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Managers and Students Playing Cournot – Experimental Evidence from Malaysia

by Israel Waichmann, Till Requate and Ch'ng Kean Siang

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Managers and Students Playing Cournot - Experimental Evidence from Malaysia*

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Abstract

We report results from a Cournot triopoly experiment with different subject pools: German students, Malaysian students, and Malaysian managers. While German students play Nash, we reject the hypothesis that both Malaysian students and managers select the Nash quantity. Moreover, Malaysian managers perform significantly less competitively than Malaysian students. Finally, the affect of gender is opposite for German and Malaysian subjects.

JEL Classification: L13, C93, C72, D43, D21

Keywords: artefactual field experiment, subject pools, Cournot oligopoly, managers, non-cooperative behavior

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1 Introduction

Laboratory experiments in industrial organization are often criticized for using students as subjects. The criticism centers on the issue of whether a sample of students can deliver information about the behavior of firms (or firms' managers). As a consequence, several experiments were designed to test the effect of subject pool selection on subject performance. These experiments came up with ambiguous evidence. While Cooper *et al.* (1999), Montmarquette *et al.* (2004), and Ball and Cech (1996) find little or no difference in performance between managers and students, Fehr and List (2004), Alpízar *et al.* (2004), and Cooper (2006) find that in particular situations managers behave more cooperatively than students.

The classical quantity-setting (Cournot) oligopoly is a prominent example of strategic interaction among firms. Due to its simplicity, it is the subject of numerous experimental studies. Despite the focus on firms' behavior, the external validity of Cournot experiments conducted with students has never been challenged by conducting similar experiments with managers.

Huck *et al.* (2004) designed a series of experiments that comprise the common features of most Cournot studies. Using student subjects they find that although participants in a duopoly sometimes collude, this rarely occurs in the market with more than two firms. In addition, they find that the Nash equilibrium is a quite accurate predictor for subject performance in a Cournot triopoly.

Since the experimental evidence by Fehr and List (2004), Alpízar *et al.* (2004), and Cooper (2006) suggests that managers show more collusive behavior than students, we replicate the design of Huck *et al.* (2004) in order to test whether the use of student subjects instead of managers in a Cournot triopoly experiment is sensible with regard to external validity. In particular, this study compares the performance of middle and high-ranking Malaysian managers mainly from the manufacturing industry with Malaysian and German undergraduate students.

Our findings support those studies suggesting that managers perform more cooperatively than students. We also find that the country matters (i.e. German students perform more cooperatively than Malaysian students), while gender affects the outcome differently in Germany and Malaysia.

2 Experimental Design and Procedure

We adopt the design of Huck *et al.* (2004) for the triopoly case, but we use different subject populations: German students, Malaysian students, and Malaysian managers.

2.1 The underlying model and design

In particular, we set up a symmetric Cournot triopoly[1] with a homogeneous product and fixed matching lasting over 25 periods. Communication between

[1] As in most oligopoly experiments, the situation was economically framed.

the firms (subjects) is not allowed; the feedback after each period contains only aggregate information about the other firms' performance.

The firms are acting in a market with the following demand function:

$$P(Q) = max\left\{100 - Q, 0\right\}, \tag{1}$$

where $Q = \sum_{i=1}^{3} q_i$. The cost function for each seller is

$$C\left(q_i\right) = q_i \tag{2}$$

Under this setting, the Nash equilibrium market quantity is $Q^N = 74.25$, whereas the symmetric collusive (monopolistic) quantity is given by $Q^M = 49.5$, and the competitive quantity by $Q^C = 99$.

Subjects could select quantities between 1 and 100 in steps of 0.01. In each period the participants were allowed to use a profit calculator for simulating their own and the other firms' decisions before taking the real-output decision.

2.2 Subjects recruitment and control

We recruited 33 undergraduate students from the University of Kiel, Germany, and 39 undergraduate students from University Sains Malaysia.[2] Additionally, we invited 33 Malaysian managers from small and medium-size firms mainly from the manufacturing industry (plastics, cable assemblers, chip manufacturers, and computer parts manufacturers) in Penang Island, West Malaysia, to participate in the experiment. Target companies were sourced from the Federation of Malaysian Manufacturers (FMM) directory, which lists all the small and medium size firms (SME) in Penang state. A letter of invitation was sent to the company secretary asking him/her to forward it to the relevant person in the company.[3] Manager age ranged between 29 and 54, most of them around 35. All of them had at least a Bachelor's degree and two of them a PhD. As they had Malaysian citizenship, the ethnicity of the managers was Chinese (90.9%) and Indian. The estimated earnings of the selected group ranged between 4000 RM and 9000 RM per month, with an estimated average of 5000-6000 RM.[4]

