2004).

managerial benefit is proportional to market share is for consistency: if the market is shared among more firms, we do not want total managerial benefit to exogenously increase as a result. Note that we allow R_i to be decreasing in c_i for large enough c_i. In electricity networks for example, high marginal costs are often associated with a lack of maintenance. Such networks are prone to outages, compensation claims and political pressure, all factors that imply higher costs and do not exactly contribute to a quiet life for the manager. Also, this choice simplifies the experimental implementation of our model. The manager of firm i is thus assumed to maximize

$$u_i = \left(p_i^y(c_i, \mathbf{c}_{-i}) - c_i\right)\alpha_i + \left(-ac_i^2 + bc_i\right)\alpha_i. \tag{2}$$

Managerial benefit is maximized by

$$c^m = \frac{b}{2a}. \tag{3}$$

If consumers value the product at v, total welfare equals

$$W = (v - p) + (p - c) + \left(-ac^2 + bc\right), \tag{4}$$

where the first term is consumer surplus, and the other two terms is the total payoff to firms. Maximizing with respect to c yields the socially optimal cost level

$$c^W = \frac{b-1}{2a}. \tag{5}$$

2.2 Yardsticks, non-cooperative behavior

With a UNIFORM yardstick,[2] the price firm i can charge equals the weighted average of all cost levels in the industry:

$$p^U(c_1, \ldots, c_n) = \sum_{j=1}^{n} \alpha_j c_j. \tag{6}$$

Plugging this into (2) and maximizing with respect to c_i yields the non-cooperative cost level

$$c_i^{U*} = \frac{b-1+\alpha_i}{2a}. \tag{7}$$

[2]As the regulation literature usually refers to the weighted uniform yardstick as "uniform", we also follow that convention here.

Note that this is a dominant strategy, as it does not depend on the cost choices of the other firms. Also note that a firm with a higher market share α_i has a stronger influence on the regulated price, hence it will choose a higher cost level. Third, with $\alpha_i < 1$, the equilibrium cost level is strictly lower than the cost level that maximizes managerial benefits, but higher than the social optimum. The regulated price now becomes

$$p^{U*} \equiv p^U\left(c_1^{U*}, \dots, c_n^{U*}\right) = \sum_{i=1}^{n} \alpha_i \frac{b-1+\alpha_i}{2a} = \frac{b-1}{2a} + \frac{\sum_{i=1}^{n} \alpha_i^2}{2a}. \tag{8}$$

With a uniform unweighted yardstick, the price firm i can charge equals the unweighted average of all cost levels in the industry:

$$p^E(c_1, \dots, c_n) = \frac{1}{n}\sum_{j=1}^{n} c_j. \tag{9}$$

In our experiment, we will refer to this treatment as EQUALW – for equal weights. Plugging (9) into (2) and maximizing with respect to c_i yields

$$c_i^{E*} = \frac{b-1+\frac{1}{n}}{2a}. \tag{10}$$

Hence, the non-cooperative cost level is now the same for all firms, as all firms have the same influence on the regulated price. Again, non-cooperative cost levels are strictly between the social optimum and the level that maximizes managerial benefits. The regulated price becomes

$$p^{E*} \equiv \left(c_1^{E*}, \dots, c_n^{E*}\right) = \frac{1}{n}\sum_{i=1}^{n} \frac{b-1+\frac{1}{n}}{2a} = \frac{b-1}{2a} + \frac{1}{2an}. \tag{11}$$

With a discriminatory yardstick (denoted DISCRIM in our experiment), the price firm i can charge equals the weighted average of the cost levels of all *other* firms in the industry:

$$p_i^D(c_1, \dots, c_n) = \frac{\sum_{j\neq i}^{n} \alpha_j c_j}{\sum_{j\neq i}^{n} \alpha_j}. \tag{12}$$

Note that our notation reflects that in this case the price is firm-specific. Plugging (12) into (2) and maximizing with respect to c_i yields

$$c_i^{D*} = \frac{b-1}{2a}. \tag{13}$$

Note therefore that this yardstick yields the social welfare optimum derived in (5). Also, all firms will choose the same cost level. The regulated price now differs per firm. Since a share of α_i of total demand is supplied by firm i, the average regulated price is

$$p^{D*} \equiv \sum_{i=1}^{n} \alpha_i p_i^D \left(c_1^{D*}, \ldots, c_n^{D*}\right) = \sum_{i=1}^{n} \alpha_i \frac{b-1}{2a} = \frac{b-1}{2a}. \tag{14}$$

With the best-practice yardstick (BestPr), the regulated price equals the lowest cost level of all firms in the industry:

$$p^B(c_1, \ldots, c_n) = \min\{c_j\}. \tag{15}$$

Finding the Nash equilibrium now is somewhat more involved. Suppose all other firms set c^*. By setting some $c < c^*$, manager 1 earns

$$u_i\left(c_1, c^*, \ldots, c^*\right) = (c - c)\,\alpha_i + \left(-ac^2 + bc\right)\alpha_i, \tag{16}$$

which is maximized by setting $c = b/2a$. This implies that if the other firms set some $c^* \leq b/2a$, this firm has no incentive to defect to a lower cost level: its maximization problem under the constraint that $c \leq c^*$ is given by the corner solution $c = c^*$.

By setting some $c > c^*$, manager i earns

$$u_i\left(c_1, c^*, \ldots, c^*\right) = (c^* - c)\,\alpha_i + \left(-ac^2 + bc\right)\alpha_i, \tag{17}$$

which is maximized by setting $c = (b-1)/2a$. This implies that if the other firms set some $c^* \geq (b-1)/2a$, this firm has no incentive to defect to a higher cost level: its maximization problem under the constraint that $c \geq c^*$ is given by the corner solution $c = c^*$. This implies that we have a continuum of equilibria: any

$$c^{B*} \in \left[(b-1)/2a, b/2a\right] \tag{18}$$

is a Nash equilibrium. Thus, possible Nash equilibria range from the social optimum to the outcome that maximizes managerial utility. By construction, (18) also gives the range of equilibrium prices. Given the multiplicity of equilibria in this case, we expect players to coordinate on the Pareto-optimal equilibrium, which implies

$$p^{B*} = b/2a. \tag{19}$$

From the above, we immediately have[3]

Theorem 1. *Regulated prices in the non-cooperative outcome are ranked*

$$\text{Discrim} < \text{EqualW} \leq \text{Uniform} < \text{BestPr}.$$

Only with symmetric market shares, EqualW = Uniform.

2.3 Collusion

As usual, a cartel is stable if the short-run benefits of defection are outweighed by the long-term losses due to a cartel breakdown. In other words, following e.g. Friedman (1971) we assume grim trigger strategies and look for the critical discount factor $\hat{\delta}$ such that all managers have an incentive to stick to the cartel agreement. With the usual arguments manager i does not defect if and only if

$$\frac{u_{iK}^y}{1-\delta} > u_{iD}^y + \frac{\delta}{1-\delta} u_{iN}^y, \tag{20}$$

with u_{iD}^y the utility of manager i when she defects, u_{iK}^y her utility in a cartel, and u_{iN}^y her utility in the non-cooperative outcome. This implies that we require

$$\delta > \hat{\delta}^y(\alpha_i) \equiv \frac{u_{iD}^y - u_{iK}^y}{u_{iD}^y - u_{iN}^y}. \tag{21}$$

For collusion to be sustainable, we need that this condition is satisfied for all managers:

$$\delta > \hat{\delta}^y \equiv \max\left\{\hat{\delta}^y(\alpha_1), \ldots, \hat{\delta}^y(\alpha_n)\right\}. \tag{22}$$

We will focus on the cartel agreement in which all managers set the same cost level c_k that maximizes the sum of their utilities. Arguably, this is the most obvious and focal agreement. We will refer to it as the perfect symmetric collusive agreement. Of course, if this would not yield a stable cartel, managers could still try to coordinate on a different agreement, either symmetric or asymmetric. In our theoretical analysis, however, we

[3]This follows from comparing (8), (11), (14) and (19). It is immediately clear that p^{D*} is the lowest. To see that $p^{E*} \leq p^{U*}$, define $\Delta_i \equiv \frac{1}{n} - \alpha_i$ for all i. We then have $\sum \alpha_i^2 = \sum \left(\frac{1}{n} - \Delta_i\right)^2 = \frac{1}{n} + \sum \Delta_i^2 - \frac{2}{n}\sum \Delta_i = \frac{1}{n} + \sum \Delta_i^2$ as $\sum \Delta_i = \sum\left(\frac{1}{n} - \alpha_i\right) = 1 - 1 = 0$. Hence $p^{U*} = p^{E*}$ if all $\Delta_i = 0$, hence if all firms are symmetric. Otherwise $p^{U*} > p^{E*}$. Finally, writing $p^{B*} = \frac{b-1}{2a} + \frac{1}{2a}$, it is immediate that $p^{B*} > p^{U*}$, as $\sum \alpha_i^2 < 1$ for $n > 1$.

rule out this option as we feel that it would be much harder to coordinate on such an alternative.[4] Of course, in the experimental implementation of our model, firms are free to try to coordinate on whatever they can agree upon.

If firms collude on a common cost level c_k, the regulated price simply equals $p^y = c_k$ for all yardsticks, so they maximize joint utility

$$U = (p^y(c_k, \ldots, c_k) - c_k) + \left(-ac_k^2 + bc_k\right) = \left(-ac_k^2 + bc_k\right), \tag{23}$$

which is maximized by setting

$$c_k^* = c^{m*} = b/2a. \tag{24}$$

As a joint cost level does not affect the price-cost margin, the cartel simply chooses to maximize its managerial benefit. This implies for all yardsticks

$$u_{iK}^y = \left(-a\left(c_k^*\right)^2 + bc_k^*\right)\alpha_i = \frac{\alpha_i}{4a}b^2. \tag{25}$$

The manager's utility in the non-cooperative outcome is

$$u_{iN}^y = \left(p^{y*} - c_i^{y*}\right)\alpha_i + \left(-a\left(c_i^{y*}\right)^2 + bc_i^{y*}\right)\alpha_i, \tag{26}$$

where $y \in \{\text{U, E, D, B}\}$. Finally, focusing on firm 1 for ease of exposition, u_{iD}^y is given by

$$u_{1D}^y = \left(p^y(c_1^{y*}, c_k, \ldots, c_k) - c_1^{y*}\right)\alpha_1 + \left(-a\left(c_1^{y*}\right)^2 + bc_1^{y*}\right)\alpha_1, \tag{27}$$

as we already showed that the one-shot optimal cost level for a firm is independent of the cost levels of the other firms. Therefore, the optimal deviation cost level is equal to the non-cooperative cost level. Defining $A_i \equiv \alpha_i/4a$, we then find the values of u_{iN}^y, u_{iD}^y and $\hat{\delta}^y(\alpha_i)$ for the different yardsticks that are given in Table 1.[5]

---

[4] Indeed, in our experiment we also observe that groups, if anything, coordinate on the perfect symmetric collusive agreement, irrespective of the distribution of market shares.

[5] For Uniform, u_{iN}^U is found by plugging (7) into (26), and u_{iD}^U by plugging (7) and (24) into (27). From (21), we then have $\hat{\delta}^U(\alpha_i)$. For EqualW, plugging (10) into (26) yields u_{iN}^E. Plugging (10) and (24) into (27) then yields u_{iD}^E. For Discrim, plugging (13) into (26) yields u_{iN}^D. Plugging (13) and (24) into (27) then yields u_{iD}^D. For BestPr, plugging (18) into (26) yields u_{iN}^B. Plugging (18) and (24) into (27) then yields u_{iD}^B.

Table 1: Non-cooperative utility (u^y_{iN}), defection utility (u^y_{iD}) and critical discount factor ($\hat{\delta}^y(\alpha_i)$).

Treatment	u^y_{iN}	u^y_{iD}	$\hat{\delta}^y(\alpha_i)$
Uniform	$A_i\left(b^2-1+2\sum_{j=1}^n \alpha_j^2-\alpha_i^2\right)$	$A_i\left(b^2+1+\alpha_i^2-2\alpha_i\right)$	$\frac{1}{2}\frac{(1-\alpha_i)^2}{1-\alpha_i-\sum_{j\neq i}^n \alpha_j^2}$
EqualW	$A_i\left(b^2-\left(\frac{n-1}{n}\right)^2\right)$	$A_i\left(b^2+\left(\frac{n-1}{n}\right)^2\right)$	$\frac{1}{2}$
Discrim	$A_i\left(b^2-1\right)$	$A_i\left(b^2+1\right)$	$\frac{1}{2}$
BestPr	$A_i\left(b^2-1\right)$	$A_i\left(b^2-1\right)$	0

Hence industry structure only influences the critical discount factor in Uniform. Under BestPr collusion is always sustainable. This is because deviation profits equal non-cooperative profits. We thus have:[6]

Theorem 2. *The critical discount factors are ranked*

$$\text{BestPr} < \text{EqualW} = \text{Discrim} \leq \text{Uniform}.$$

Only with symmetric market shares, Discrim = Uniform.

2.4 Summing up

From the analysis above, we thus have the following. If managers indeed set their cost levels non-cooperatively, we expect to see the highest prices in BestPr, followed by Uniform; EqualW; and Discrim, respectively. Yet, collusion is easiest to sustain in BestPr, followed by EqualW and Discrim; and Uniform, respectively.

From a theoretical perspective, we thus expect to see the highest prices in BestPr: noncooperative cost levels are then the highest, and collusion is easiest to sustain. We also expect prices to be higher in EqualW than in Discrim, as noncooperative cost

[6] First note that the critical discount factor in a treatment is the highest critical discount factor of all individual firms. Most of the results follow directly from Table 1. Note that $\hat{\delta}^U(\alpha_i) \leq 1/2$ if and only if $(1-\alpha_i)^2 \leq 1-\alpha_i-\sum_{j\neq i}\alpha_j^2$, hence if and only if $\alpha_i \geq \sum_j \alpha_j^2$. From footnote 3, $\sum_j \alpha_j^2 \geq 1/n$, with equality if all firms are equally sized. As $\alpha_i \geq \sum_j \alpha_j^2$ has to be satisfied for all firms, this implies that it cannot be satified if $\alpha_i < 1/n$, and is satisfied with equality if all firm are of size $1/n$.

levels are higher, and collusion is equally hard to sustain. But it is ambiguous how prices in UNIFORM compare to those in either EQUALW or DISCRIM. On the one hand, noncooperative cost levels are higher in UNIFORM, but on the other hand, collusion is harder to sustain, rendering the net effect ambiguous. Therefore, we use an experiment to compare the price effects of these treatments.

