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Good deeds, business, and social responsibility in a market experiment

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Abstract

We study how commitment of entrepreneurs to corporate social responsibility practices might effectively improve the social impact of market competition: to this end we devised a market experiment in which profit maximization and socially-concerned behavior were both potential goals of producers. Our subject pool included two distinct types of students having different prosocial attitudes. The two types adopted significantly different strategies in the treatment group, where producers could contribute to a positive externality, whereas they behaved similarly in the control group, where the only objective was profit maximization. Subjects who were ex-ante more prosocial chose to produce with more focus on the positive externality than their counterparts. However, they failed to actually deliver a larger social impact, since that also required winning a large enough market share. We conclude that producers often commit to social responsibility, even though well-meaning conducts do not necessarily beget equally good outcomes.

Keywords: social responsibility, market experiment, charitable giving, vertical differentiation

JEL Classification: C92, D22, D40, D64

1 Introduction

Nowadays firms often try to persuade stakeholders that their goods and services are of high quality, while also pledging that their business activities are (or are becoming) more socially-responsible. How can we interpret this phenomenon? According to many scholars, standard strategic motives push firms towards more socially responsible actions. For instance, Arora and Gangopadhyay (1995) were the first to emphasize how corporate social responsibility (CSR henceforth) can help firms achieve new market niches of socially-aware consumers. Brekke and Nyborg (2010) argue that CSR can allow firms to reduce the wages of their socially-motivated workers. Maxwell et al. (2000) focus on the possibility of using CSR as a way to preempt stricter and more expensive regulations by public authorities. CSR activities are thus defined as voluntary actions that internalize socio-environmental externalities, taken without being forced to do so by laws or regulations, whatever the underlying motivations. As a consequence, in this perspective CSR can operate hand in hand with profit maximization and does not represent a real change in governance. For this reason, these types of activities are usually labeled as "strategic" CSR (Baron, 2001).

Throughout the paper the following abbreviations are used: CSR for "corporate social responsibility", C for "Control", T for "Treatment", DS for "Development Studies" and BM for "Business and Management".

In many contexts however, individual behaviour does not comply with the homo economicus paradigm (see e.g. Meyer, 2007) but rather reveals a prosocial attitude. Indeed, individuals make charitable contributions, engage in voluntary work, donate blood, and sometimes agree to pay higher prices in order to consume responsibly. For this reason we would like to investigate whether prosocial motivations can also influence the choices of individuals involved in the role of entrepreneurs by making them forego part of their profit for the greater (social) good.[1] In the theoretical literature there have only been a few instances where firms, or entrepreneurs, were not profit maximizers. Baron (2007) offers one of the first attempts to give a theoretical rationale for the behaviour of a social entrepreneur undertaking CSR activities at a financial loss. More recently Doni and Ricchiuti (2013) have developed a model in which firms can have different degrees of CSR, based on the relative weight of profits and social objectives within their utility function.

Nevertheless, many of the authors who have studied this phenomenon are skeptical of the empirical relevance of purely non-selfish CSR.[2] Indeed, a survey of the empirical literature by Kitzmuller and Shimschack (2012, p. 71) concludes that *"quantitative empirical data are not consistent with hypotheses suggesting that not-for-profit motivations systematically drive observed CSR."* However, the evidence of strategic CSR is also weak because, as Margolis et al. (2007) have argued, empirical data shows low levels of correlation between CSR and profitability. Besides, there is some evidence suggesting causality in the opposite direction: the more profitable a firm is, the more likely it is to engage in CSR activities.

Empirical analysis seems therefore inconclusive with regard to the actual motivations of CSR behaviour. Moreover, the empirical literature is almost completely focused on large corporations: no studies have been undertaken that look at the potential for socially-responsible behaviour among small business enterprises and single entrepreneurs, probably due to sheer lack of data on CSR at that level. A further difficulty is that we can expect significant self-serving bias in answers from direct interviews of managers or entrepreneurs, to overstate their social attitudes and improve their perceived reputation, which parallels what happens with consumers and the well documented gap in terms of stated and actual purchasing decisions when there are socially related issues.[3] For this reason, as suggested by Schmitz et al. (2015), incentivized experiments may be better suited to examine the actual motivations behind CSR production as well as, more in general, to study strategic behaviour in market environments (see for example Normann and Ruffle, 2011 and Potters and Suetens, 2013).

A few experimental studies in recent years have dealt with the phenomena of ethical product differentiation and corporate social responsibility (see Rode, 2008; Bartling et al., 2015; Georgantzis and Vasileiou, 2015; Valente, 2015; Feicht et al., 2016; Etilé and Teyssier, 2016; Pigors and Rockenbach, 2016). These papers share a very similar framework, oftentimes featuring markets with sellers and consumers interacting for a predetermined number of rounds. In each round, sellers must determine a price for a good that has a social attribute (i.e. a positive externality). Usually, the higher the social attribute of a good, the higher the resulting donation to a charity organization once that good is sold.[4] Consumers observe the price and, in some

[1] According to authors as Reinhardt et al. (2008), Benabou and Tirole (2010), we are dealing with genuine CSR behavior only in this case.

