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Subject Pool Effects in Price Competition Games: Students versus Professionals

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Abstract

Questioning the external validity of experiments that rely on student participants is an evergreen in experimental economics. Yet, there is ambiguous evidence of potential subject-pool bias. We add to the subject-pool debate by enlarging the set of experiments for which subject-pool differences have been studied. In a duopolistic Bertrand market setup designed to test for collusive behavior, we test two treatments. The first is a baseline treatment, where participants cannot communicate with each other, the second is a communication treatment in which participants are allowed to communicate. Each treatment is first conducted with students and then replicated with professionals. Our results show that student subjects and professionals differ significantly. However, these differences manifest themselves in quantitative rather than qualitative terms. Professionals do collude more, but their behavioral difference between treatments is similar. Students are thus a valid surrogate, if the research question is qualitative, but results generated by student samples should be handled with caution, if quantitative differences matter.

Keywords Subject-pool effect · Bertrand oligopoly · Professionals
JEL Classification B4 L1 L4

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1 Introduction

For experimental economists, it is common practice to use student participants in economic experiments. After all, students are a convenient and readily available source for academic researchers. Although experimental methods are widely accepted, it is still typically argued that this subject pool homogeneity induces bias. Critics question whether the results obtained using student subjects enable drawing valid conclusions about real world economic problems. Expressed differently, the external validity of the experimental results is put into question. The more abstract the experiment, the more difficult it seems to maintain external validity. A growing number of studies has intended to shed light on subject-pool differences in various experimental settings, with yet inconclusive results.

In this paper, we focus on the external validity of market experiments in an industrial organization context. Experimental markets in the form of duopolies competing over quantities (Cournot model) or prices (Bertrand model) are the most common models in this field. Central to both is that participants represent a firm and decide on quantities or prices like a real world manager. It is thus reasonable to assume that professional rules of conduct play a distinct role in these settings and that hence, the subject pool effect is of particular relevance, as students are usually not accustomed to these rules. For a Cournot setting, subject pool differences have been investigated by Waichman et al (2010). They indeed confirm significant differences in experimental behaviour between Malaysian students and Malaysian managers. For Bertrand markets, however, robustness regarding the subject pool has not been investigated so far. Given the high relevance of this type of market game, there is good reason to close this gap. Our research aims to do so.

The paper is organized as follows. In the next section, we provide a brief review of related literature (Section 2). We then introduce the design and procedure of our experiments (Section 3). Section 4 provides the research hypothesis and Section 5 adds the results. An overall conclusion is given in Section 6.

2 Related Literature

Interest in subject-pool differences and their effect on the external validity of experiments is as old as experimental economics itself. Given the steadily increasing interest in experimental economics, it is not surprising that methodological problems such as the subject-pool under study, have attracted more and more interest in the last 20 years. Previous work on subject-pool differences spans a variety of experimental settings and subject-pools. Yet, the results are ambiguous and there is substantial methodological heterogeneity. In what follows, we briefly describe what has been done so far, distinguishing between the different types of economic experiments. The works described are not exhaustive, but should yield a condensed and sufficient overview of the subject-pool-related work to date.

Experiments for which subject-pool differences, and thus external validity, has been challenged, include those testing for social preferences (mostly bargaining games and social dilemmas), auctions, market experiments and a long list of experiments with specific, individual settings. The subject-pools contrasted with the usual student participants, range from professionals to children (Murnighan and Saxon (1998)), prisoners (Block and Gerety (1995)), indigenes (Henrich (2000)) or the general population of a certain country (Bortolotti et al (2015)). Our main interest lies with those studies comparing professionals and students. It is noteworthy that the term professional has no exact definition, and is sometimes used rather arbitrarily in the studies under consideration. Some of the works presented here define their counterparting subject-pool as workers (referring to blue-collar workers), some use distinct professions such as nurses, fishermen or CEOs. Other studies, such as Montmarquette et al (2004) or Waichman et al (2011), employ managers as their subject group. However, there are varying and coexisting definitions of what makes a manager. While Montmarquette et al (2004) use a certain threshold of annual salaries as the basis for their definition, Waichman et al (2011) define managers as employees supervising at least five others, irrespective of the salary. In our study we do not distinguish between employees with managerial tasks and those with admin-

istrative tasks. Neither do we account for distinct professions. Instead, we classify subjects from a business environment as relevant comparison to our work, including all of the aforementioned factors, irrespective of hierarchy level, type of profession or country of origin. As mentioned above, we believe that professional rules of conduct in general might be a source of bias, irrespective of the occupational category.