We thus have

Corollary 1. *Prices in* BESTPR *are higher than prices in any other treatment. Prices in* EQUALW *are higher than those in* UNIFORM. *All other pairwise comparisons are ambiguous from a theoretical perspective.*

3 Experimental Design

In our experiment subjects play the game described above for at least 20 rounds. We set $a = 1/24$ and $b = 1$ which ensures that the non-cooperative and collusive cost levels in all our treatments are integers. To avoid possible end-game effects, the experiment ends with a probability of 20% in each round from round 20 onwards (see also Normann and Wallace, 2012). Subjects are randomly matched into groups at the beginning of the experiment and play all rounds within the same group.

Every round consists of three steps. First, subjects can communicate using a chat screen. This chat is completely anonymous. Second, subjects unilaterally choose cost levels c_i from the set $\{1, 2, \ldots, 20\}$.[7] Third, prices are determined using the relevant yardstick. After each round, subjects learn the profits and managerial benefits they have realized, and the cost levels that each subject has set.[8] The unrestricted communication we allow for creates circumstances that are closest to the real world. Also, without communication, it is hard to sustain collusion in a cartel experiment with more than

[7] As we saw in the theory section, both the non-cooperative and the collusive strategy are independent of the competitors' actions. In that sense, our game boils down to a relatively straightforward prisoners' dilemma game with two strategies. Still, we choose not to represent it as such in our experiment, as that would get rid of much of the regulatory context that we feel is crucial for our purpose.

[8] Of course, in our set-up profit and managerial benefit are equally important in determining payoffs. This was also outlined in the experimental instructions. Subjects indeed seemed to understand this as they correctly answered control questions on this topic.

two players, see e.g. Haan et al. (2009).[9]

Our experiment consists of two parts. Part A serves to compare the four different yardsticks, and does so in an industry structure with two firms, where one firm is twice as big as the other: with equally sized firms, there would be no difference between the UNIFORM and EQUALW treatments. Part B zooms in on the difference between the DISCRIM and UNIFORM. These two yardsticks are most often used in the real world, whereas we do not have a clear theoretical prediction concerning the relative performance of the two, making a closer look all the more relevant. We do so by considering a number of industry structures that differ with respect to the number of firms as well as their relative size.

Table 2: Treatments part A.

Treatment	Competitive Cost Level			Collusive Cost Level	$\hat{\delta}$
	c_1^*	c_2^*	price		
UNIFORM	8	4	6.67	12	1.00
EQUALW	6	6	6.00	12	0.50
DISCRIM	1	1	1.00	12	0.50
BESTPR	12	12	12.00	12	0.00

All treatments: $\alpha_1 = 2/3$, $\alpha_2 = 1/3$.

The treatments in part A are given in Table 2. For each treatment, the Table also shows the non-cooperative cost level of each firm, the regulated price that results, the symmetric cost level that maximizes joint profits, and the critical discount factor. All these results follow from our discussion in section 2.[10]

[9] Although illegal in practice, note that cartels cannot be prosecuted or fined in this experiment.

[10] In fact, strictly speaking, in DISCRIM, the theoretical prediction would be for all firms to set a cost level equal to 0. However, we do not allow our experimental subjects to choose cost levels lower than 1; doing so would not only yield zero profits but also zero managerial benefits, which is likely to affect their behavior in ways that interfere with the purpose of our experiment. However, that also has an effect on the incentives to collude; taking into account that costs can not be lower than 1 imply a critical discount factor of $\hat{\delta}^D = 0.54$. After careful deliberation, we have decided to work with our original theoretical predictions – effectively assuming that for the subjects, the difference between $\hat{\delta} = 0.50$ and $\hat{\delta} = 0.54$ is negligible. Using $\hat{\delta}^D = 0.54$ rather than $\hat{\delta}^D = 0.50$ would hardly affect our results. If we would use $\hat{\delta}^D = 0.54$, our statistical test when comparing the incidence of collusion should be one-sided rather than two-sided when comparing UNIFORM and DISCRIM, or when comparing EQUALW and DISCRIM. In that case, the comparison in Duo66 in Table 9 would become significant at 10% (contradicting our

Throughout the experiment, we will use a loose interpretation of the critical discount factor: rather than the strict theoretical interpretation that there will always be collusion if the discount factor is bigger than $\hat{\delta}$, and there will never be collusion if it is smaller than $\hat{\delta}$, we will interpret a higher $\hat{\delta}$ as it being less likely that there will be collusion. Note that for our specific parametrization the critical discount factor in UNIFORM is equal to 1, which implies that the theoretical prediction is that a cartel will never be stable under that yardstick.

Table 3: Treatments part B.

Industry Structure	Market Share			Competitive Cost Level					Collusive Cost Level		
				UNIFORM				DISCRIM			
	1	2	3	c_1^*	c_2^*	c_3^*	p^*	c_i^*, p^*		$\hat{\delta}^U$	$\hat{\delta}^D$
Trio444	1/3	1/3	1/3	4	4	4	4.00	1.00	12	0.50	0.50
Trio633	1/2	1/4	1/4	6	3	3	4.50	1.00	12	0.64	0.50
Trio642	1/2	1/3	1/6	6	4	2	4.67	1.00	12	0.74	0.50
Duo66	1/2	1/2		6	6		6.00	1.00	12	0.50	0.50
Duo84	2/3	1/3		8	4		6.67	1.00	12	1.00	0.50

Part B consists of 10 treatments: we study 5 different industry structures and consider DISCRIM and UNIFORM in each. We now look at treatments with 2 and with 3 firms, that range from equally-sized to highly asymmetric firms. Table 3 gives an overview of the treatments. Treatments with 3 firms are denoted TrioXYZ, with X, Y and Z the relative sizes of firms 1, 2 and 3, respectively. Treatments with 2 firms are denoted DuoXY, with X and Y the relative sizes of firms 1 and 2. Treatments Duo84 are identical to those in part A; we include them here as well for ease of comparison. The five treatments with a uniform yardstick are also studied in a companion paper (Dijkstra et al., 2014), where we study the effect of industry structure on the performance of the (weighted) uniform yardstick. Again, the table shows the non-cooperative cost level of each firm in each treatment, the regulatory price that results, the symmetric collusive cost level, and the critical discount factor that all follow directly from the analysis in

hypothesis), as would that in Trio444 (confirming our hypothesis). In Table 5 the comparison between EQUALW and DISCRIM would become significant at 5% rather than 10%.

Section 2.

The experiment was conducted at the Groningen Experimental Economics Laboratory (GrEELab) at the University of Groningen in 2013. A total of 132 subjects participated in Part A, and 423 in part B, all students from the University of Groningen (86%) or the Hanze University of Applied Sciences (14%), most of them in the fields of economics and business (62%). Every session consisted of one treatment and lasted between 80 and 130 minutes. Subjects signed in for sessions, while treatments were randomly assigned to sessions.

Every treatment with two players was played in two sessions, every treatment with three players in three. Between 14 and 18 subjects participated in a session, resulting in 15 to 18 groups per treatment. The experiment was programmed in z-Tree (Fischbacher, 2007). Printed instructions were provided and read aloud. On their computer, subjects first had to answer a number of questions correctly to ensure understanding of the experiment. Participants were paid their cumulative earnings in euros. Since firm size differed between participants, exchange rates were varied such that they would receive identical amounts if they collude on cost level 12.[11] Also, participants received an initial endowment of €4. Average earnings were €16.22, ranging from €4.70 to €24.00.

4 Comparing the four yardsticks

In this section, we discuss the results of part A, where we compare 4 yardsticks in a given industry structure. Figure 1 shows average prices over time.[12] The figure suggests that BestPr indeed yields the highest prices, while Discrim yields the lowest.

A Kruskal-Wallis test rejects the hypothesis that all four yardsticks lead to the same price ($p < 1\%$). For pairwise comparisons between any two treatments, we use the Mann-Whitney U (MWU) test. Results are given in Table 4. The entries in the right-hand panels indicate whether the row treatment yields prices that are significantly lower (<) or higher (>) than the column treatment, or whether the difference is not significant

[11]This allows us to focus on the effect of asymmetries in industry structure without the possible interference of fairness issues.

[12]Note that in Discrim, we take the weighted average price as defined in (14).

Figure 1: Average price per round (across all groups).

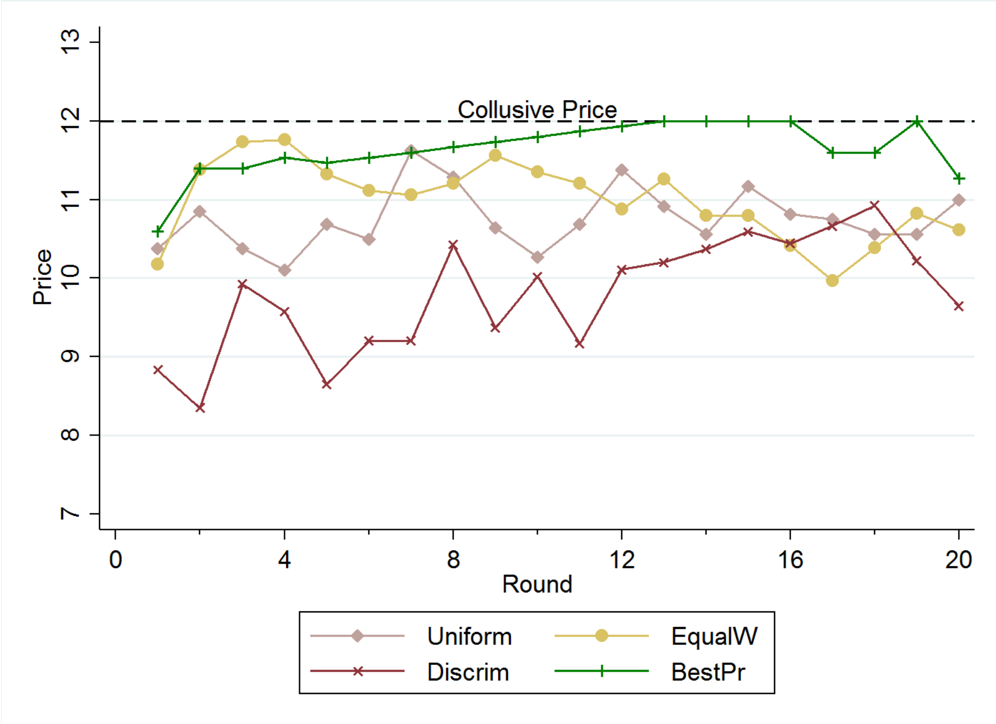


Table 4: Price per treatment (across all rounds and groups).

Treatment	Average	EqualW	Discrim	BestPr
Uniform	10.76	≈	≈	$<^{**}$
EqualW	10.99		$>^{*}$	$<^{+}$
Discrim	9.80			$<^{***}$
BestPr	11.65			

Entries in the right-hand panel indicate whether the row treatment yields prices that are significantly lower (<), significantly higher (>) or that do not differ significantly (≈) from the prices in the column treatment. Differences between two treatments are tested using the MWU test for equality (two-sided for Uniform–EqualW and Uniform–Discrim, one-sided for the other comparisons). $^{+}$ significantly different at 10%; * at 5%; ** at 1%; *** at 0.1%.

(≈). We use this convention throughout this paper.

We thus have the following:

Result 1. *Prices with a best-practice yardstick are higher than prices with any other yardstick. Prices with a uniform yardstick with an unweighted price are higher than* *those with a discriminatory yardstick.*

Note that the first part of the Result is in line with Corollary 1. We also find that prices in EqualW are significantly higher than those in Uniform. Apparently, in this case, the collusion effect (collusion is easier to sustain in EqualW) dominates the non-cooperative effect (non-cooperative cost levels are lower in EqualW). Corollary 1 also predicts that prices in EqualW are higher than those in Uniform, but our experimental results do not bear that out.

In the above, we only tested Corollary 1, which considers the net effect on regulated prices of non-cooperative cost levels on the one hand, and the extent of collusion on the other. Yet, our experimental results also allows us to disentangle these two effects.

Table 5: Incidence of full collusion per treatment (across all rounds and groups).

Treatment	Average	EqualW	Discrim	BestPr
Uniform	43.4%	$<^{*}$	$\approx$	$<^{***}$
EqualW	71.2%		$>^{+}$	$<^{+}$
Discrim	56.1%			$<^{***}$
BestPr	92.0%			

Entries in the right-hand panel indicate whether the row treatment yields collusion rates that are significantly lower (<), significantly higher (>) or that do not differ significantly (≈) from the rates in the column treatment. Differences between two treatments are tested using the MWU test for equality (two-sided for EqualW–Discrim, one-sided for the other comparisons). $^{+}$ significantly different at 10%; * at 5%; *** at 0.1%.

First consider the extent of collusion. Table 5 considers the incidence of full collusion (i.e. the percentage of cases where all firms set the collusive cost level of 12). A Kruskal-Wallis test indicates differences between all yardsticks ($p < 0.1\%$). Pairwise comparisons are given in Table 5. Theorem 2 predicts the highest incidence of collusion in BestPr, followed by EqualW and Discrim, whereas Uniform has the lowest incidence. This is largely what we find in Table 5: the incidence of full collusion in BestPr is significantly higher than in any other treatment, whereas the incidence in Uniform is significantly lower than that in EqualW and BestPr. We do however find a difference between Discrim and EqualW (albeit only significant at 10%), whereas we do not find a difference between DISCRIM and UNIFORM. A Jonckheere-Terpstra test[13] with the ordered alternative hypothesis that the incidence of full collusion is highest in BESTPR, followed by EQUALW, DISCRIM, and UNIFORM, respectively, is highly significant ($p < 0.1\%$).