[2] According to Portney (2008, p. 262), "*if we confine our discussion of CSR only to those cases where a corporation knows it is sacrificing profits, then that discussion will be an awfully short one.*"

[3] See Devinney et al. (2010) for both empirical and survey-based literature regarding social consumerism.

[4] In Bartling et al. (2015) the externality of a transaction does not involve a donation to a charity organization but rather a higher payoff for a third player who has no active role in the experiment. A similar design is also adopted in Danz et al. (2020) and Pigors and Rockenbach (2016) both of which focus on fair wages and feature a third player who plays the role of a seller's employee. In Georgantzis and Vasileiou (2015) the positive externality consists in the production of a public good shared among all players.

cases, they have knowledge of the social quality of each good (and such information can be more or less credible). When all consumers have chosen which goods to buy, each agent is informed of the market outcome and the game is repeated for various rounds.

These papers take advantage of the experimental market to investigate how institutional framework and information setting can affect market outcomes and the behavior of individual actors. For instance, Rode (2008) studies the relevance of what buyers know about the additional costs related to a specific social attribute. Georgantzis and Vasileiou (2015) and Valente (2015) focus on the effect of ethical differentiation on market outcomes, consumer behavior and profits. Bartling et al. (2015) analyze the influence of increased competitive pressure and the impact of the information about the social quality of each proposal. Both Bartling et al. (2015) and Feicht et al. (2016) consider cases in which a product's social attribute has varying efficiency in terms of external impact. Feicht et al. (2016), in particular, analyze the influence of the commitment power of sellers to donate the initially announced amount. Meanwhile, Etilé and Teyssier (2016) go into the issue of credibility in more depth by comparing treatments where sellers have different signaling devices in order to make the social aspects of their proposal credible for consumers.[5]

These experiments, however, are typically designed so that there is no way to determine whether producers' strategies are consistent with standard profit maximization and CSR is therefore driven by consumer preferences, or rather if producers strategies imply genuine willingness to sacrifice profits in the social interest. Indeed, in (all of) the experiments previously cited, market outcomes are the result of the interaction between the social attitudes of both producers and consumers. In order to fully understand the impact of sellers, this aspect needs to be disentangled from the potential heterogeneity of buyers. To do so, while we retain a similar framework in order to analyze CSR strategies, we simulate the demand side of the market by means of an algorithm.[6] To our knowledge, the present study is the first to focus exclusively on the social attitudes of producers when production entails some social externality and market shares depend, at least partially, on CSR activities.

Our design inquires the extent to which experimental subjects playing as producers behave as profit maximizers when their choices may have a social impact, marked by a donation to a charity organization that is selected by the individual producer from a predetermined list before the start of the experiment. We contrast the result against a control treatment where the game was the same as in the main treatment, with the only exception that the social dimension of quality was dropped. In that case, the algorithm represents consumers interested in quality *per se* and market transactions have no external impact.

A further issue we study is whether (and how) subjects with different prosocial attitudes adopt different strategies and affect the market outcome accordingly. To this end we selected an ad-hoc sample of economics majors, recruiting students from two rather different areas of economic studies: Business and Management and Development Studies. Indeed, as we detail below, the two groups of students are quite different, on average, in terms of their prosocial attitudes and aspirations.

Our findings can be summarized as follows. When production may have positive externalities (i.e. in our main treatment), players with higher prosocial attitudes display greater willingness

[5]Pigors and Rockenbach (2017) investigate the relevance of the kind of information buyers have on the wage received by workers involved in the production of goods sold on the market.

[6]Our algorithm is inspired by standard models of vertically-differentiated markets, where consumers are (heterogeneously) willing to pay for the quality of the goods (see Mussa and Rosen, 1978; Gabszewicz and Thisse, 1979). This framework has already been adopted by many authors investigating various issues related to CSR (see Arora and Gangopadhyay, 1995; Bansal and Gangopadhyay, 2003; Eriksson, 2004; Lombardini-Riipinen, 2005; Rodriguez-Ibeas, 2007; Garcia-Gallego and Georgantzis, 2009; Doni and Ricchiuti, 2013). In turn this type of behaviour emerges in experimental papers with human (as opposed to computerized) consumers, such as Georgantzis and Vasileiou, 2015, Valente, 2015.

to contribute to such positive externalities and often ended up earning less, whilst no such differences emerge when such externalities are removed (i.e. in the control). The evidence as to whether prosocial producers generate more positive social impact is ambiguous. Indeed market competition appeared to act as a countervailing force with respect to the intention to trigger positive social impacts: in other words the drive toward CSR is to some extent offset by competitive pressure.

2 Experimental Design and Procedures

2.1 Design

The experiment consists of a simple incentivized duopolistic market environment over ten periods followed by a questionnaire about demographic background, views on consumer ethics and behavioral traits. Subjects play the role of firms, offering a differentiated good for which they have to decide price and quality. The demand side of the market is played by an algorithm.