Table 1 provides an overview of the studies under consideration, that is including professional participants as we define them. In sum, 15 out of 19 studies report differences between subject-pools. Most of them are bargaining games (e.g. Ultimatum Game, Dictator Game, Trust Game) and experiments involving social preferences (also referred to as other-regarding preferences). Some authors point to the "social framing of the workplace"(Carpenter et al (2005)) or the "business context"(Potters and van Winden (2000)) as a potential source of subject-pool differences. These business norms and conventions might be even more relevant in market experiments, where students are asked to represent a firm. Thus, it is even more surprising that market games have not yet comprehensively been studied with regard to subject-pool effects. This is the point of departure for our research question.

Subject-pool effects in market experiments have been examined by Waichman et al (2010)Waichman et al (2011)). For oligopolistic markets with quantity-setting firms (Cournot Competition), the authors confirm significant subject-pool effects. This study is the closest to ours. However, our study considers markets where prices rather than quantities are the strategic variable (Bertrand Competition). In addition, we look at participants of a different nationality - Germans rather than Malays.

3 Experimental Design and Procedure

Following the setup of Fonseca and Normann (2012), Fonseca and Normann (2014), we conduct duopolistic market games with Bertrand-competition. In each market, there are $n = 2$ firms that produce a homogenous good. Firms do not face capacity constraints or any cost of production. There is inelastic demand, amounting to 300 units of the good in each market in each period. Each period of the experiment starts with firms' decisions about the market price $p_t = \{0; 1; \dots; 100\}$. Markets clear according to the following rule: the firm that offers the lowest price p^* attracts the entire market-demand and thus generates a profit of $p^* \cdot 300$. The other firm's profit is zero. If firms offer the same price, demand is split evenly among them. The resulting profits are $p^* \cdot 300/2$. In total, the experiment included 25 periods with fixed partner matching. To avoid end-of-the-game-bias, participants were informed that after the 25th period, the game was to be continued with a probability of $1/6$ (rolling a dice). As we employ a Bertrand model, theory suggests that market prices will be pushed towards marginal cost. The unique Nash-equilibrium is thus given by $p_1 = p_2 = 0$ with a collective profit of zero. The payoff maximizing (collusive) price is $p_1 = p_2 = 100$, resulting in a profit of 15,000 for each firm. At the end of each period, participants received feedback about prices and payoffs for both firms in the market, as well as information on their own cumulative profit until that point in time.

We test two treatments. A baseline treatment, in which communication between participants is not allowed, and a communication treatment, in which participants in a market are allowed to freely communicate. Communication takes place in the form of a chat window. After the communication decision is made, the window opens for 45 seconds. We provided instructions, in which participants were informed about the procedure of the experiment and the treatment-specific profit scheme. During the experiment, payoffs were calculated and displayed in Experimental Currency Units (ECU), labelled Taler (an old German coin). The subject group-specific exchange rate to EUR was provided in the instructions. At the end of the experiment, participants were asked to answer some survey questions. We collected data on demographic characteristics, education, profession and previous experience with market experiments.