Table 6: Price if no collusion, per treatment

Treatment	Average	EQUALW	DISCRIM	BESTPR
UNIFORM	9.76	$>^{+}$	$>^{**}$	$>^{*}$
EQUALW	8.59		$>^{+}$	$\approx$
DISCRIM	7.12			$\approx$
BESTPR	7.11			

Only rounds are included in which not all firms in a group set the fully collusive cost level of 12. Entries in the right-hand panel indicate whether the row treatment yields prices that are significantly lower (<), significantly higher (>) or that do not differ significantly (≈) from the average prices in the column treatment. Differences between two treatments are tested using the MWU test for equality (one-sided). $^{+}$ significantly different at 10%; * at 5%; ** at 1%.

Second, consider the effect on the non-cooperative cost level. Table 6 looks at the average price in rounds where there is no collusion in the sense defined above (i.e. it is not the case that all firms set a cost level of 12). Arguably, these are the cases in which firms behave non-cooperatively. Note that for BESTPR the results are hard to interpret, as there both the collusive and the non-ccoperative cost level equals 12. The results for the other treatments are perfectly in line with Theorem 1: prices in DISCRIM are lower than those in either UNIFORM or EQUALW, whereas prices in UNIFORM are also higher than those in EQUALW. A Jonckheere-Terpstra test with the ordered alternative hypothesis that prices in UNIFORM are higher than those in EQUALW which in turn are higher than those in DISCRIM, is highly significant ($p < 0.1\%$).

5 Comparing the uniform and discriminatory benchmarks

Figure 2 gives the average price in each period in UNIFORM and DISCRIM, for each of the 5 industry structures we consider in part B of our experiment. In Table 7 we compare prices for each industry structure.

[13]This test is equivalent to the Kruskal-Wallis test but has an unordered alternative hypothesis. See Jonckheere (1954) or Terpstra (1952).

Figure 2: Average price per round for each industry structure (across all groups).

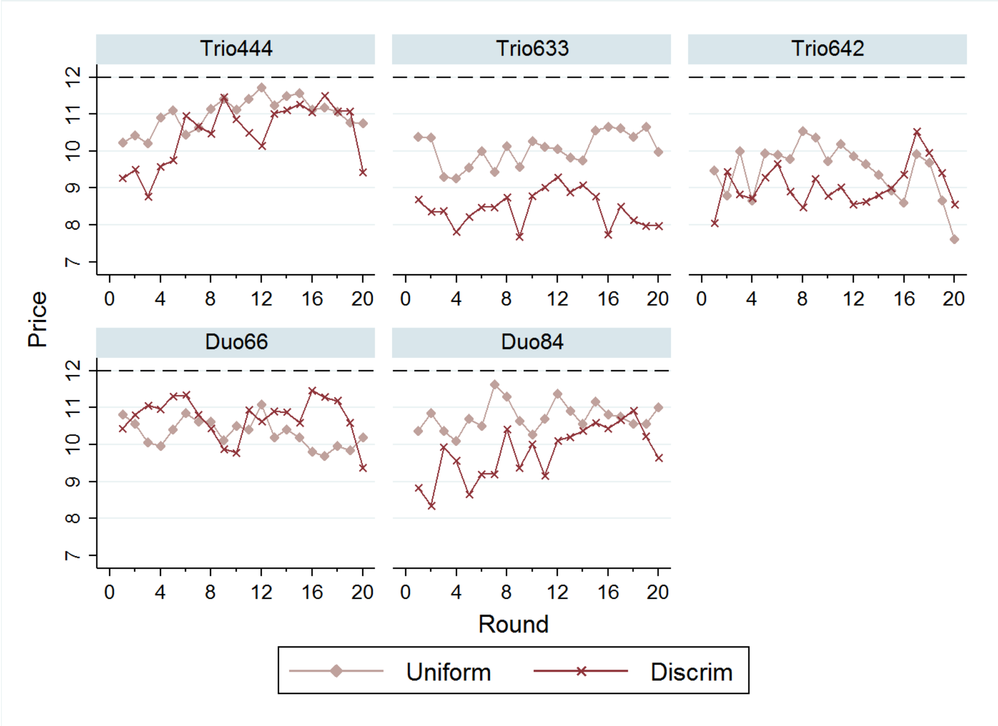


Table 7: Comparison of Price for UNIFORM and DISCRIM for each industry structure (averages across all rounds and groups).

Structure	UNIFORM		DISCRIM
Trio444	11.00	$>^{+}$	10.48
Trio633	10.04	$>^{*}$	8.45
Trio642	9.48	$\approx$	9.06
Triopolies	10.18	$>^{*}$	9.34
Duo66	10.32	$\approx$	10.73
Duo84	10.76	$\approx$	9.80
Duopolies	10.54	$\approx$	10.24
Homogeneous	10.67	$\approx$	10.61
Heterogeneous	10.08	$>^{*}$	9.13
All	10.32	$>^{+}$	9.71

Entries between values indicate whether prices in UNIFORM are significantly lower (<), significantly higher (>), or do not differ significantly (≈) from those in DISCRIM. Differences are tested using the MWU test for equality (one-sided for Trio444, Duo66 and Homogeneous; two-sided for other comparisons). $^{+}$: significant at 10%; * at 5%.

For most industry structures we find higher prices with UNIFORM. This difference is significant for Trio444 and Trio633. The only exception is Duo66, where DISCRIM yields higher prices – but not significantly so. Interestingly, Potters et al. (2004) also found higher prices with a discriminatory rather than a uniform yardstick, in an industry structure that is equivalent to our Duo66.

Tests for multiple industry structures indicate that DISCRIM yields significantly lower prices in triopolies and heterogeneous industries. Most importantly, taking all industry structures together, DISCRIM yields significantly lower prices at the 10%-level.[14]

Table 8: Explaining price by yardstick design and industry structure.

	(1)	(2)
DISCRIM	-0.603^{+}	-0.618^{+}
	(0.356)	(0.340)
Trio633		-1.487**
		(0.533)
Trio642		-1.467**
		(0.527)
Duo66		-0.209
		(0.489)
Duo84		-0.468
		(0.563)
Constant	10.32***	11.04***
	(0.221)	(0.392)
Observations	3260	3260

Standard errors in parentheses. $^{+}$ p<0.1, * p<0.05, ** p<0.01, *** p<0.001.

[14] In this case, we have done the tests for multiple industries by simply interpreting all data generated by the UNIFORM treatments as coming from a single population, and treating all data generated by the DISCRIM treatments likewise. One alternative to make the data generated by different industry structures more comparable, is to do the following. First subtract the average price in DISCRIM/Trio444 from all observations in Trio444. Then, do the same for all other industry structures (thus, subtract the average price in DISCRIM/Trio633 from all observations in Trio633, etc.). Treating the resulting cleaned data generated by the UNIFORM treatments as coming from a single population, and treating all resulting cleaned data generated by the DISCRIM treatments likewise, allows us to filter out the effect of industry structure while still doing a non-parametric test on the difference between the two yardsticks. Performing this analysis, however, yields the same qualitative results as those given in the Table.

Table 9: Incidence of full collusion in UNIFORM and DISCRIM for each industry structure (averages across all rounds and groups).

Structure	UNIFORM		DISCRIM
Trio444	71.7%	≈	62.8%
Trio633	58.1%	$>^*$	26.3%
Trio642	34.4%	≈	44.0%
Triopolies	54.7%	≈	44.4%
Duo66	56.2%	≈	73.8%
Duo84	43.4%	≈	56.1%
Duopolies	49.8%	≈	64.4%
Homogeneous	64.2%	≈	68.3%
Heterogeneous	45.1%	≈	42.7%
Overall	52.8%	≈	52.8%

Entries between values indicate whether the incidence of full collusion under UNIFORM is significantly lower (<), significantly higher (>), or does not differ significantly (≈) from the price under DISCRIM. Differences between two treatments are tested using the MWU test for equality (two-sided for Trio444, Duo66, Homogeneous, Triopolies, Duopolies and Overall; one-sided for other comparisons). *: significant at 5%.

Table 8 takes a parametric approach, comparing both yardsticks by means of random-effects OLS regressions. Column (1) explains price solely by a constant and a DISCRIM-dummy. Column (2) adds dummies to correct for the effect of different industry structures.[15] In both regressions, DISCRIM yardstick leads to significantly lower prices at the 10%-level. We thus have

Result 2. *Prices are lower with a discriminatory yardstick than with a uniform yardstick. This effect is largely driven by industries with 3 firms, and industries where market shares are heterogeneous.*

Again, we can disentangle the effects of collusion and noncooperative cost levels. Table 9 looks at the incidence of collusion. In this case, we see little difference between the two yardsticks, even after aggregating them. The only significant difference is found in Trio633, where UNIFORM leads to a higher incidence of collusion, an effect that runs counter to our theoretical prediction. Average prices in non-collusive periods are given in Table 10. Non-cooperative cost levels in UNIFORM are indeed clearly higher than those

[15]Note therefore that this is essentially the parametric version of then non-parametric test we propose in fn. 14.

in DISCRIM, at a significance level of 0.1%. Hence, lower non-cooperative cost levels are the driving force behind the lower prices in DISCRIM.

Table 10: Prices if no full collusion in UNIFORM and DISCRIM for each industry structure (averages across all rounds and groups).

Structure	UNIFORM		DISCRIM
Trio444	8.03	$\approx$	8.09
Trio633	7.78	$\approx$	7.27
Trio642	8.27	$>^{*}$	6.91
Triopolies	8.07	$>^{+}$	7.43
Duo66	8.73	$>^{+}$	6.96
Duo84	9.76	$>^{**}$	7.12
Duopolies	9.26	$>^{***}$	7.06
Homogeneous	8.44	$\approx$	7.62
Heterogeneous	8.70	$>^{***}$	7.11
Overall	8.61	$>^{***}$	7.29

Entries between values indicate whether prices under UNIFORM are significantly lower (<), significantly higher (>), or do not differ significantly ($\approx$) from the price under DISCRIM. Differences are tested using the MWU test for equality (one-sided). $^{+}$: significant at 10%; * at 5%; ** at 1%; *** at 0.1%.

Whereas our theoretical framework predicts a tradeoff between a non-cooperative and a collusive effect when comparing DISCRIM and UNIFORM, our experimental results indicate that the collusive effect in fact is not really there. That is remarkable, as we do find strong support for our theoretical predictions concerning the extent of collusion when we compare four yardstick in part A of our experiment.

6 Conclusion

In this paper we have analyzed the effect of the design of yardstick competition on the prices consumers have to pay. As alternative designs, we distinguish the uniform yardstick, the unweighted uniform yardstick, the discriminatory yardstick, and the best-practice yardstick. In all cases, the effect of a design on prices depends on two different mechanisms: the incentives for firms to increase efficiency on the one hand and the incentives for firms to collude on the other. The risk of collusion in case of yardstick competition was already mentioned by Shleifer (1985), but to what extent that risk could mitigate the benefits of yardstick competition has hardly been analyzed up to now. In an economic experiment, Potters et al. (2004) find that the benefits of a discriminatory yardstick in terms of a higher productive efficiency are more than neutralized by the costs in terms of higher prices resulting from an increased risk of collusion. This experiment is conducted using two equally sized firms, triggering the question whether it also holds in heterogeneous industries. In an earlier paper (Dijkstra et al., 2014), we found that the degree of heterogeneity affects the probability of collusion. More specifically, we found that the probability of collusion in case of a uniform yardstick is negatively related to the level of heterogeneity of an industry. Using a similar experimental set up, we now have analyzed the ultimate price effects of different yardstick designs against the background of a heterogeneous industry.

On the basis of a theoretical analysis we find that the best-practice yardstick yields the lowest power of incentive to improve efficiency as well as the highest probability of collusion. Hence, this yardstick is expected to result in the highest prices, which was confirmed by the experimental analysis. Despite its name, the best-practice yardstick has the worst performance seen from the perspective of consumer prices. The theoretical analysis also shows that the discriminatory yardstick results in lower prices than the unweighted uniform yardstick, which was also confirmed by the economic experiment. The theory, however, does not give a clear answer on the relative performance of the discriminatory versus the uniform yardstick. The discriminatory yardstick gives the highest power of incentive to reduce costs, but it also has a higher probability of collusion than the uniform yardstick. In the experimental analysis, we find that the advantage of the discriminatory yardstick in terms of giving incentives to improve productive efficiency exceeds the disadvantage of a relatively higher risk of collusion. This conclusion appears to be robust for different degrees of heterogeneity of the industry. So, we conclude that the discriminatory yardstick yields the lowest prices for consumers.

From our analysis, we learn that yardstick competition may indeed result in collusion between the regulated firms, but that this effect does generally not outweigh the benefits of this type of competition for consumer prices. So, implementing yardstick competition in order to mimic competition in industries where otherwise no competition would exist, can be beneficial for consumers. Having said this, it must be acknowledged that collusion may occur and the risk of it depends on the degree of heterogeneity of the industry.

Appendix

A Instructions Trio642 Discriminatory

Introduction
You are going to participate in an experiment in economics. We will first read the instructions aloud. Then you will have time to read them on your own. The instructions are identical for all participants. After reading, there is the possibility to ask questions individually. The experiment is expected to last for approximately 90 minutes. Please refrain from talking during the entire experiment.

You will play with two other players, chosen at random. Together, you and those two other players form a group. You will never learn who the other players are. The experiment lasts for at least 20 rounds. In each round, you will play with the same two players. Before the experiment starts, we randomly determine whether you are player 1, player 2 or player 3 in your group.

In this experiment you can earn points. The number of points you earn depends on the decisions made by you and those made by the other players in your group.

Instructions
In the experiment, each player represents a company. Each player owns a number of production units. In each round, each player has to choose one cost level for all production units that he or she owns. Player 1 owns 1 production unit. Player 2 owns 2 production units. Player 3 owns 3 production units. At the beginning of the experiment, each player starts with 40 points for each production unit that he or she owns. Player 1 will thus receive 40 points, player 2 receives 80 points and player 3 receives 120 points. In each round, the number of points you earn consists of two components: **profit** and **managerial benefit**. At the end of each round, the points that you earned in that round will be added to your account.

After the experiment the number of points in your account will be converted to euros. Player 1 will receive €1 for every 10 points that he or she has, player 2 will receive €1 for every 20 points, and player 3 will receive €1 for every 30 points.

Each round consists of three steps. These steps are the same in every round.

Step 1: communication
A chat box will appear on your screen. You can discuss anything you want with the other players in your group. However, you are not allowed to identify yourself by name, gender, appearance, nationality, or in any other way. If you do, you will not receive any payment after the experiment. You are only allowed to communicate in English.