The experiment involves two between-subjects treatments: a main treatment (T) and a control treatment (C). In T, the good's quality serves two different purposes. Firms can differentiate their products by choosing different quality levels. Besides, if market share is positive, then quality determines a donation to a charity (which is chosen by the subject during the registration phase). As a result the subjects can choose quality levels in order to both obtain higher profits through product differentiation and/or contribute to the charitable cause. In C, there are no charities involved and only the product differentiation motive remains. In both treatments, each experimental market consists of two sellers and an artificial continuum of buyers. Each pair of randomly matched sellers stick together throughout the 10 periods (fixed matching). Earnings are expressed in experimental currency units (ECU).

Each period seller i chooses quality q_i and price p_i for the supplied good, subject to the constraint $0 \leq q_i \leq p_i \leq 400$. Likewise seller j simultaneously and independently chooses q_j and p_j so that $0 \leq q_j \leq p_j \leq 400$. Once qualities and prices are selected, an algorithm representing the demand side (see 2.1.1 below for the details) determines the market share of each seller, s_i and s_j. Each player then receives information about both firms' posted prices and qualities as well as their own market share and resulting payoffs in the current period. At the beginning of the session each seller is informed that their own market share is positively correlated to both the quality of their good and the price of their competitor's good, and negatively correlated to the price of their good and to the quality of the competitor's good. Instructions and screen-shots can be found in the Appendix A.

The profit of seller i is $\pi_i = (p_i - q_i)s_i$ and it is therefore computed as markup (price minus quality which represents a cost) times market share. Similarly, the other seller gets $\pi_j = (p_j - q_j)s_j$.

In T, the instructions specify that each subject has to choose the social quality of a fictitious good, thus illustrating that this social aspect is a potential attribute of the production process (e.g. the use of less polluting material or the absence of child labor in the supply chain). In every round the choices of seller i give rise to a positive social impact $I_i = 1.5q_is_i$ where the use of a multiplicative factor, 1.5 in this case, is a standard way of making donations more appealing with respect to the option of maximizing earnings during the experiment and then donating part of them to a charity when the experiment is over. Conversely, in C, quality is described as inherent to the intrinsic characteristics of the good, with no reference to any external impact.

Participants are aware that at the end of the market game one out of the 10 rounds is randomly drawn to determine the actual earnings (equal to π in that specific round) and, in

T, the donations corresponding to I in that round. This choice is meant to prevent possible wealth-effect and/or risk-related distortions of the incentive scheme.[7] The ECUs are changed into Euros at the end of the experiment at a ratio of 1 Euro for every 20 ECUs.

2.1.1 Market shares

The algorithm defining the buyers' behaviour and determining the market shares between the two sellers works as follows. Let $q_1 < q_2$ and p_1, p_2 be the choices of the two sellers. Then the proportion of consumers in the market served by the two sellers, i.e. market shares s_1, s_2 will be computed as:

$$\boxed{s_1 = \begin{cases} 0 & if \quad p_1 > p_2 \\ \frac{2}{3}\frac{p_2-p_1}{q_2-q_1} & if \quad \frac{p_2-p_1}{q_2-q_1} \in \left(0, \frac{3}{2}\right) \\ 1 & if \quad p_2 > p_1 + \frac{3}{2}\left(q_2 - q_1\right) \end{cases}} \quad \boxed{s_2 = 1 - s_1}$$

The rationale behind this rule is that it reproduces the outcome of a vertically-differentiated duopoly facing consumers with an heterogeneous willingness to pay for quality (for a similar setup, see e.g. Moorthy, 1988 and Wauthy, 1996). In particular, suppose there is a unit mass of consumers, whereby consumer k has preferences over price and quality that can be represented by the utility function

$$U_k\left(q, p\right) = v + \theta_k q - p$$

where θ_k is a random variable uniformly distributed in $[0, \frac{3}{2}]$ and measures the willingness to pay for quality,[8] and v is a constant, large enough to ensure that U is always positive on the $[0, \frac{3}{2}]$ support. In this context the proportion of consumers preferring good 1 that sells at p_1 and has quality q_1 over good 2 selling at p_2 with quality $q_2 > q_1$ is determined by the indifferent consumer. There is indeed a threshold $\hat{\theta} = \frac{p_2-p_1}{q_2-q_1}$ such that consumer k prefers good 1 to good 2 if and only if $\theta_k < \hat{\theta}$.

When $q_1 = q_2$ instead

$$\boxed{s_1 = \begin{cases} 0 & if \quad p_1 > p_2 \\ \frac{1}{2} & if \quad p_1 = p_2 \\ 1 & if \quad p_1 < p_2 \end{cases}} \quad \boxed{s_2 = 1 - s_1}$$

When qualities are equal, the shares are entirely determined by the price difference. When both qualities and prices are equal, the market is equally split between the two firms, so their market share is exactly one half.