In total 94 subjects participated in the experiment, allocated to four sessions. We recruited a total

Table 1 Literature Overview (chronologically sorted)

Authors	Subjects	Type of Game	Main Results
Choo et al (2016)	Students vs. Professionals	Real Effort Game	"We find subject pool differences: self-assessed taxpayers are the most compliant, while students are the least compliant."
Dragone et al (2015)	Students vs. Professionals	Dictator Game Public Goods Game	"In the Dictator Game student are less beneficent than workers. Temporary and permanent workers do not differ." "() we find that students tend to be more self-oriented, and less willing to cooperate in a public good game."
Bolton et al (2012)	Students vs. Managers	News vendor Problem	"The results of our study show that, at least for the news vendor model, the direction of effects is the same for students and managers, but that the magnitude of the effects can be different."
Waichman et al (2011)	Students vs. Managers	Market Game (Cournot)	"We find that Malaysian managers perform significantly more collusively than Malaysian students."
Carpenter and Seki (2011)	Students vs. Fishermen	Public Goods Game	"() we find that student behavior in our voluntary contribution experiment is significantly less cooperative than our second subject pool, fishermen."
Waichman et al (2010)	Students vs. Managers	Market Game (Cournot)	"For one of the most prominent experiments we found that the choice of subject pools can matter."
Alevy et al (2007)	Students vs. Professionals	Decision Making	"Analysis of over 1,500 individual decisions suggests that CBOF professionals behave differently from our student control group."
Alatas et al (2009)	Students vs. Public Servants	Corruption Game	"We find that the Indonesian public servant subjects are significantly less likely to engage in corruption than the Indonesian student subjects."
List et al (2005)	Students vs. Professionals	Lottery (Allais Paradox)	"We find some evidence that both students and professional traders behave in accordance with the Allais paradox."
Carpenter et al (2005)	Students vs. Professionals	Ultimatum Game Dictator Game	"Workers behaved distinctly from both student groups in that their allocations do not decrease between games, an effect we attribute to the social framing of the workplace."

Table 1 continued

Authors	Subjects	Type of Game	Main Results
Haigh and List (2005)	Students vs. Professionals	Loss Aversion	"() we do indeed find behavioral differences between professionals and students."
Fehr and List (2004)	Students vs. CEOs	Trust Games	"Our data show that CEOs exhibit considerably more trustful and trustworthy behavior than students."
Montmarquette et al (2004)	Students vs. Managers	Social Dilemma	"Results from the student-subject pool differ in strategy more than in substance, allowing confirmation of the external validity of laboratory experiments."
Alpizar et al (2004)	Students vs. Managers	Pollution Compliance Game	"In all cases, our analysis allows us to reject the hypothesis that managers and students performed similarly in this experiment."
Potters and van Winden (2000)	Students vs. Professionals	Signalling Game	"Our experimental study of lobbying shows that professional lobbyists behave more in line with game-theoretic predictions, show a higher degree of information disclosure (separation), and earn more money."
Cooper et al (1999)	Students vs. Managers	Signalling Game	"Games played in context generated greater levels of strategic play for managers, with minimal impact on students."
Cadsby and Maynes (1998)	Students vs. Nurses	Public Goods Game	"The behavior of economics and business students is compared with that of nurses. The results are dramatically different."
Dyer et al (1989)	Students vs. Professionals	Common Value Auction	"Finally similar results are reported almost without exception across students and business executives. We conclude that the winner's curse phenomenon is robust across auction form, market size and subject population."
Dejong et al (1988)	Students vs. Professionals	Sealed Offer Market	"()the behavior observed in a laboratory market with "real" businessmen is in many ways similar to that observed in a market with student subjects."

of 48 students, most of them being enrolled in business administration courses. In addition, we recruited 46 professionals via online invitations, randomly directed at companies affiliated with the university. Table 2 provides an overview of the subjects characteristics. Participants received a performance-related payment, based on their opportunity costs. Students' opportunity costs are defined as a students' hourly salary (typically the minimum wage plus a certain markup). Professionals' opportunity costs are calculated using statistics on hourly salaries provided by the German Federal Statistical Office. All experiments were programmed using the z-Tree software provided by Fischbacher (2007) and conducted in the experimental laboratory of the Ostwestfalen-Lippe University of Applied Sciences in Lemgo, Germany.