You have a limited amount of time to chat. A timer in the top right corner of the screen will inform you of the amount of time you have left. If you prefer not to chat any more, you can leave the chat by pressing the "Leave Chat" button. Once you have left the chat, you cannot return in that round. Once two persons have left the chat, the chat will end automatically.

Step 2: choice of cost level

Each player chooses one cost level for all the production units that he or she owns. You can choose your cost level from the following possibilities:

$$1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20.$$

The cost level you choose will influence the profits in that round for you and the other players. It will also influence your managerial benefit.

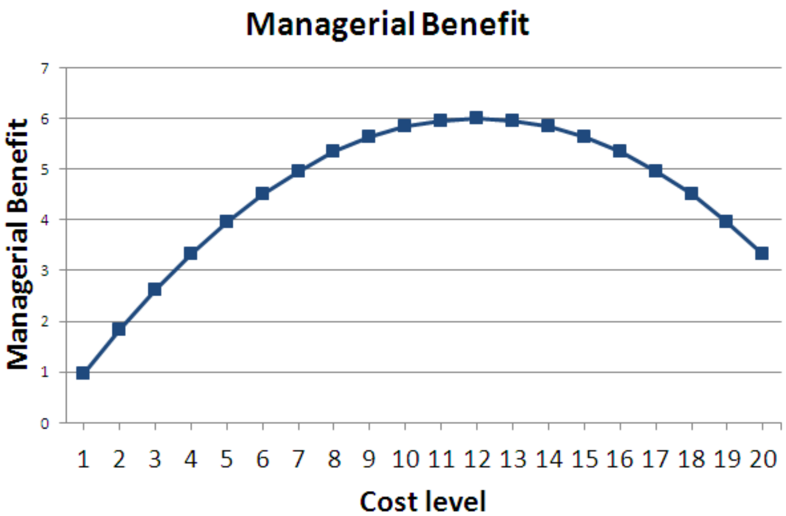
Each production unit produces one unit of output. The price you will receive per unit of output equals the average cost level of all production units owned by the *other* players.

Example. Suppose that player 1 chooses a cost level of 8, player 2 chooses a cost level of 5 and player 3 chooses a cost level of 10. Keeping in mind that player 2 owns 2 production units, and player 3 owns 3 production units, the price for each unit of output for player 1 is then $\frac{2\times5+3\times10}{2+3} = \frac{10+30}{5} = \frac{40}{5} = 8$, which is the average cost level of the production units owned by players 2 and 3. The price per unit for player 2 then equals $\frac{1\times8+3\times10}{1+3} = 38/4 = 9.5$, which is the average cost level of the production units owned by players 1 and 3. The price per unit for player 3 then equals $\frac{1\times8+2\times5}{1+2} = 18/3 = 6$. ■

The profit you earn on each unit of output equals your price minus your cost level:

$$\text{your profit} = \text{your number of production units} \times (\text{your price} - \text{your cost level})\,.$$

For each of your production units you also receive a managerial benefit. This graph shows how your managerial benefit per production unit depends on your cost level:



The number of points you receive in a round is equal to your profit plus your managerial benefit.

If you prefer, you can also calculate your profit and managerial benefit using a profit calculator that we will provide on screen during the experiment. Alternatively, you can find your profit and your managerial benefit in a table that we provide. These tables are added to these instructions. Please put these tables in front of you now.

Each table reads as follows. Rows represent the possible cost levels you can choose. Columns represent the average cost level per production unit of the other two players. Where a row and a column intersect, you can find your profit. Your managerial benefit is indicated in the last column.

Example. We consider a case in which player 1 chooses a cost level of 8, player 2 chooses a cost level of 5 and player 3 chooses a cost level of 10. Prices, profits, managerial benefits, and number of points for all players can be found as follows.

- Consider player 1. Its cost level is 8. The average cost level of the production units owned by players 2 and 3 is $\frac{2\times5+3\times10}{2+3} = \frac{10+30}{5} = 8$. Player 1's profit can be found in Table 1, in the row marked 8, and the column marked 8. You can see that player 1 receives a profit of 0.00 points. Note that player 1 can also calculate this directly. The price per unit of output for player 1 equals the average cost level of all production units owned by the other players, which is 8. As player 1 owns one production unit, profit is $8 - 8 = 0$.

  At the end of the row marked 8, you can see that player 1 receives a managerial benefit of 5.33 points. This can also roughly be seen from the graph.

  In total, player 1 thus receives $0.00 + 5.33 = 5.33$ points.

- Consider player 2. Its cost level is 5. The average cost level of the production units owned by players 1 and 3 is $\frac{1\times8+3\times10}{1+3} = \frac{38}{4} = 9.5$. If it were 9, player 2's profit could be found in Table 2 (the row marked 5, the column marked 9) to equal 8.00. If it were 10, player 2's profit could be found in Table 2 (the row marked 5, the column marked 10) to equal 10.00. As the average cost level of the other production units is 9.5, player 2's profit is exactly halfway and thus equals 9.00 points. Alternatively, note that price per unit for player 2 equals 9.5. As player 2 owns two production units, profit is $2 \times (9.5 - 5) = 9$.

  The managerial benefit of player 2 can be found at the end of the row marked 5 to equal 7.92 points. This can also roughly be seen from the graph. With cost level 5, managerial benefit per production unit is roughly 3.95, which implies total managerial benefit of $2 \times 3.95 \approx 7.9$.

  In total, player 2 thus receives $9.00 + 7.92 = 16.92$ points.

- Consider player 3. Its cost level is 10. The average cost level of the production units owned by players 1 and 2 is $\frac{1\times8+2\times5}{1+2} = \frac{18}{3} = 6$. Player 3's profit can be found in Table 3 (the row marked 10, the column marked 6), to equal -12.00 points.

Alternatively, price per unit for player 3 equals 6. As player 3 owns three production units, profit is $3 \times (6 - 10) = -12$.

The managerial benefit of player 3 can be found at the end of the row marked 10 to equal 17.50 points. This can also roughly be seen from the graph. With cost level 10, managerial benefit per production unit is roughly 5.8, which implies total managerial benefit of $3 \times 5.8 \approx 17.5$.

In total, player 3 thus receives $-12.00 + 17.50 = 5.50$ points.

Step 3: summary

After all players have made their decision, you will receive the following information: the cost levels chosen by the other players, your price for each unit of output, your profit, your managerial benefit, and the current state of your account. Throughout the experiment, there will also be a box on your screen where you can observe the decisions made by you and the other players in each previous round.

End of experiment

You will at least play 20 rounds. From round 20 onwards, the experiment ends with a 20% probability at the end of each round. With a probability of 80%, a new round starts. You receive a message on your screen if no further round will take place.

At the end of the experiment the number of points in your account will be converted to euros. Before you can collect your payment in private, you have to hand in the instructions.

After the experiment, please do not discuss the content of the experiment with anyone, including people who did not participate.

Please refrain from talking throughout the experiment.

Table 1: player 1's profit and managerial benefit

Your cost level	Average cost level of production units owned by players 2 and 3																				Managerial benefit
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	0.96
2	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	1.83
3	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	2.63
4	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	3.33
5	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	3.96
6	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	4.50
7	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	4.96
8	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	5.33
9	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	5.63
10	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	5.83
11	-10.00	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	5.96
12	-11.00	-10.00	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	6.00
13	-12.00	-11.00	-10.00	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	5.96
14	-13.00	-12.00	-11.00	-10.00	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	6.00	5.83
15	-14.00	-13.00	-12.00	-11.00	-10.00	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	5.63
16	-15.00	-14.00	-13.00	-12.00	-11.00	-10.00	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.33
17	-16.00	-15.00	-14.00	-13.00	-12.00	-11.00	-10.00	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.96
18	-17.00	-16.00	-15.00	-14.00	-13.00	-12.00	-11.00	-10.00	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	4.50
19	-18.00	-17.00	-16.00	-15.00	-14.00	-13.00	-12.00	-11.00	-10.00	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	3.96
20	-19.00	-18.00	-17.00	-16.00	-15.00	-14.00	-13.00	-12.00	-11.00	-10.00	-9.00	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	3.33

Table 2: player 2's profit and managerial benefit

Your cost level	Average cost level of production units owned by players 1 and 3																				Managerial benefit
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	34.00	36.00	38.00	1.92
2	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	34.00	36.00	3.67
3	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	34.00	5.25
4	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	6.67
5	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	7.92
6	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	9.00
7	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	9.92
8	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	10.67
9	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	11.25
10	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	11.67
11	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	11.92
12	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	12.00
13	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	11.92
14	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	11.67
15	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	11.25
16	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.67
17	-32.00	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	9.92
18	-34.00	-32.00	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	9.00
19	-36.00	-34.00	-32.00	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	7.92
20	-38.00	-36.00	-34.00	-32.00	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	6.67

Table 3: player 3's profit and managerial benefit

Your cost level	Average cost level of production units owned by players 1 and 2																				Managerial benefit
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1	0.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	33.00	36.00	39.00	42.00	45.00	48.00	51.00	54.00	57.00	2.88
2	-3.00	0.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	33.00	36.00	39.00	42.00	45.00	48.00	51.00	54.00	5.50
3	-6.00	-3.00	0.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	33.00	36.00	39.00	42.00	45.00	48.00	51.00	7.88
4	-9.00	-6.00	-3.00	0.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	33.00	36.00	39.00	42.00	45.00	48.00	10.00
5	-12.00	-9.00	-6.00	-3.00	0.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	33.00	36.00	39.00	42.00	45.00	11.88
6	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	33.00	36.00	39.00	42.00	13.50
7	-18.00	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	33.00	36.00	39.00	14.88
8	-21.00	-18.00	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	33.00	36.00	16.00
9	-24.00	-21.00	-18.00	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	33.00	16.88
10	-27.00	-24.00	-21.00	-18.00	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	30.00	17.50
11	-30.00	-27.00	-24.00	-21.00	-18.00	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	27.00	17.88
12	-33.00	-30.00	-27.00	-24.00	-21.00	-18.00	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00	24.00	18.00
13	-36.00	-33.00	-30.00	-27.00	-24.00	-21.00	-18.00	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	3.00	6.00	9.00	12.00	15.00	18.00	21.00	17.88
14	-39.00	-36.00	-33.00	-30.00	-27.00	-24.00	-21.00	-18.00	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	3.00	6.00	9.00	12.00	15.00	18.00	17.50
15	-42.00	-39.00	-36.00	-33.00	-30.00	-27.00	-24.00	-21.00	-18.00	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	3.00	6.00	9.00	12.00	15.00	16.88
16	-45.00	-42.00	-39.00	-36.00	-33.00	-30.00	-27.00	-24.00	-21.00	-18.00	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	3.00	6.00	9.00	12.00	16.00
17	-48.00	-45.00	-42.00	-39.00	-36.00	-33.00	-30.00	-27.00	-24.00	-21.00	-18.00	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	3.00	6.00	9.00	14.88
18	-51.00	-48.00	-45.00	-42.00	-39.00	-36.00	-33.00	-30.00	-27.00	-24.00	-21.00	-18.00	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	3.00	6.00	13.50
19	-54.00	-51.00	-48.00	-45.00	-42.00	-39.00	-36.00	-33.00	-30.00	-27.00	-24.00	-21.00	-18.00	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	3.00	11.88
20	-57.00	-54.00	-51.00	-48.00	-45.00	-42.00	-39.00	-36.00	-33.00	-30.00	-27.00	-24.00	-21.00	-18.00	-15.00	-12.00	-9.00	-6.00	-3.00	0.00	10.00

B Cost levels and Prices in all groups

B.1 Part A

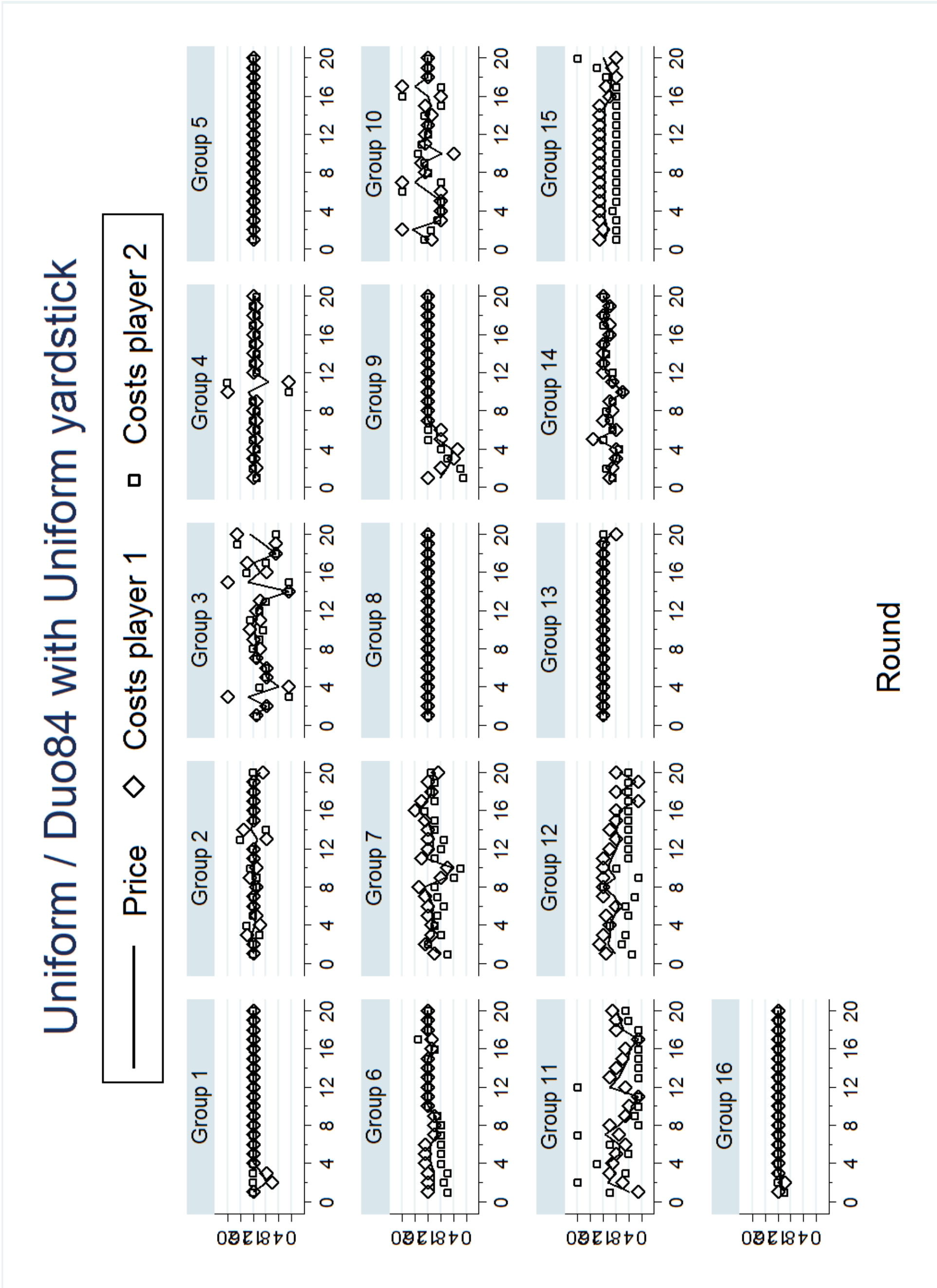


Figure B.1: Cost levels chosen and resulting price in each round per group in Uniform / Duo84 with a Uniform yardstick.