2.2 Recruitment

Subjects were recruited from the School of Economics and Management at the University of Florence. We invited BSc and MSc students from either Business and Management (BM) or Development Studies (DS) because we were interested in selecting individuals whose prosocial attitudes were likely to be heterogeneous. The AlmaLaurea Survey on Graduates Profiles shows that these two populations hold diverse views along several dimensions and the answers collected in our final questionnaire (in Appendix B) corroborates the presence of such differences.[9]

[7] Ham et al. (2005) show evidence of the influence of an income effect on the experimental choices in a repeated auction laboratory game where all rounds are paid. Schmidt and Hewig (2015) prove that subjects appear more risk seeking in multiple lotteries when all decisions are paid. See also Charness et al. (2016) for a more detailed discussion of pros and cons of alternative payments schemes.

[8] These assumptions imply that no consumer is willing to pay for quality more than its possible social impact (which we set to 1.5) and the median consumer willingness to pay equals exactly half of the social impact.

[9] See Section 4.2 for a more thorough discussion.

We canvassed every student from the School of Economics and received positive feedback from more than 400 students (158 from the Business and Management, 81 from the Development Studies and the remaining from Economics, Statistics and Finance).[10] We randomly chose and invited 146 students from the list of respondents - 73 from BM courses and 73 from DS - to take part in the experiment. Given our interest in studying how the outcome of the market game was influenced by the subjects' field of study, we planned a specific procedure in order to ensure a mixed composition of couples in each session. Table 1 reports the main data related to participation in the experiment with details about the groups' composition in each treatment.

	Subjects			Groups		
	Totals	BM	DS	BM-BM	BM-DS	DS-DS
T	82	41	41	12	17	12
C	64	32	32	10	12	10
Total	146	73	73	22	29	22

Table 1: Subjects and groups composition

2.3 Implementation

The experimental sessions were computerized using oTree (Chen et al., 2016) and were conducted at the University of Florence's Behavioural and Experimental Economics Laboratory (BEELab) between November 2015 and May 2016 and during October 2018. In the T sessions, students received general instructions upon arrival at the registration desk and were asked to choose a charity they wanted to support in case some additional money should emerge during the experiment as a consequence of their own choices. Participants were asked to choose one of six charities - be it international, national or local - with activities ranging from environmental protection to international cooperation and social intervention.[11] The C sessions, by contrast, received only general instructions.

At the beginning of the experiment the market game instructions were shown to each participant on the computer screen. A researcher read them aloud and students could ask for clarification at any time. Each subject then had to answer three control questions devised to improve understanding of the game rules and logic. Each session began with the market game and was followed by one or more, unrelated experimental activities. The complete sessions lasted 80 to 100 minutes. Each session ended with a questionnaire covering personal data and behavioural attitudes. The average donations made in the main treatment were €7.3 while the average private earnings for the complete sessions were €11.5. At the end of each session, cash payments were made in a separate room by the administrative staff in order to preserve anonymity. The donations to the charities were made on-line and receipts for the bank transfers were e-mailed to all the participants.

[10] The initial announcement was extended to all the students in the School of Economics in order to avoid revealing any unnecessary information to the students - most notably the fact that their field of study was an important element of our research.

[11] The list included: "UNHCR", "Oxfam", "Greenpeace", "Manitese" (a national organization involved in international cooperation), "Fondazione ANT" and "Noi per voi Onlus" (associations supporting families coping with serious health problems).

3 Theory predictions and hypotheses

The design of our experiment follows the previous literature, notably e.g. Feicht et al. 2016.[12] It is well known that in this setup, where sellers simultaneously choose quality and price and consumers are vertically differentiated, if firms are profit maximizers then no Nash equilibria in pure strategies exist (see Stokey, 1980; Moorthy, 1988, p. 151). However, while it is reasonable to expect subjects in C to maximize their own payoff, subjects in T could be motivated by the desire to contribute to a charity, besides their self-interest.

In order to understand how a different objective function could affect the players' strategies we studied the best reply functions of a profit-maximizing firm and that of a nonprofit firm that is trying to maximize its positive impact on the social welfare.[13] In general, a nonprofit firm will impose zero markup while a profit maximizing firm will go for a strictly positive markup. Moreover, on the basis of their best reply strategies, nonprofit firms always set quality within the interval between 200 and 400 ECUs, while profit maximizing firms always choose a quality level smaller than 1000/3 ECUs. We prove that when a profit maximizing firm plays a nonprofit one, a Nash equilibrium exists according to which the former chooses a null quality and a price equal to 200, while the latter sets both the quality and the price at the maximum level of 400. Conversely, no Nash equilibrium in pure strategies exists when both competitors are nonprofit firms maximizing social impact (as well as when they are are profit maximizers, as already established in the literature).

In fact our expectation is that most actual experimental subjects fall somewhere in between exclusive profit maximization and social impact maximization. While analyzing the strategic interaction between subjects who variously balance both objectives is quite difficult (and beyond the scope of this work), knowledge of the best reply functions for these extreme cases helps suggesting the likely behavior of subjects in the experiment. For example, we can predict that individuals who tend to emphasize social impact over private earnings will set a higher quality and a lower markup with respect to more self-interested individuals.

The presence of possible charity donations should induce subjects having strong prosocial inclinations to produce with higher quality, on top of the strategic motive induced by vertical differentiation. Such effect should not be quite as visible in less prosocial subjects. On the other side, when the quality only holds a strategic value, there is no reason to assume that a different behavior could stem from differences in prosociality. Hence we expect that BM and DS quality choices be different in T but not in C.