The subjects participating in the three treatments had not previously participated in an experiment. The experiment was programmed and conducted using the z-Tree (Fischbacher, 2007) experimental program. In all treatments we followed the same procedure, and used the same experimenter.[5] The experiment was explained and conducted in English (in Malaysia) and German. The instructions (based on an English translation of Huck *et al.*, 2004) were carefully inspected by the experimenters (one is linguistically and culturally fluent in Malaysian English, the other is in German). Regarding the *currency effect*, the payment was calculated to have a similar purchasing power across countries,

[2]Most students in Germany and Malaysia were recruited from Economics courses.

[3]We did not reveal the nature of the experiment, merely that it was a computer-based experiment designed to analyze decision-making, We also announced the expected payoff range.

[4]5000-6000 RM≈1500-1900 US$.

[5]We followed the procedure of Roth *et al.* (1991) concerning the cross-country aspects.

so that a German student choosing the Nash equilibrium quantity along the experiment (given that the whole industry also decides on the Nash equilibrium quantity) earns €15. Under similar conditions, a Malaysian student earns 9.5 RM.[6]

3 Results

Following the approach of Huck *et al.* (2004), we start by averaging market quantities over time. This approach allows us to explore the average performance of each oligopoly market. Second, in order to figure out the time-series properties of the data, we average market quantities at each time period. Last, we inspect the pooled data across markets and over time.

3.1 The effect of subject pool on performance

- Table 1 about here -

Table 1 presents the market quantities averaged over all periods, over the last 9 periods, and over the intermediate 16 periods (periods 5 to 20, in order to exclude beginning and end effects). Table 1 suggests that the averaged quantity selected by the Malaysian students is larger than the average quantities selected by both the Malaysian managers and the German students. Formally, using a Flinger and Policello robust rank order test (F-P test) we find that the median quantity selected by the Malaysian students is different from the median quantity selected by each of the other two samples at the 5% s.l. Also, we cannot reject the null hypothesis that the median quantities selected by the German students and the Malaysian managers are not different from the Nash equilibrium quantity of 74.25, but we reject this hypothesis for the Malaysian student sample.[7]

- Figure 1 about here -

Regarding analysis over time, Figure 1 presents the quantities at each time period, averaged across oligopoly markets. The most prominent inspection from that figure is that at almost every time period the averaged quantities across markets selected by the Malaysian students are larger than the quantities selected by the other two samples. Formally, using an F-P test we find that the quantities selected by Malaysian students are different from the quantities selected by Malaysian managers and German students at the 1% s.l., respectively.

[6] On the one hand, a vegetarian sandwich and a bottle of Coca-Cola cost about 3 RM at the University Sains Malaysia campus, in comparison with about €3.5 at the University of Kiel Campus. On the other hand, students' earnings per hour (alternative cost) are about 3.5 RM in Penang in comparison with about €6.5 in Kiel. The payment is a weighted average of these two examples.

[7] In addition, using an F-P test we confirm that the results by Huck *et al.* (2004) in Berlin are indistinguishable from our result in Kiel (2007) at the 10% s.l.

In addition, we observe a significant time-trend in the initial periods of the German student treatment. This time-trend vanishes already after six periods.[8] By contrast, no significant time-trend is observed in the Malaysian treatments.

- Figure 2 about here -

Finally, we pool the data across oligopoly markets and over time. Figure 2 presents the histograms of the pooled quantities in each treatment. Using a t-test, we cannot reject the null hypothesis that the mean quantity selected by the German students is not different from the Nash equilibrium level of 74.25 at the 10% s.l. However, we reject this hypothesis for the Malaysian samples (at the 1% s.l for the Malaysian student sample and at the 5% s.l for the Malaysian manager sample).

- Table 2 about here -

To sum up, Table 2 presents the results of a one-sample Wilcoxon sign rank test and a t-test on whether triopoly markets perform at the Nash equilibrium level. Accordingly, we can formulate:

Result 1: *The Nash equilibrium is a quite accurate predictor for performance in triopoly markets conducted with German students. By contrast, we reject the hypothesis that both the Malaysian students and managers select the Nash quantity.*

- Table 3 about here -

Table 3 presents the results of statistical tests regarding differences in performance between subject pools. We can now formulate the next result.