Table 2 Descriptive statistics of the sample

	No. of subjects	Age (mean)	Male (%)	Work Experience (years)
Students				
Baseline (B)	24	23	0.71	-
Communication (C)	24	24	0.63	-
Professionals				
Baseline (B)	22	39	0.69	13.4
Communication (C)	24	40	0.71	13.1
Total	94	31	0.66	-

4 Hypotheses

Conventional wisdom implies that allowing open communication should facilitate collusive behavior. The work of Fonseca and Normann (2012) and Waichman et al (2014) demonstrate that this holds for Bertrand as well as Cournot competition. We review the impact of communication in our first hypotheses.

Hypothesis 1 (communication): Allowing open communication between market-participants leads to higher price levels than a situation without the option to communicate, irrespective of the subject-pool.

Next, we focus on the differences between subject-pools. As outlined in Section 2, there is reason to assume that student participants and professionals differ with regard to their market decisions, so that focusing on students as surrogates for professionals might induce subject-pool bias. We therefore formulate our second research hypothesis as follows.

Hypothesis 2 (subject-pool bias): Professionals achieve higher price levels than students, irrespective of the option to communicate.

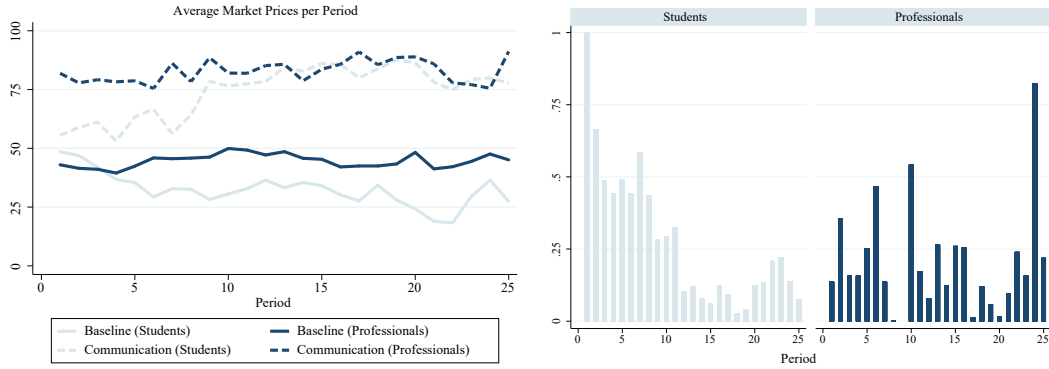


Fig. 1 Average market prices (left panel) and distance to collusive prices (right panel) per period by subject-group and treatment (left panel) and average prices by subject-group and treatment (right panel)

5 Results

Table 3 provides an overview of our results. The descriptive statistics indicate that, on average, professionals select higher market prices than students. Students thus played more competitively, i.e. closer to the Nash equilibrium. This holds for both treatments, baseline and communication. Observed payoffs varied between 12.07 EUR for the average student participating and an average of 31.30 EUR for professionals. Displaying average prices per period across all markets, Figure 1

Table 3 Descriptive statistics of market prices

	Students		Professionals		All		Δ	Δ
	B	C	B	C	B	C	Treatment	Subject Pool
Average	32,42	74,27	44,65	82,76	38,54	78,33	39,79	10,36
Median	32,83	78,08	45,08	82,00	41,38	79,18	37,80	8,09
Std. Dev.	6,93	10,67	2,78	4,79	8,08	9,40	1,32	5,02

(left panel) indicates that students played at more competitive levels under the baseline treatment, compared to professionals. Allowing for communication yields somewhat more similar price-levels. However, even under free communication, it seems that student subjects need a substantial learning-period (periods 0-14) until they catch up to price levels similar to those in the markets played by professionals. Looking at the distance to the collusive outcome (the mutual payoff-maximizing price), it becomes evident that students had a much larger gap to close (Figure 1 (right panel)). Their initial approach to oligopoly pricing differs fundamentally from that of professionals. Presumably, this is the result of implicit codes of conduct that apply to businessmen but not to students.