H1a. *In T, DS students will choose higher quality than BM students.*

H1b. *In C, quality will not significantly differ among BM and DS students.*

On a different perspective, the markup (or equivalently, the price) plays a key strategic role in bringing forth market shares and hence the market outcome. For subjects who set the same markup, the one with higher quality would get just a 1/3 market share (because higher quality and same markup imply higher price). So in order to give rise to a significant social impact, beside going for high quality, a subject should forgo part of the possible profit by setting markup below that of the competitor. Instead, it is less clear what a clever strategy would be for a profit maximizing agent because an increase in the markup could result in a loss of market share, the optimal choice also depending on the competitor's choice. So, we again expect that in T, DS students settle on lower markup than BM students. No differences should instead emerge in C.

H2a. *In T, DS students will choose lower markup than BM students.*

[12] Note that in the literature quoted in the introduction and related to the experimental analysis of market games with social externality, a design similar to ours is typically used, with the only exception that real consumers, rather than an exogenous algorithm, determine the market shares of each producer.

[13] The details and the results are contained in Appendix C.

H2b. *In C, markup will not significantly differ among BM and DS students.*

The basic idea is that all subjects in C should simply attempt to maximize their private earnings and hence display statistically similar behavior. Conversely substantial differences between BM and DS are to be expected in T: we conjecture that individuals who are more concerned with social responsibility will offer a comparatively greater quality and require a smaller markup.

While our focus is mostly on differences in prosocial attitudes of the two cohorts of students, and how they affect the experimental outcomes, it is also possible that differences in observed behavior between T and C could emerge regardless of students' type. In particular, when quality has a social byproduct we might expect all or most subjects to ascribe some importance to the external impact of their decisions within the market (social responsibility), thus increasing the overall average quality of their fictional production with respect to the scenario where no such byproduct exists. If this were true we should observe higher quality on average in T than in C.

H3. *The average quality will be higher in T than in C.*

Last, concerning the variables that measure the outcomes of the market game, namely profits and social impact, it is less obvious to have clear expectations, since the effect of the subjects' decisions might be possibly mitigated (or intensified) by market forces. In principle, differences on quality and markup may spill over into profits and social impact but, given the key role played by the market shares, it is difficult to anticipate the outcome of the interaction between subjects. We will discuss these and other aspects of market interplay in the next section.

4 Results and discussion

This section presents the experimental data and performs several checks of whether the hypotheses of Section 3 are supported.[14]

The following tables show descriptive statistics for the most relevant variables. Table 2 suggests that all descriptive variables are only marginally higher in T. Figure 1 shows averages at each round. Table 3 shows the results of regressions of the main variables on the current round number, to check for the presence of time trends, with clustered-robust standard errors (at group level). Note that there is no trend in profits and impact, whilst quality has no relevant trend in T but it is decreasing in C. The remaining variables, price and markup, display a slightly decreasing trend in both T and C.

Figure 2 focuses only on T, showing the average choices of DS and BM students. We can observe that, with the only exception of the first round, BM students choose on average a quality level lower than DS ones, but this fact in some round does not entail a lower average social impact. Conversely, the two groups of students appear to behave on average very similarly with respect to the markup and they achieve almost the same profit on average at each round.

[14]All of the following analyses were performed by dropping the first observation, given the lack of actual trial periods in the experiment.