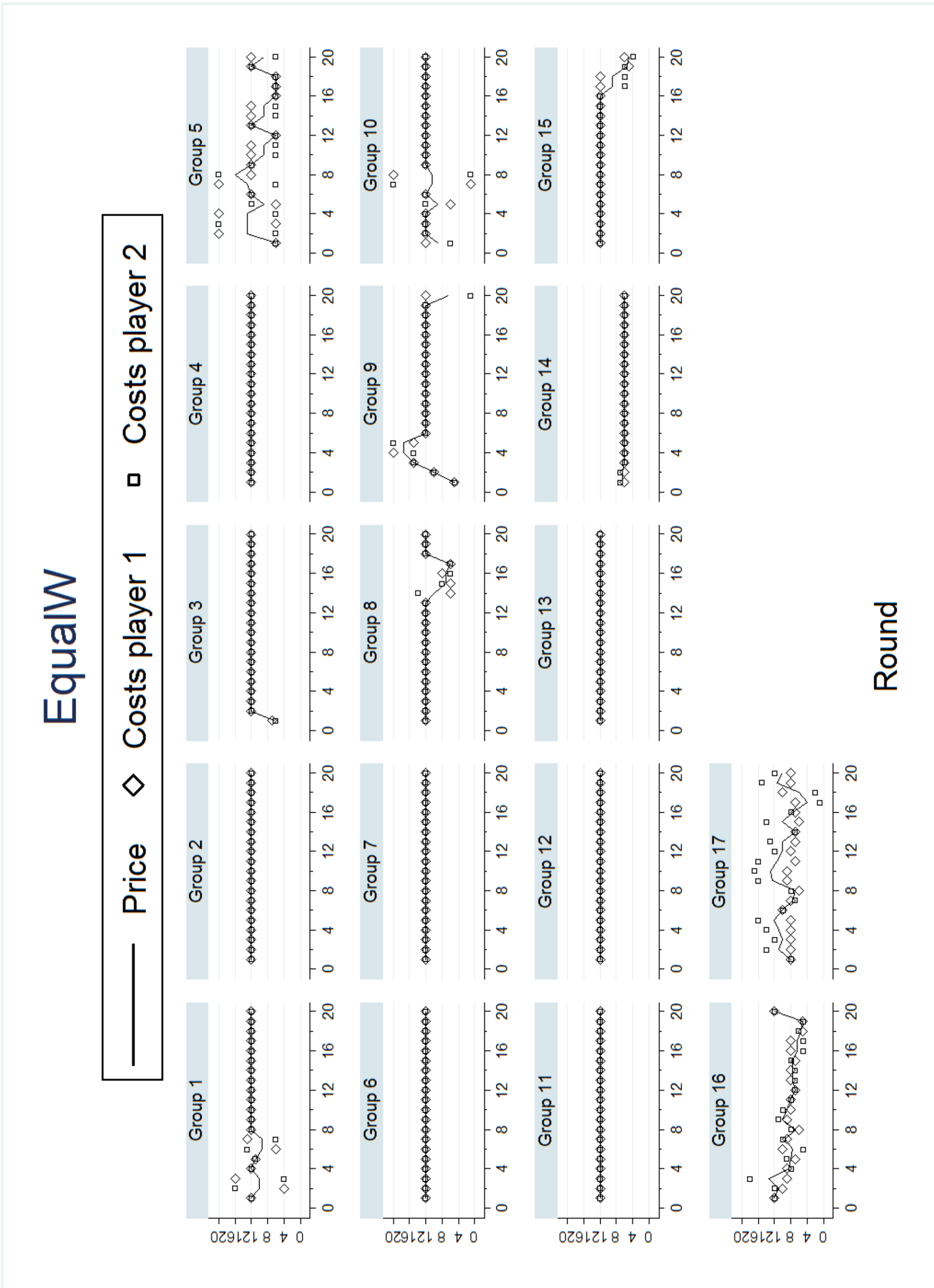


Figure B.2: Cost levels chosen and resulting price in each round per group in EqualW / Duo84 with a uniform unweighted yardstick.

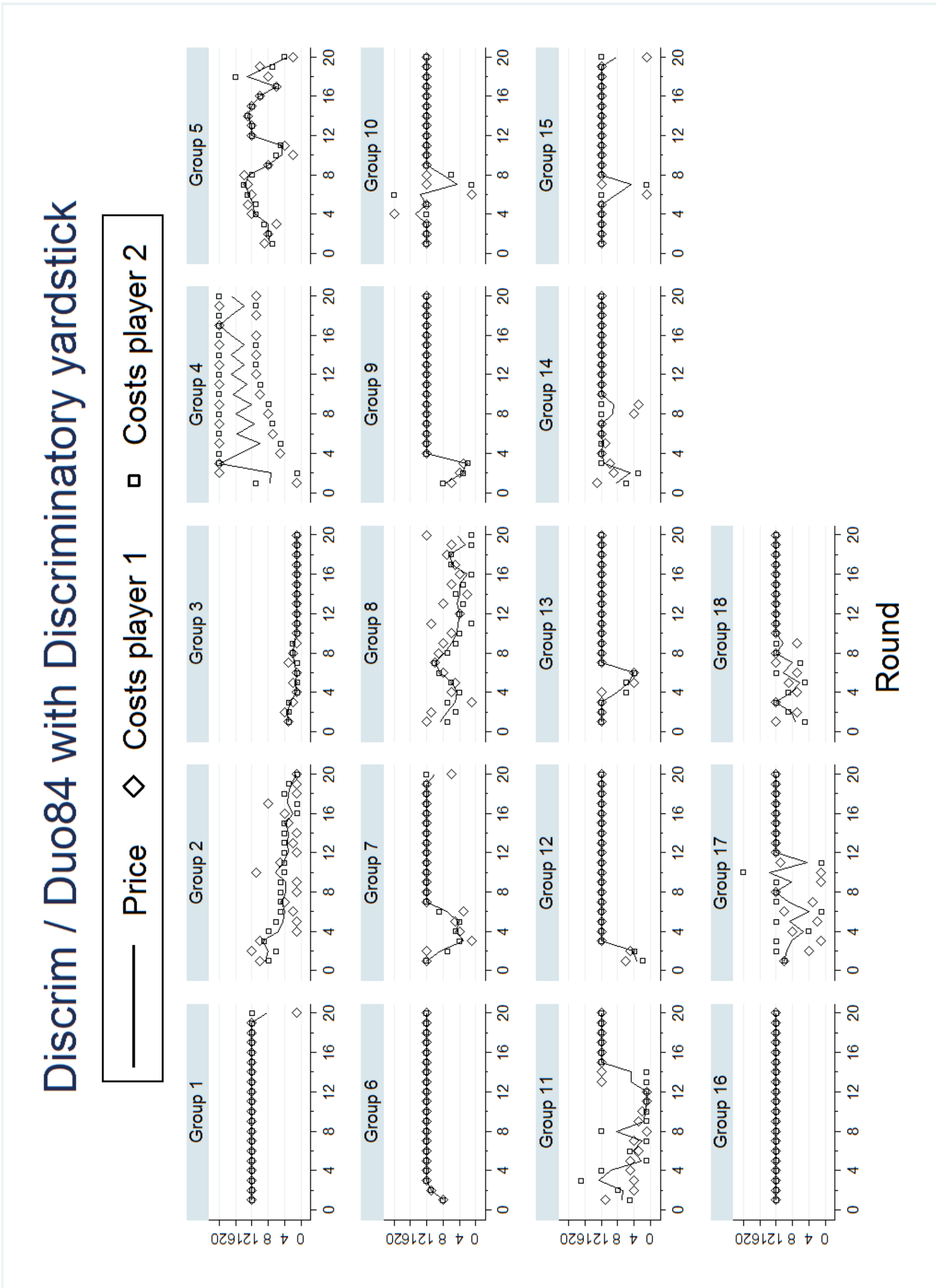


Figure B.3: Cost levels chosen and resulting price in each round per group in DISCRIM / Duo84 with a Discriminatory yardstick.

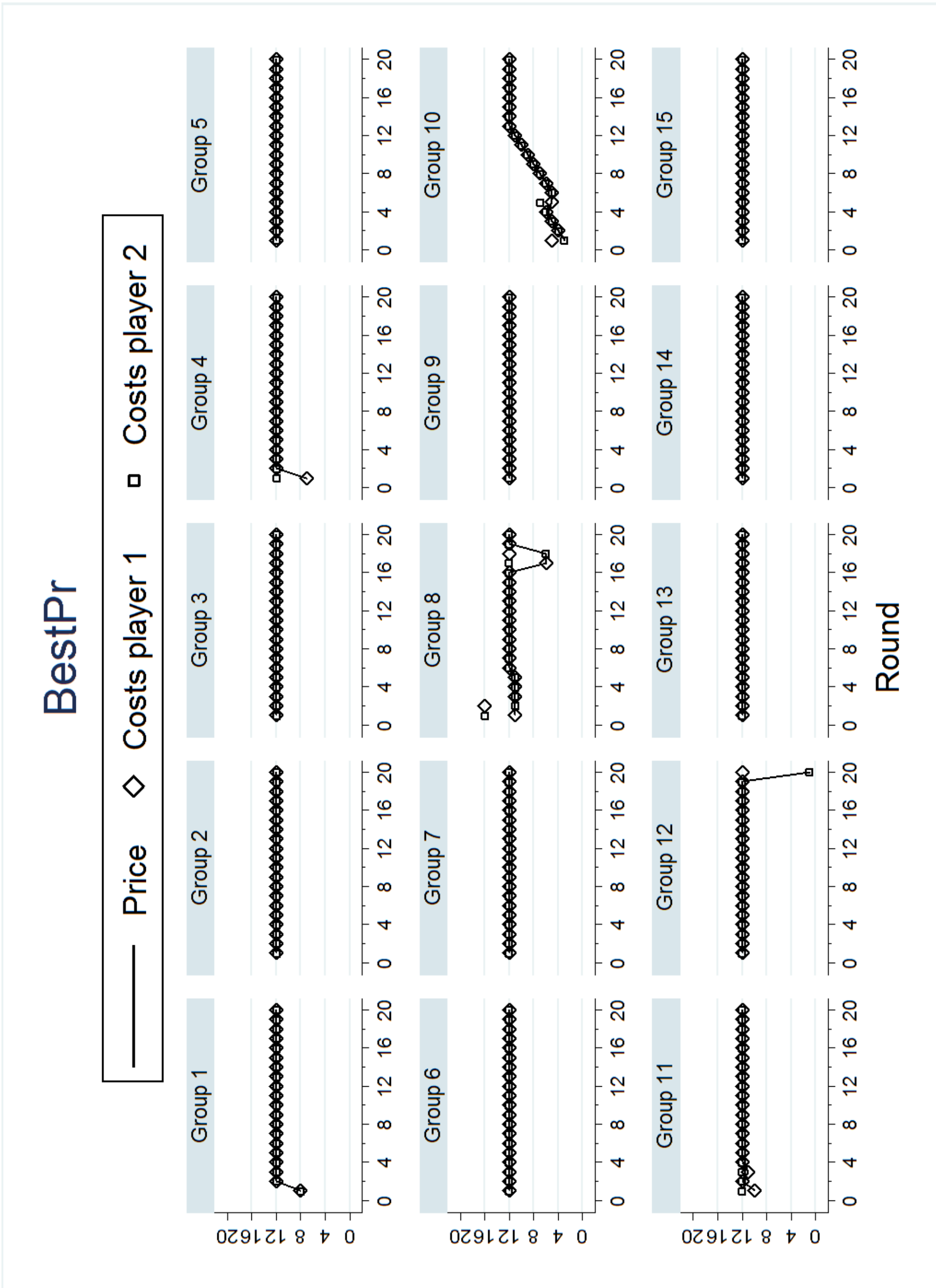


Figure B.4: Cost levels chosen and resulting price in each round per group in BestPr / Duo84 with a Best-Practice yardstick.