Turning to our main research question, namely the influence of the subject pool, visual inspection (compare Figure 2 (right panel)) implies differences between students and professionals. Median prices appear to be similar under the baseline treatment, but not under the communication treatment. We employ two nonparametric tests to test for differences between the subject pools, the Wilcoxon-Mann-Whitney rank order test (for differences in central tendencies) and the Kolmogorov-Smirnov test (for differences in the cumulative distributions). The results are displayed in Table 4. The test results indicate that the distributions differ significantly and thus confirm our first research hypothesis. Pooling across the subject pools, we find a sharp rise in market prices for the communication treatment (+ 39.79 ECU), compared to the Benchmark treatment. In size and magnitude, this finding is in line with that of Fonseca and Normann (2012). As expected, these differences turned out to be highly significant (U-statistic of the Wilcoxon rank-sum test: -26.63). We proceed by refining this analysis to the subject-group level and look at the aforementioned treatment effect for each subject group individually. Both groups exhibit highly significant differences in market prices between treat-

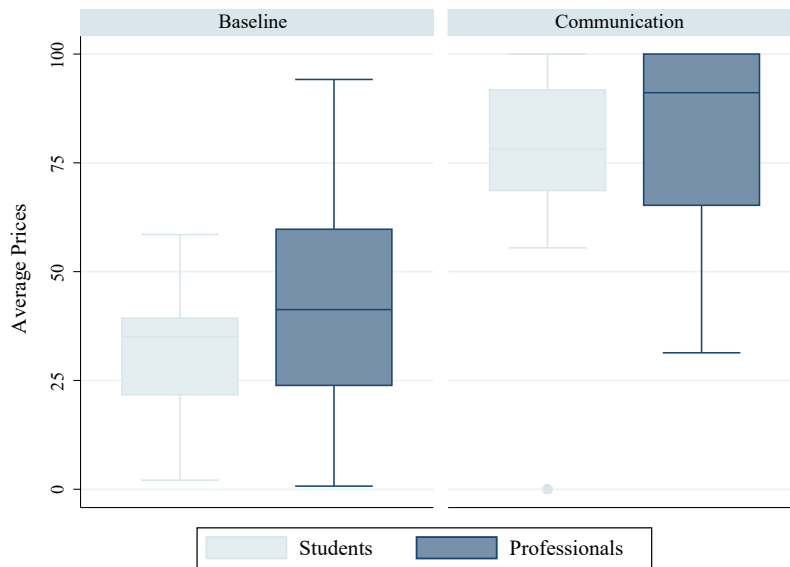


Fig. 2 Boxplots of market prices (averaged over markets and periods)

ments ($U = -18.25$ in the student sample and $U = -20.25$ in the professionals sample). Thus, we can confirm our second hypothesis.

Table 4 Wilcoxon-Mann-Whitney (U) and Kolmogorov-Smirnov (KS) test statistics for Differences in Distributions between Students and Professionals

	Wilcoxon-Mann-Whitney	Kolmogorov-Smirnov	Observations
Baseline	$U = -3.904$ ($p < 0.01$)	$KS = 0.253$ ($p < 0.01$)	600
Communication	$U = -2.801$ ($p < 0.01$)	$KS = 0.140$ ($p < 0.01$)	575

6 Conclusion

Our main finding is that students and professionals behave largely similarly when faced with policy changes. Despite this directional homogeneity, we confirm pronounced differences in effect size. Our results thus support qualitative rather than quantitative external validity and we confirm an effect which Carpenter et al (2005) have labelled limitation in calibration. In other words, we observe qualitatively similar results, supporting external validity, but at the same time we find quantitative differences.

Students need some time to converge to price-levels similar to those of the professionals. For experimental economists, this makes another case. Relatively short experiments or "one-shot games" with student participants should be regarded with suspicion. Is it possible to generalize findings from the lab to the real world? If we focus on the directional effects between treatments, i.e. the question of whether the possibility to communicate has a significant influence on collusion, our answer is confirmative. If, instead, the aim is to extrapolate quantitative results, experiments based on student subjects should be interpreted with caution. Yet, the concept of external validity, although used in various methodological papers, has no generally accepted definition. As Kessler and Vesterlund (2015) have pointed out, the debate should center on qualitative rather than quantitative external validity.

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