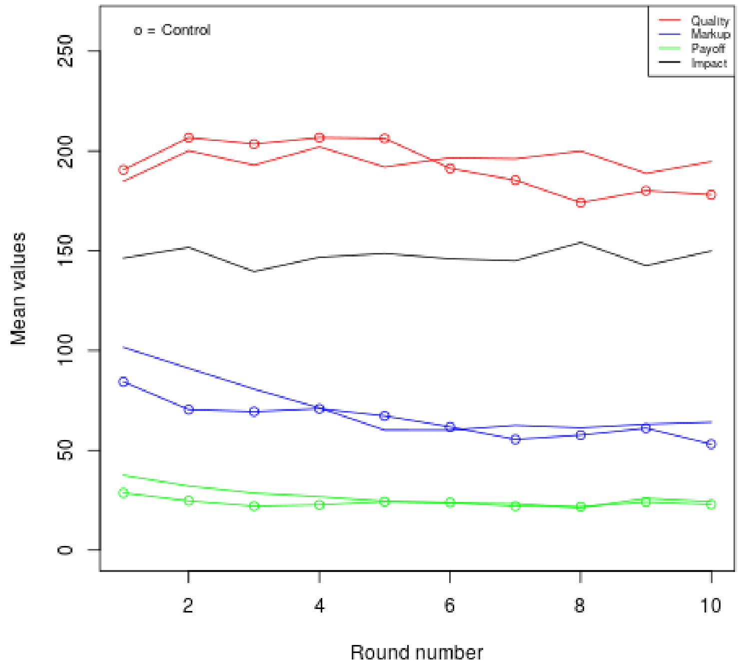

Figure 1: Main variables averages in T and C

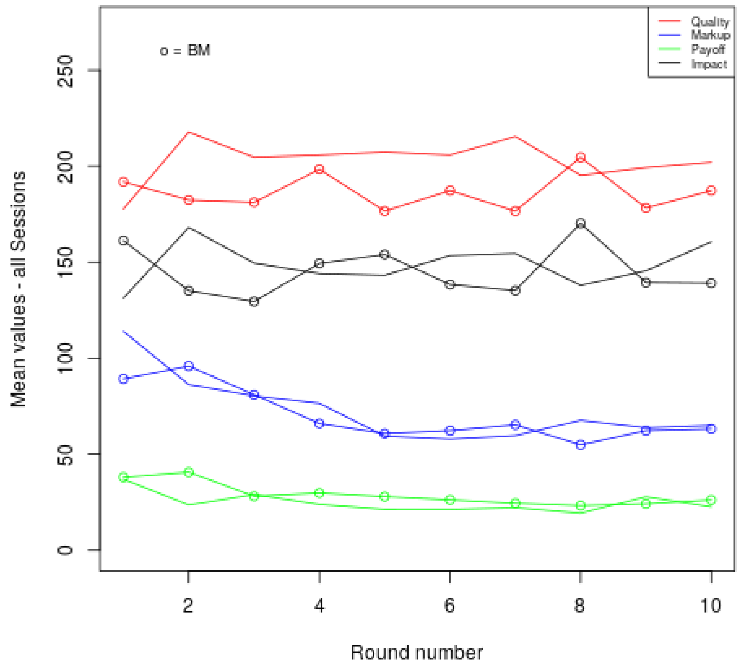

Figure 2: Main variables averages in T: DS vs BM

In order to validate the statements postulated by hypotheses ***H1*** - ***H2*** we resort to regressions. Given the panel structure of our data, whereby dependence (and heterogeneity) may arise both within each pair of matched subjects and at the subject level, we ran regressions of the observed qualities on the dummy DS (equal to 1 for DS students), on the gender and age of the subject, including fixed effects for the specific couple ID which the subject was part of and then

Table 2:
Descriptive statistics for T

Statistics	N	Mean	St. Dev.
Quality	738	195.6	101.2
Markup	738	68.2	68.6
Profit	738	25.6	34.2
Impact	738	147.0	134.6

Descriptive statistics for C

Statistic	N	Mean	St. Dev.
Quality	576	192.4	97.1
Markup	576	62.9	61.0
Profit	576	23.2	27.5

Table 3: Trend in the main variables

Variable	Estimate	p-value
Quality - C	-4.514	0.008
Quality - T	-0.571	0.669
Price - C	-6.722	0.00004
Price - T	-3.543	0.01
Profit - C	-0.088	0.836
Profit - T	-0.847	0.06
Markup - C	-2.208	0.011
Markup - T	-2.973	0.00004
Impact - T	0.214	0.904

computing clustered standard errors at subject ID level.

Table 4, its even-numbered columns in particular, shows that DS and BM behaved similarly in C. Indeed, there is no significant difference in terms of their main strategic variables, i.e. quality and markup (the sixth column shows that the two groups achieve also similar results given that their profits are not statistically different). This result supports ***H1b*** and ***H2b*** and constitutes evidence that the two groups of experimental subjects cannot be told apart when the only plausible objective is the maximization of earnings.

Odd-numbered columns in Table 4 on the contrary, show some differences in the behaviour of DS and BM in T. More specifically, DS students on average set a higher quality than BM students, while no significant differences arise in terms of the markup they set. The former result is consistent with ***H1a*** while ***H2a*** is not borne out by the data.

Interestingly, if we look at the variables concerning the outcomes, profit and social impact, we obtain different results. Indeed, albeit DS students on average set a higher quality, the difference between DS and BM students in terms of social impact is not statistically significant. As a consequence, DS and BM are clearly different in their intentions with respect to the social impact, but not so much in terms of their actual outcomes. A reversed pattern can be observed in the other two variables: while no significant differences arise in terms of markup, profits are nonetheless higher among BM students than they are among DS students. In this case DS and BM do not seem to differ in their intentions, but they do in terms of actual outcomes.

These relationships - between quality and social impact and between markup and profits - can

Table 4: Differences between DS and BM (in T and C)