B.2 Part B

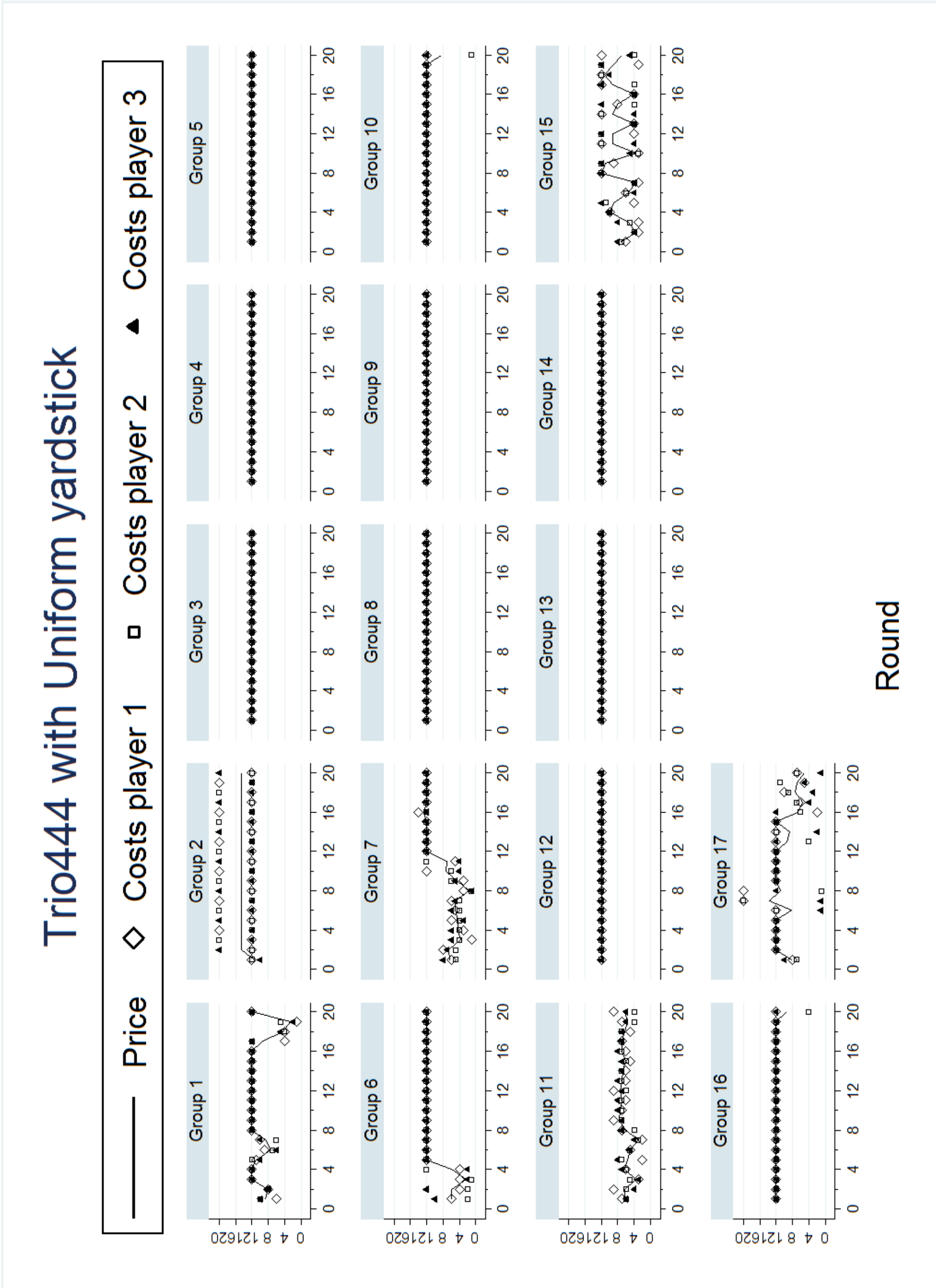


Figure B.5: Cost levels chosen and resulting price in each round per group in Trio444 with a Uniform yardstick.

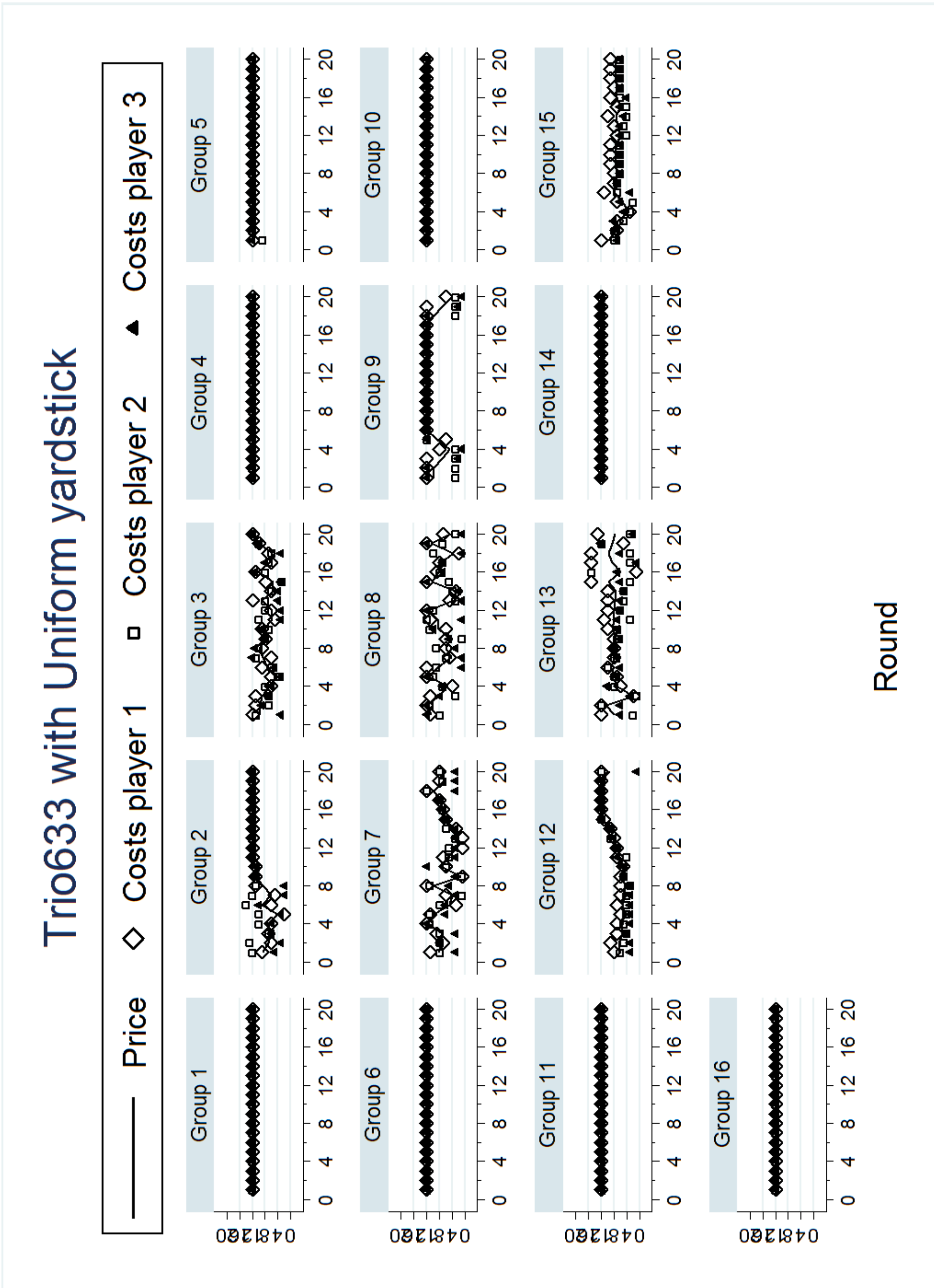


Figure B.6: Cost levels chosen and resulting price in each round per group in Trio633 with a Uniform yardstick.

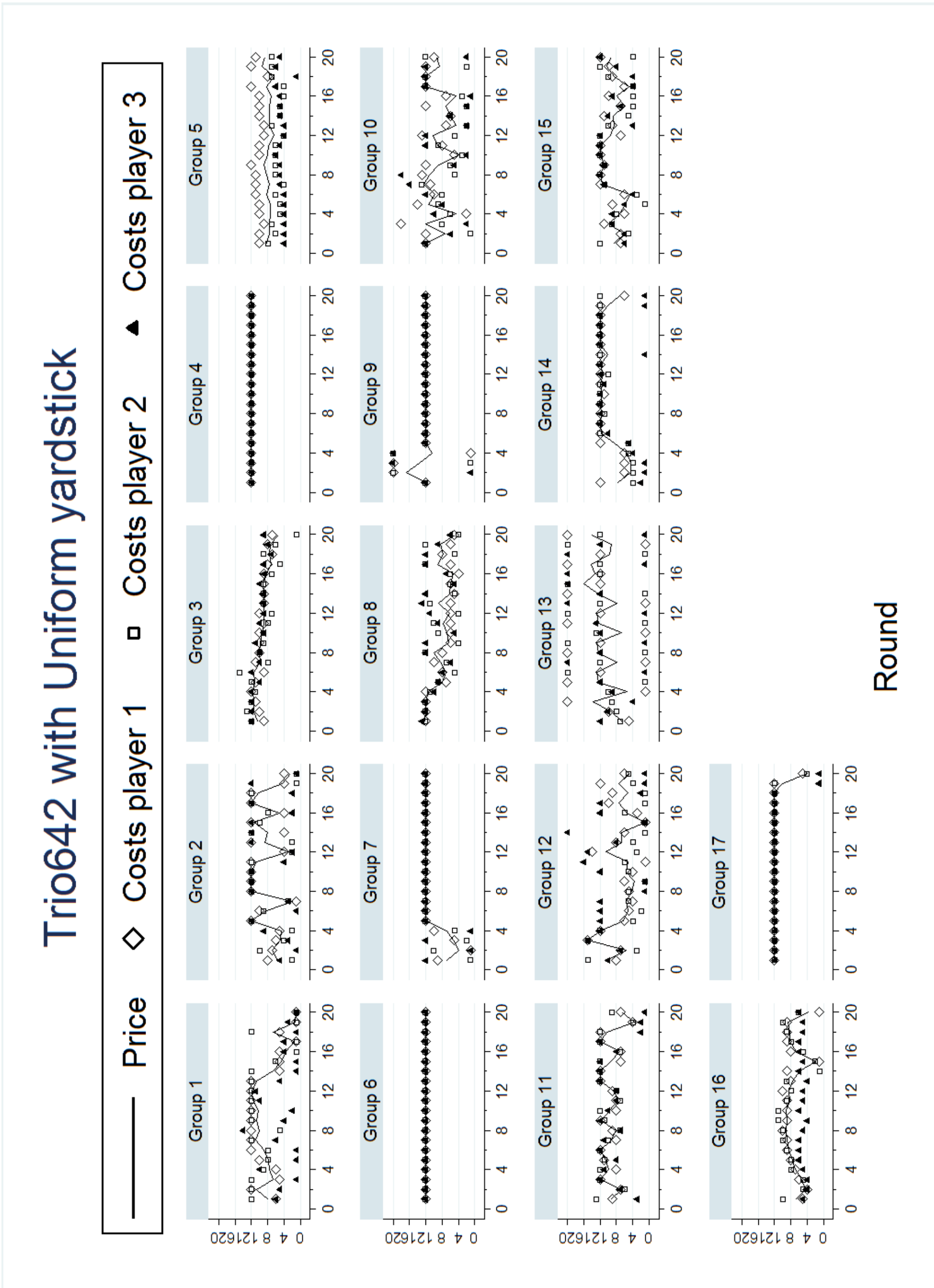


Figure B.7: Cost levels chosen and resulting price in each round per group in Trio642 with a Uniform yardstick.

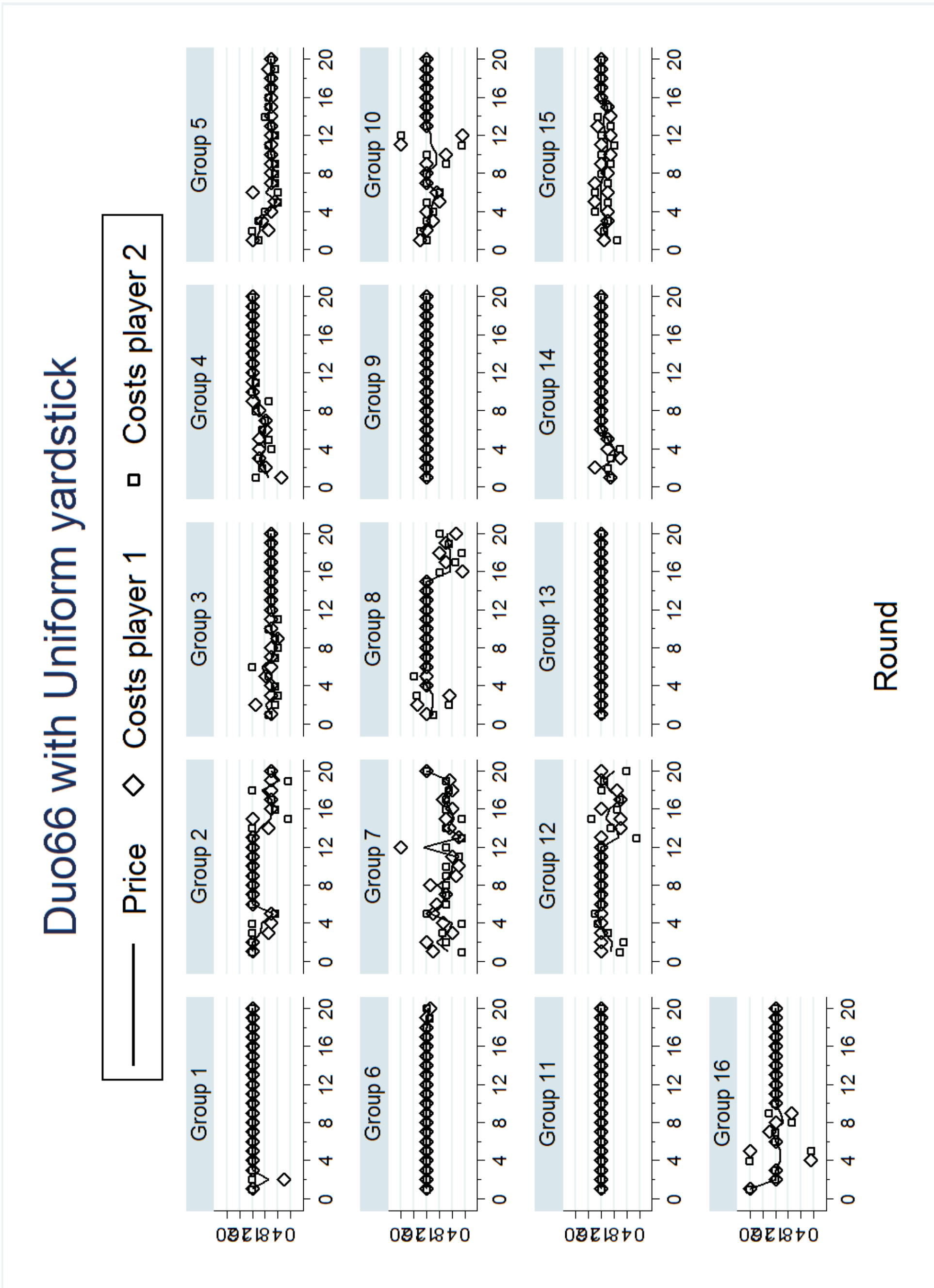


Figure B.8: Cost levels chosen and resulting price in each round per group in Duo66 with a Uniform yardstick.