Result 2: *Malaysian students perform more competitively than both Malaysian managers and German students.*

3.2 The effect of gender on performance

Table 4 presents the mean quantity (and standard deviation) according to gender in each sample.[9] Using a t-test, we find that the mean quantity selected by German females is smaller (less competitive) than the mean quantity selected by German males at the 1% s.l. Using the same procedure for the Malaysian treatments, we find that for both samples Malaysian males are less competitive

[8] Like Huck *et al.* (2004), we verified the time-trend by regressing the averaged quantities on time. Huck *et al.* (2004) also observed a time-trend, however, in their case it vanishes after four periods.

[9] The analysis in this section is based on the pooled data across subjects (firms) and over time.

than Malaysian females.[10] These findings are reflected in the Pearson correlation coefficient between male gender and the quantity selected by the subjects. For the German sample it equals 0.22, whereas for the Malaysian students and managers it is equals -0.13 and -0.15, respectively (all the results being significant at the 1% level). Accordingly, we can portray result 3.

Result 3: *In Germany and Malaysia gender affects subject performance in opposite directions. German males are more competitive than German females, while Malaysian males behave less competitively than Malaysian females.*

- Table 4 about here -

3.3 The profit calculator

In order to obtain further insights about subject behavior in the three treatments we inspect the 'profit-calculator' data. Pooling the data across subjects and over time and using a total of 2625 observations, we find that use intensity of the profit calculator (number of calculations per period) is negatively correlated with the output decision.[11] A possible interpretation of this result is that subjects who decide to play collusively act in a more thoughtful way.

We also verify that the larger the average hypothetical quantity fed into the profit calculator in a given period, the larger the actual quantity selected by the subject at that period.

4 Concluding Remarks

This study confirms the findings by Huck *et al.* (2004) that, by and large, the Cournot-Nash equilibrium is a good predictor for subject performance in Cournot triopoly experiments (at least, the quantities selected by the three subject pools are closer to the Nash quantity than to the other two benchmark quantities). However, while German students follow the Cournot strategy almost perfectly, the Malaysian subjects' quantities (both students' and managers') are significantly different from the Cournot-Nash quantity. Furthermore, we find that the Malaysian students perform more competitively than the Malaysian managers, a result consistent with the previous studies by Fehr and List (2004), Alpízar *et al.* (2004), and Cooper (2006).

Finally, we find that gender does affect subject performance. Regarding the German student sample, we find that females behave more cooperatively than males[12], while the opposite holds for the Malaysian samples. This result supports findings by Gneezy *et al.* (2009) suggesting that societal structure is crucially linked to observed gender differences in behavior.

[10] Significant at the 1% s.l.

[11] Pearson's correlation coefficient is equal to -0.07; it is significant at the 1% level.

[12] This result is in line with the study by Mason and Phillips (1991) (conducted with American students), who find that females cooperate more than males in a Cournot duopoly.

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A Instructions

- Welcome to our experiment. Please read these instructions carefully! From now until the end of the experiment you are not allowed to communicate with the other participants. If you have any questions, please raise your hand, and we will answer them individualy.
- At the beginning of the experiment, each one of you will be assigned a number. From then on, you and the other participants will be identified by this number. Please keep it until you receive your payment. In addition, there are two empty sheets of paper that you can use during the experiment.
- In this experiment you will repeatedly be asked to make decisions that can earn you a reasonable amount of money. How much you earn depends not only on your decisions but also on the decisions of the other participants.
- All participants receive the same instructions.
- In this experiment you represent a firm that produces and sells the same product, as two other firms, in the market. You will be matched with the same two firms during the whole experiment.
- You will stay anonymous for the other firms, both during and after the experiment.
- In each period all firms have to make one decision, namely what quantity they wish to produce.
- The cost of production is 1 ECU (Experimental Currency Unit) per unit (this holds for all firms).
- The following important rule holds: The higher the total (aggregate) quantity produced by all firms, the lower the price in the market. Moreover, from a certain amount of total output upwards the price will be zero.
- Your profit per unit of output will be the difference between the market price and the unit cost of 1 ECU. Note that you will make a loss if the market price is below the unit cost. Your profit per period is thus equal to the profit per unit multiplied by the number of units you sell.
- During the experiment you can use a 'profit calculator' before you decide on the quantity to produce. You enter your quantity and the total (aggregate) quantity of the other two firms and the 'profit calculator' will calculate your earnings.
- In each period, the output decisions of the other two firms will be registered, the corresponding price determined, and the profits computed.