	Dependent variable:						
	quality		markup		profit		impact
	T	C	T	C	T	C	T
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DS	−12.582 →						
DS	34.361	−12.582	−0.356	3.754	−8.411	−2.905	4.573
	(14.026)	(8.291)	(9.248)	(6.104)	(5.245)	(2.363)	(17.713)
	p = 0.015	p = 0.130	p = 0.970	p = 0.539	p = 0.109	p = 0.219	p = 0.797
female	8.362	9.189	−1.467	1.759	−7.081	−4.943	−0.303
	(8.796)	(5.871)	(4.849)	(7.517)	(2.744)	(2.895)	(14.783)
	p = 0.342	p = 0.118	p = 0.763	p = 0.815	p = 0.010	p = 0.088	p = 0.984
age	−1.755	−9.169	0.580	2.991	0.058	−1.538	1.108
	(1.141)	(1.813)	(0.719)	(2.832)	(0.402)	(0.937)	(1.978)
	p = 0.124	p = 0.00000	p = 0.420	p = 0.291	p = 0.885	p = 0.101	p = 0.576
Constant	270.257	350.490	80.192	53.625	37.925	95.947	160.628
	(28.868)	(48.450)	(20.912)	(66.582)	(10.675)	(22.396)	(83.391)
	p = 0.000	p = 0.000	p = 0.0002	p = 0.421	p = 0.0004	p = 0.00002	p = 0.055
Observations	738	576	738	576	738	576	738
R^2	0.513	0.471	0.510	0.435	0.363	0.299	0.178
Adjusted R^2	0.483	0.437	0.480	0.399	0.323	0.255	0.127
F Statistic	17.009*** (df = 43; 694)	14.143*** (df = 34; 541)	16.819*** (df = 43; 694)	12.238*** (df = 34; 541)	9.186*** (df = 43; 694)	6.785*** (df = 34; 541)	3.487*** (df = 43; 694)

Note: OLS estimates, with coupleID fixed effects (dummy variables estimated coefficients not included here). Standard errors in parenthesis are clustered by subject ID. *p<0.1; **p<0.05; ***p<0.01

appear paradoxical, but they are coherent with (and possibly a consequence of) the fundamental mechanism underlying market shares in our experiment. Indeed, given the calibration of the algorithm determining the market shares, when players set a similar markup, the player who picks the higher quality (hence a higher cost) will achieve a lower market share (around 1/3 of the whole market). Consequently, given the above mentioned statistics, choices over quality and markup may have placed, on average, DS students at a disadvantage. This is supported by the data, showing that BM students attained larger market shares than DS students (about 55% vs. 45% on average in mixed groups of one BM and one DS student). Whether this prominence was due to superior strategic abilities of BM students, to DS students failing to identify the trade-off between quality and markup needed to hold on to market shares or simply was the straightforward consequence of heuristics focusing on setting the quality while leaving the markup at a "reasonable" level, it is hard to tell.

However, according to these results, in the experimental market context we designed and for the specific subject pool we used, good intentions proved insufficient to warrant good outcomes. Delivering a larger social impact required to secure a significant market share, failing which the choice of a high quality level remained inconsequential in terms of triggering the positive externality.

Concerning ***H3***, Figure 3 shows that the distributions of the level of quality chosen by players are very similar in C and T, (p-value = 0.53 in a Wilcoxon rank sum test) which suggests that players do not choose a statistically different level of quality, on average, between the two treatments: the presence of a social impact as a byproduct of the quality of the good in T, bears no impact on the absolute level of the quality chosen on average by players as a whole; it does however have an effect on the positioning of subjects with different social attitude. Indeed, in T, DS students choose higher quality (in line with ***H1a***).

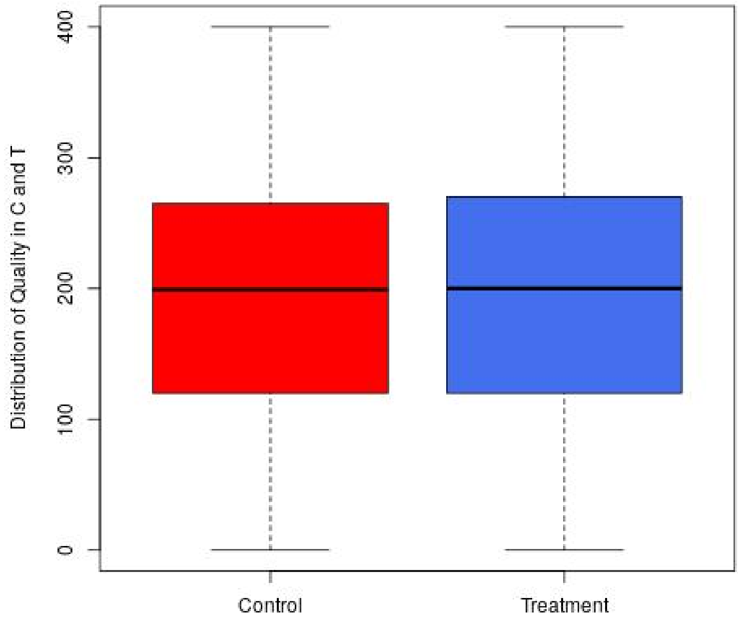

Figure 3: Quality in C and T

Further insights on different behaviours of DS and BM students in T can be gained by looking at the influence of the types of counterparts with which the subjects happened to be matched. Each couple could be Homogeneous, when both subjects were from the same field of study, or Mixed. Interestingly, such circumstance, though unobservable for the subjects, affected their behavior. Indeed, Table 5 shows that while homogeneous groups of DS or BM did not differ significantly in terms of quality, in mixed groups DS subjects chose a higher quality level than BM. Conversely, in homogeneous groups, DS subjects set a lower mark-up, and achieved lower profit than BM, whereas in mixed groups two types did not differ in terms of mark-up, and DS subjects obtained a slightly lower profit than BM. Finally, the variable DS fails to have a significant influence on the social impact. There is evidence therefore that H1a fits the observed behaviour in mixed groups quite well, while in homogeneous groups we find stronger evidence of H2a.