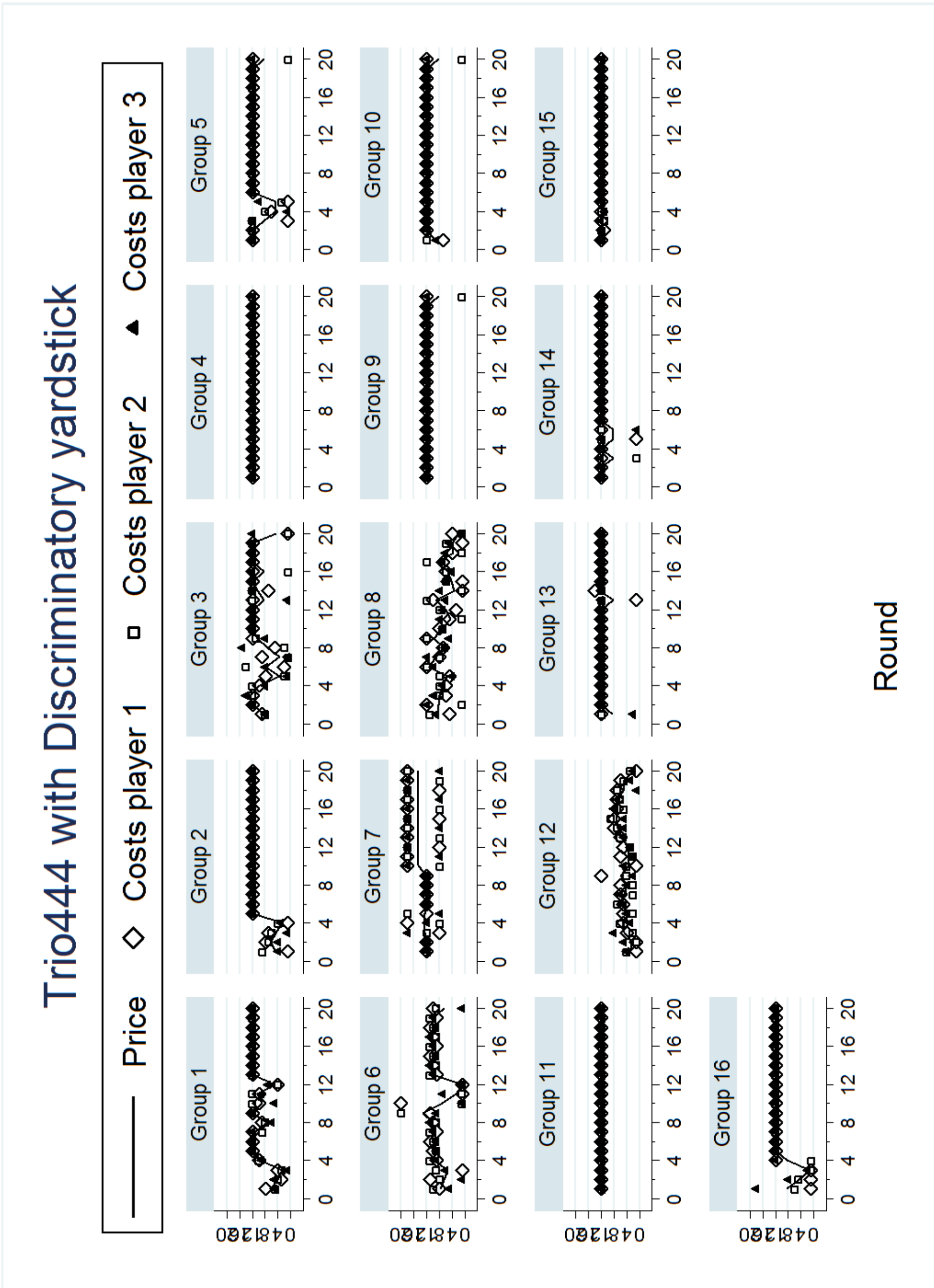


Figure B.9: Cost levels chosen and resulting price in each round per group in Trio444 with a Discriminatory yardstick.

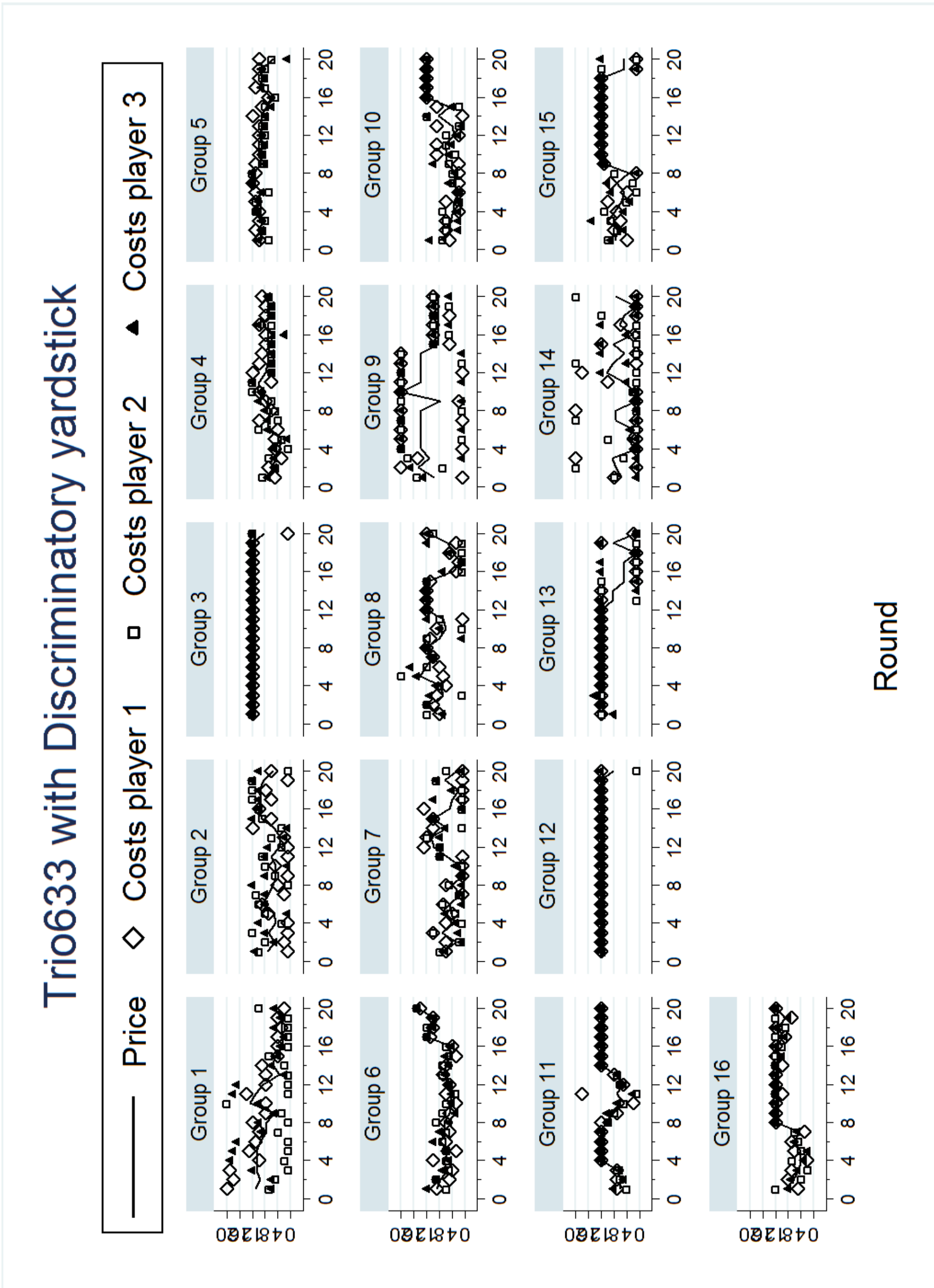


Figure B.10: Cost levels chosen and resulting price in each round per group in Trio633 with a Discriminatory yardstick.

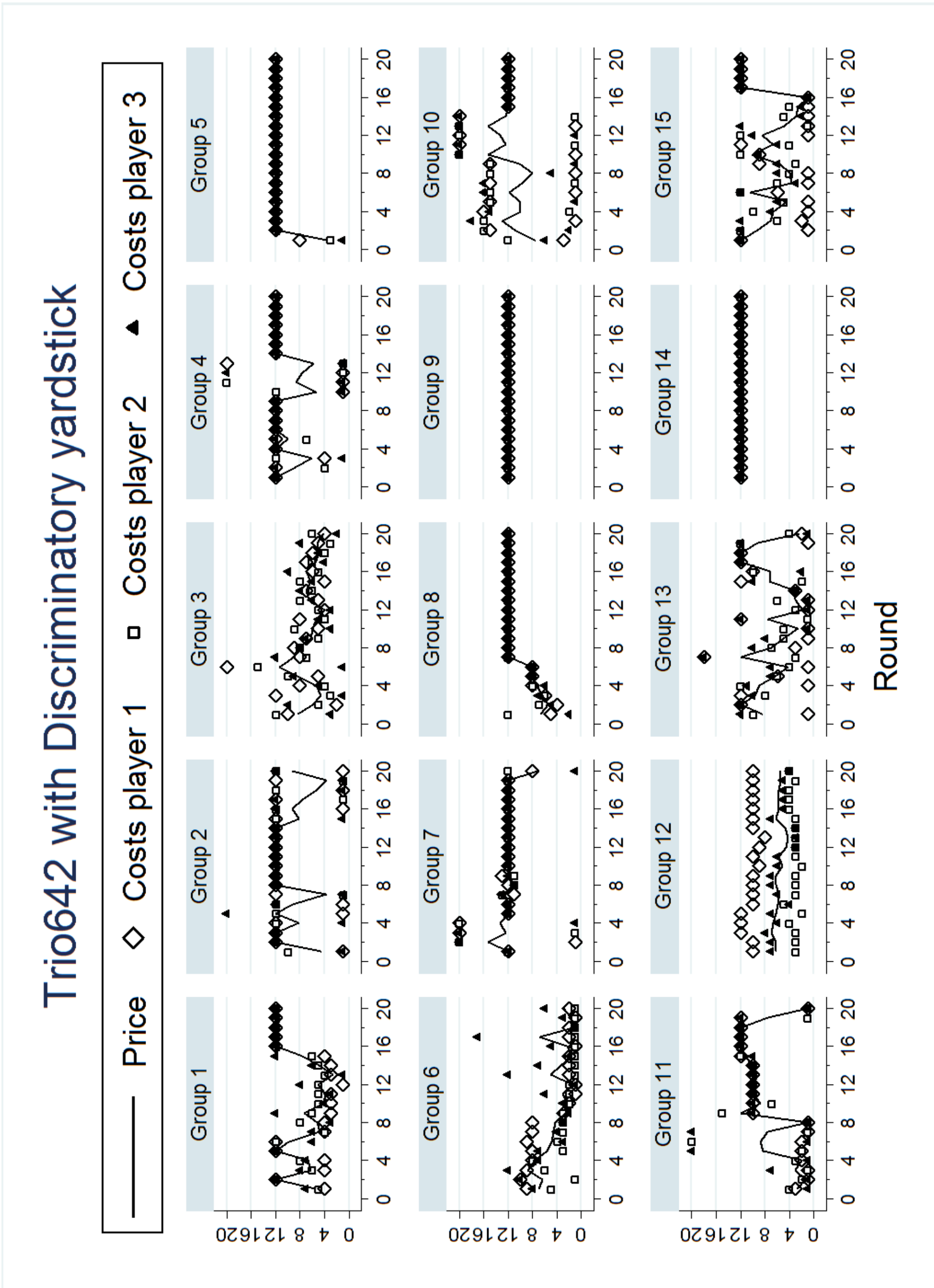


Figure B.11: Cost levels chosen and resulting price in each round per group in Trio642 with a Discriminatory yardstick.

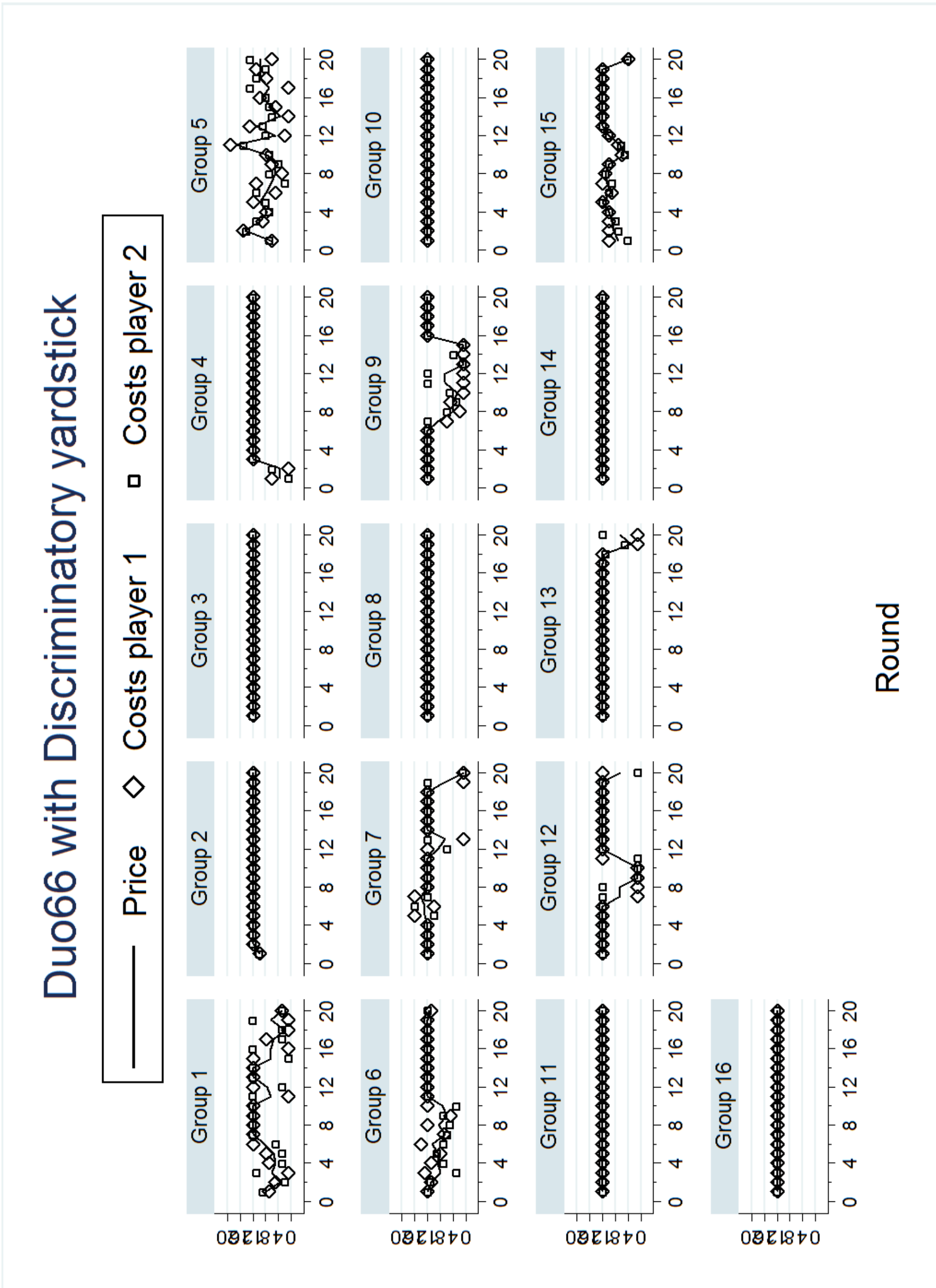


Figure B.12: Cost levels chosen and resulting price in each round per group in Duo66 with a Discriminatory yardstick.