- After each period, you will get information on your screen about the quantity chosen by you, the aggregate quantity chosen by the other two firms, your payoff in the current period, and your commulative payoff starting from the first period.
- The experiment consists of exactly 25 periods.
- During the experiment, all payoffs are given in ECU. Each participant starts with an initial amount of 500 ECU.
- After the experiment we will convert your payoff to RM. The exchange rate is 66.5 ECU/RM, that is, 66.5 ECU is equal to 1 RM.[13]
- Your total profit in the experiment is the total amount you earned in the 25 periods of the experiment (plus the initial amount of 500 RM).
- At the end of the experiment we will calculate your money payoff reward. This will be done in way that ensures that the other participants will not see how much you earned and you will not see how much they earned. You will receive your money immediately in cash.

[13]The currencies and the exchange rates differed across treatments.

B Tables and Figures

	German Students	Malaysian Students	Malaysian Managers
$\bar{Q}_{1-25}$	74.66 (5.19)	80.83 (8.85)	75.91 (4.88)
$\bar{Q}_{17-25}$	76.18 (5.79)	81.25 (6.93)	76.21 (4.94)
$\bar{Q}_{5-20}$	75.51 (5.81)	80.05 (9.16)	75.96 (5.08)

Table 1: *Mean (and standard deviation) of the market quantities averaged over time.* $\bar{Q}_{1-25}$ *is the average over all periods,* $\bar{Q}_{17-25}$ *is the average over the last 9 periods,* $\bar{Q}_{5-20}$ *is the average over the middle 16 periods.*

	German Students	Malaysian Students	Malaysian Managers
Average quantity	74.64	80.81	75.91
Across-market analysis	n.d	d. at 5%	n.d
Over-time analysis	n.d	d. at 1%	d. at 1%
Pooled-data analysis[14]	n.d	d. at 1%	d. at 5%

Table 2: *Results of a one sample Wilcoxon sign rank test to find whether the median quantities in the three treatments are statistically different from the Nash equilibrium quantity of* 74.25. *"n.d" denotes "no difference" at the 10% s.l, "d" denotes "significant difference" at a 10% s.l. or lower.*

[14] A T-test was also performed on the pooled regression. The results confirm the median test.

(a) Analysis across Oligopoly Markets

Test	Difference between Treatments
Median test	Malaysian students $*>$ Malaysian managers = German students
Variance test	Malaysian students = Malaysian managers = German students

(b) Analysis over Time

Test	Difference between Treatments
Mean test	Malaysian students $>$ Malaysian managers = German students
Median test	Malaysian students $>$ Malaysian managers = German students
Variance test	Malaysian students = Malaysian managers = German students

(c) Analysis of Pooled Data

Test	Difference between treatments
Mean test	Malaysian students $>$ Malaysian managers = German students
Median test	Malaysian students $>$ Malaysian managers = German students
Variance test	Malaysian students $**>$ Malaysian managers $>$ German students

Table 3: *The result of a mean test (t-test), a median test (Wilcoxon sign rank test and Flinger and Policello Robust rank order test), and a variance test (Siegel-Tukey test) testing whether the quantities selected in the three treatments differ from each other. The symbols* $=$, $>$, $*>$, *and* $**>$ *denote no difference at the 10% significant level, difference at the 1%, 5%, and 10% s.l., respectively.*

Treatment	Males	Females
German students	26.63 (5.92)	24.00 (4.81)
Malaysian students	25.06 (10.67)	28.55 (14.80)
Malaysian managers	24.51 (8.91)	26.50 (8.72)

Table 4: *The mean (and standard deviation) of the selected individual quantities, differentiated with respect to gender in the different treatments.*