References

BLÁZQUES-GÓMEZ, L., AND E. GRIFELL-TATJÉ (2011): "Evaluating the Regulator: Winners and Losers in the Regulation of Spanish Electricity Distribution," *Energy Economics*, 33(5), 807–815.

DALEN, D. M., AND A. GOMEZ-LOBO (2002): "Regulatory Contracts and Cost Efficiency in the Norwegian Bus Industry: Do High-Powered Contracts Really Work?," Discussion Paper 6, Norwegian School of Management.

DASSLER, T., D. PARKER, AND D. S. SAAL (2006): "Methods and Trends of Performance Benchmarking in UK Utility Regulation," *Utilities Policy*, 14(3), 166–174.

DIJKSTRA, P. T., M. A. HAAN, AND M. MULDER (2014): "Industry Structure and Collusion with Uniform Yardstick Competition: Theory and Experiments," Research Report 14010-EEF, University of Groningen, Research Institute SOM (Systems, Organisations and Management).

FISCHBACHER, U. (2007): "z-Tree: Zurich Toolbox for Ready-Made Economic Experiments," *Experimental Economics*, 10(21), 171–178.

FRIEDMAN, J. W. (1971): "A Non-Cooperative Equilibrium for Supergames," *Review of Economic Studies*, 38(1), 1–12.

HAAN, M. A., L. SCHOONBEEK, AND B. M. WINKEL (2009): "Experimental Results on Collusion," in *Experiments and Competition Policy*, ed. by J. Hinloopen, and H.-T. Normann, chap. 2, pp. 9–33. Cambridge University Press.

HAFFNER, R., D. HELMER, AND H. VAN TIL (2010): "Investment and Regulation: The Dutch Experience," *The Electricity Journal*, 23(5), 34–46.

JAMASB, T., AND M. POLLITT (2007): "Incentive Regulation of Electricity Distribution Networks: Lessons from the Experience from Britain," *Energy Policy*, 35(12), 6163–6187.

JONCKHEERE, A. R. (1954): "A Distribution-Free k-Sample Test against Ordered Alternatives," *Biometrika*, 41(1/2), 133–145.

MIZUTANI, F., H. KOZUMI, AND N. MATSUSHIMA (2009): "Does Yardstick Regulation really work? Empirical Evidence from Japans Rail Industry," *Journal of Regulatory Economics*, 36(3), 308–323.

NORMANN, H.-T., AND B. WALLACE (2012): "The Impact of the Termination Rule on Cooperation in a Prisoner's Dilemma Experiment," *International Journal of Game Theory*, 41(3), 707–718.

POTTERS, J., B. ROCKENBACH, A. SADRIEHC, AND E. VAN DAMME (2004): "Collusion under Yardstick Competition: An Experimental Study," *International Journal of Industrial Organization*, 22(7), 1017–1038.

Shleifer, A. (1985): “A Theory of Yardstick Competition,” *RAND Journal of Economics*, 16(3), 319–327.

Tangerås, T. P. (2002): “Collusion-Proof Yardstick Competition,” *Journal of Public Economics*, 83(2), 231–254.

Terpstra, T. J. (1952): “The Asymptotic Normality and Consistency of Kendall’s Test against Trend, when Ties are Present in One Ranking,” *Indagationes Mathematicae*, 14(3), 327–333.

List of research reports

12001-HRM&OB: Veltrop, D.B., C.L.M. Hermes, T.J.B.M. Postma and J. de Haan, A Tale of Two Factions: Exploring the Relationship between Factional Faultlines and Conflict Management in Pension Fund Boards

12002-EEF: Angelini, V. and J.O. Mierau, Social and Economic Aspects of Childhood Health: Evidence from Western-Europe

12003-Other: Valkenhoef, G.H.M. van, T. Tervonen, E.O. de Brock and H. Hillege, Clinical trials information in drug development and regulation: existing systems and standards

12004-EEF: Toolsema, L.A. and M.A. Allers, Welfare financing: Grant allocation and efficiency

12005-EEF: Boonman, T.M., J.P.A.M. Jacobs and G.H. Kuper, The Global Financial Crisis and currency crises in Latin America

12006-EEF: Kuper, G.H. and E. Sterken, Participation and Performance at the London 2012 Olympics

12007-Other: Zhao, J., G.H.M. van Valkenhoef, E.O. de Brock and H. Hillege, ADDIS: an automated way to do network meta-analysis

12008-GEM: Hoorn, A.A.J. van, Individualism and the cultural roots of management practices

12009-EEF: Dungey, M., J.P.A.M. Jacobs, J. Tian and S. van Norden, On trend-cycle decomposition and data revision

12010-EEF: Jong-A-Pin, R., J-E. Sturm and J. de Haan, Using real-time data to test for political budget cycles

12011-EEF: Samarina, A., Monetary targeting and financial system characteristics: An empirical analysis

12012-EEF: Alessie, R., V. Angelini and P. van Santen, Pension wealth and household savings in Europe: Evidence from SHARELIFE

13001-EEF: Kuper, G.H. and M. Mulder, Cross-border infrastructure constraints, regulatory measures and economic integration of the Dutch – German gas market

13002-EEF: Klein Goldewijk, G.M. and J.P.A.M. Jacobs, The relation between stature and long bone length in the Roman Empire

13003-EEF: Mulder, M. and L. Schoonbeek, Decomposing changes in competition in the Dutch electricity market through the Residual Supply Index

13004-EEF: Kuper, G.H. and M. Mulder, Cross-border constraints, institutional changes and integration of the Dutch – German gas market

13005-EEF: Wiese, R., Do political or economic factors drive healthcare financing privatisations? Empirical evidence from OECD countries

13006-EEF: Elhorst, J.P., P. Heijnen, A. Samarina and J.P.A.M. Jacobs, State transfers at different moments in time: A spatial probit approach

13007-EEF: Mierau, J.O., The activity and lethality of militant groups: Ideology, capacity, and environment

13008-EEF: Dijkstra, P.T., M.A. Haan and M. Mulder, The effect of industry structure and yardstick design on strategic behavior with yardstick competition: an experimental study

13009-GEM: Hoorn, A.A.J. van, Values of financial services professionals and the global financial crisis as a crisis of ethics

13010-EEF: Boonman, T.M., Sovereign defaults, business cycles and economic growth in Latin America, 1870-2012

13011-EEF: He, X., J.P.A.M Jacobs, G.H. Kuper and J.E. Ligthart, On the impact of the global financial crisis on the euro area

13012-GEM: Hoorn, A.A.J. van, Generational shifts in managerial values and the coming of a global business culture

13013-EEF: Samarina, A. and J.E. Sturm, Factors leading to inflation targeting – The impact of adoption

13014-EEF: Allers, M.A. and E. Merkus, Soft budget constraint but no moral hazard? The Dutch local government bailout puzzle

13015-GEM: Hoorn, A.A.J. van, Trust and management: Explaining cross-national differences in work autonomy

13016-EEF: Boonman, T.M., J.P.A.M. Jacobs and G.H. Kuper, Sovereign debt crises in Latin America: A market pressure approach

13017-GEM: Oosterhaven, J., M.C. Bouwmeester and M. Nozaki, The impact of production and infrastructure shocks: A non-linear input-output programming approach, tested on an hypothetical economy

13018-EEF: Cavapozzi, D., W. Han and R. Miniaci, Alternative weighting structures for multidimensional poverty assessment

14001-OPERA: Germs, R. and N.D. van Foreest, Optimal control of production-inventory systems with constant and compound poisson demand

14002-EEF: Bao, T. and J. Duffy, Adaptive vs. eductive learning: Theory and evidence

14003-OPERA: Syntetos, A.A. and R.H. Teunter, On the calculation of safety stocks

14004-EEF: Bouwmeester, M.C., J. Oosterhaven and J.M. Rueda-Cantuche, Measuring the EU value added embodied in EU foreign exports by consolidating 27 national supply and use tables for 2000-2007

14005-OPERA: Prak, D.R.J., R.H. Teunter and J. Riezebos, Periodic review and continuous ordering

14006-EEF: Reijnders, L.S.M., The college gender gap reversal: Insights from a life-cycle perspective

14007-EEF: Reijnders, L.S.M., Child care subsidies with endogenous education and fertility

14008-EEF: Otter, P.W., J.P.A.M. Jacobs and A.H.J. den Reijer, A criterion for the number of factors in a data-rich environment

14009-EEF: Mierau, J.O. and E. Suari Andreu, Fiscal rules and government size in the European Union

14010-EEF: Dijkstra, P.T., M.A. Haan and M. Mulder, Industry structure and collusion with uniform yardstick competition: theory and experiments

14011-EEF: Huizingh, E. and M. Mulder, Effectiveness of regulatory interventions on firm behavior: a randomized field experiment with e-commerce firms

14012-GEM: Bressand, A., Proving the old spell wrong: New African hydrocarbon producers and the 'resource curse'

14013-EEF: Dijkstra P.T., Price leadership and unequal market sharing: Collusion in experimental markets

14014-EEF: Angelini, V., M. Bertoni, and L. Corazzini, Unpacking the determinants of life satisfaction: A survey experiment

14015-EEF: Heijdra, B.J., J.O. Mierau, and T. Trimborn, Stimulating annuity markets

14016-GEM: Bezemer, D., M. Grydaki, and L. Zhang, Is financial development bad for growth?

14017-EEF: De Cao, E. and C. Lutz, Sensitive survey questions: measuring attitudes regarding female circumcision through a list experiment

14018-EEF: De Cao, E., The height production function from birth to maturity

14019-EEF: Allers, M.A. and J.B. Geertsema, The effects of local government amalgamation on public spending and service levels. Evidence from 15 years of municipal boundary reform

14020-EEF: Kuper, G.H. and J.H. Veurink, Central bank independence and political pressure in the Greenspan era

14021-GEM: Samarina, A. and D. Bezemer, Capital flows and financial intermediation: is EMU different?

14022-EEF: Soetevent, A.R. and L. Zhou, Loss Modification Incentives for Insurers Under ExpectedUtility and Loss Aversion

14023-EEF: Allers, M.A. and W. Vermeulen, Fiscal Equalization, Capitalization and the Flypaper Effect.

14024-GEM: Hoorn, A.A.J. van, Trust, Workplace Organization, and Comparative Economic Development.

14025-GEM: Bezemer, D., and L. Zhang, From Boom to Bust in de Credit Cycle: The Role of Mortgage Credit.

14026-GEM: Zhang, L., and D. Bezemer, How the Credit Cycle Affects Growth: The Role of Bank Balance Sheets.

14027-EEF: Bružikas, T., and A.R. Soetevent, Detailed Data and Changes in Market Structure: The Move to Unmanned Gasoline Service Stations.

14028-EEF: Bouwmeester, M.C., and B. Scholtens, Cross-border Spillovers from European Gas Infrastructure Investments.

14029-EEF: Lestano, and G.H. Kuper, Correlation Dynamics in East Asian Financial Markets.

14030-GEM: Bezemer, D.J., and M. Grydaki, Nonfinancial Sectors Debt and the U.S. Great Moderation.

14031-EEF: Hermes, N., and R. Lensink, Financial Liberalization and Capital Flight: Evidence from the African Continent.

14032-OPERA: Blok, C. de, A. Seepma, I. Roukema, D.P. van Donk, B. Keulen, and R. Otte, Digitalisering in Strafrechtketens: Ervaringen in Denemarken, Engeland, Oostenrijk en Estland vanuit een Supply Chain Perspectief.

14033-OPERA: Olde Keizer, M.C.A., and R.H. Teunter, Opportunistic condition-based maintenance and aperiodic inspections for a two-unit series system.

14034-EEF: Kuper, G.H., G. Sierksma, and F.C.R. Spieksma, Using Tennis Rankings to Predict Performance in Upcoming Tournaments

15001-EEF: Bao, T., X. Tian, X. Yu, Dictator Game with Indivisibility of Money

15002-GEM: Chen, Q., E. Dietzenbacher, and B. Los, The Effects of Ageing and Urbanization on China's Future Population and Labor Force

15003-EEF: Allers, M., B. van Ommeren, and B. Geertsema, Does intermunicipal cooperation create inefficiency? A comparison of interest rates paid by intermunicipal organizations, amalgamated municipalities and not recently amalgamated municipalities

15004-EEF: Dijkstra, P.T., M.A. Haan, and M. Mulder, Design of Yardstick Competition and Consumer Prices: Experimental Evidence www.rug.nl/feb