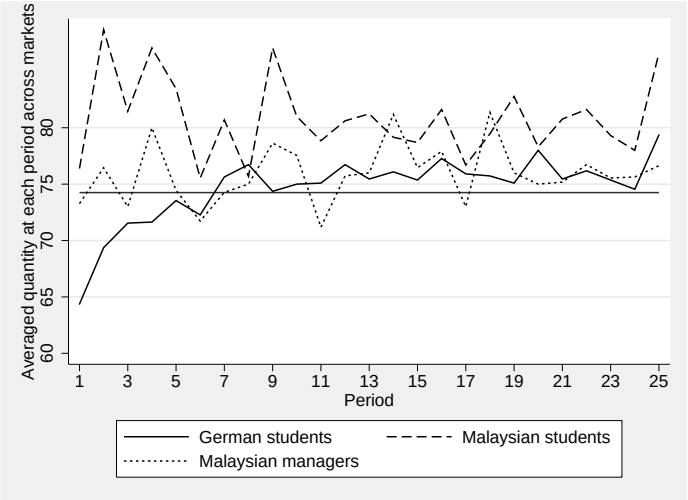
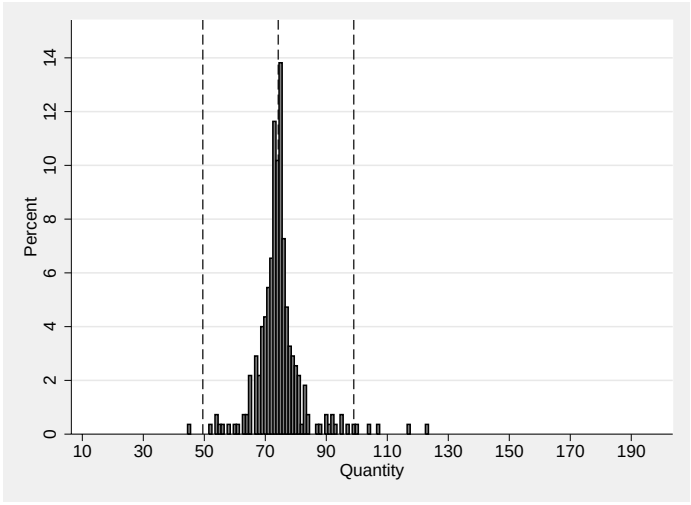
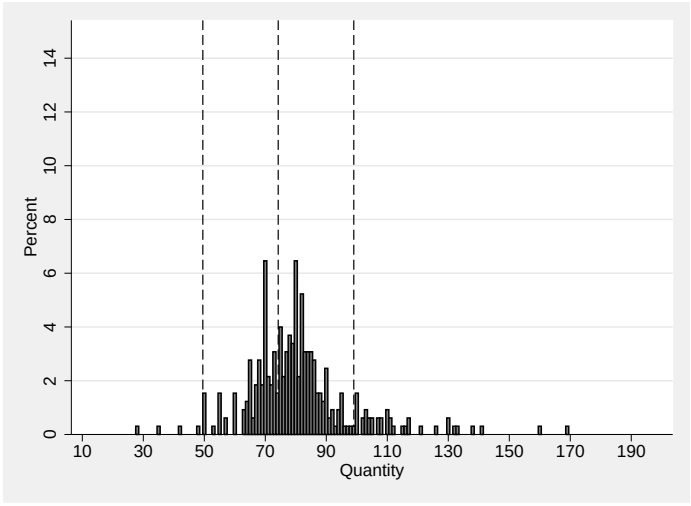


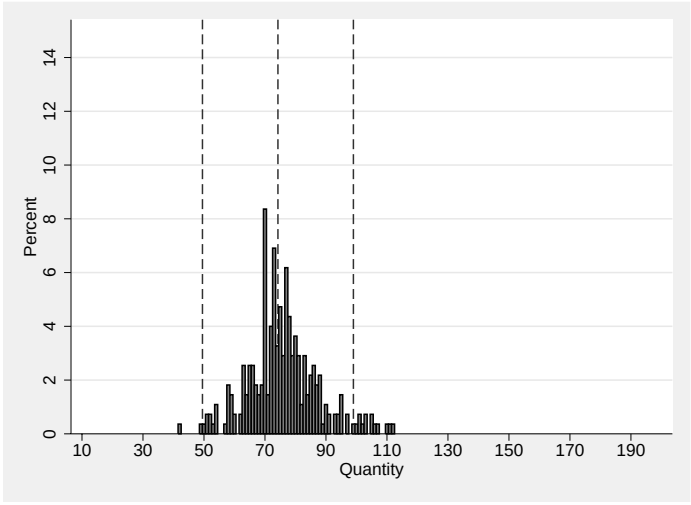
Figure 1: *Quantities averaged across oligopoly markets at each time period (a total of 25 periods). The straight line denotes the Nash equilibrium quantity,* 74.25.



(a) German student treatment



(b) Malaysian student treatment



(c) Malaysian manager treatment

Figure 2: *Histograms of the quantities pooled across oligopoly markets and over time. The dashed lines denote the benchmark quantities:* 49.5 *is the cooperative quantity,* 74.25 *is the Nash quantity, and* 99 *is the competitive quantity.*