These results seem to be consistent with theoretical predictions in suggesting that the heterogeneity of objective functions in mixed groups pushes individual choices towards more differentiation of quality, relaxing competition and allowing higher mark-up irrespective of type of subject. In any case, as previously remarked, when firms set a similar mark-up then whoever provides larger quality ends up with a smaller market share and hence lower profits. On the other hand, focusing on homogeneous groups, the association between being a DS and lower mark-up and profits, can be interpreted as a signal of more willingness (relative to BM) to forego individual interest to achieve social impact, which, given the constraints placed by the market mechanism, they failed to deliver: so H3 is not supported. Again, in the specific experimental setting larger quality and willingness to renounce profits were not sufficient to generate significant social impact.

In the next section we look further into the data, in order to identify the existence of adjustment patterns in the subjects' choices round after round and whether such patterns vary between DS and BM students and/or between T and C.

Table 5: Differences between DS and BM in T - Homogeneous (H) vs. Mixed (M) groups

	Dependent variable:							
	quality		markup		profit		impact	
	(H)	(M)	(H)	(M)	(H)	(M)	(H)	(M)
DS	−41.964	31.087	−83.908	0.567	−30.675	−9.439	−65.380	6.450
	(26.197)	(14.031)	(17.580)	(9.696)	(7.830)	(5.571)	(76.715)	(17.923)
	p = 0.110	p = 0.027	p = 0.00001	p = 0.954	p = 0.0001	p = 0.091	p = 0.395	p = 0.719
female	20.032	−47.403	−5.183	16.909	−6.751	−3.812	5.294	−44.895
	(8.983)	(14.994)	(5.423)	(5.011)	(2.961)	(2.629)	(16.574)	(25.013)
	p = 0.026	p = 0.002	p = 0.340	p = 0.001	p = 0.023	p = 0.148	p = 0.750	p = 0.073
age	−2.404	−1.759	0.684	0.692	−0.768	0.922	3.774	−2.080
	(2.031)	(1.096)	(1.112)	(0.907)	(0.564)	(0.444)	(3.049)	(1.486)
	p = 0.237	p = 0.109	p = 0.539	p = 0.446	p = 0.174	p = 0.038	p = 0.216	p = 0.162
Constant	278.707	227.282	79.769	−5.862	55.933	−6.124	99.177	192.202
	(47.485)	(25.061)	(28.686)	(19.716)	(14.205)	(7.929)	(98.261)	(42.478)
	p = 0.000	p = 0.000	p = 0.006	p = 0.767	p = 0.0001	p = 0.440	p = 0.313	p = 0.00001
Observations	432	306	432	306	432	306	432	306
R^2	0.540	0.493	0.357	0.611	0.255	0.437	0.162	0.218
Adjusted R^2	0.511	0.459	0.317	0.585	0.209	0.399	0.110	0.166
F Statistic	19.050*** (df = 25; 406)	14.622*** (df = 19; 286)	9.016*** (df = 25; 406)	23.658*** (df = 19; 286)	5.567*** (df = 25; 406)	11.676*** (df = 19; 286)	3.130*** (df = 25; 406)	4.204*** (df = 19; 286)

Note: *p<0.1; **p<0.05; ***p<0.01

4.1 Learning and adjustment

In this experiment players need setting price and quality levels consistent with their objective function, while also taking into account the expected outcome of the interaction of their choices with their rival's in terms of market share. Given the complexity of the strategic environment, we expect agents to rely, to some extent, on observable data from previous interactions, as revealed by the information supplied to subjects after each round about the price and the quality level chosen by each player.[15] There is a rather well-established literature, within the framework of multi-agent Cournot models, that investigates the adjustment of agents' choices between rounds and that points out the use of certain heuristics (see Huck et al., 1999; Offerman et al., 2002; Bigoni and Fort, 2013). In particular the heuristics that emerge are adaptive learning (in which one plays the best response to the choices of others in the previous round), imitation (in which one replicates the behaviour of rivals), and trial-and-error (players adjusts the choice variable and observe the effect on profit, keeping pace and direction of adjustment in case of positive effect on their own payoff, reversing the direction in the opposite case). In our context, adaptive learning is not applicable because no tool was available to calculate the best response (as is the case in some experiments described in the literature). There is instead scope for the imitation and trial-and-error components. In order to capture the existence of such adjustment patterns in the choice variables we ran regressions (summarized in Table 6) to model the variation in a specific choice between the current and the previous round ($\Delta^t_{quality}$ and Δ^t_{markup}). To account for the imitation heuristics the regressors include the observed differences, in the previous round, between choices of subject and competitor. In particular, $d^{t-1}_{quality}$ equals 1, 0 or -1 according to whether, the previous round, the competitor had set quality higher, equal or lower than the player. So there is imitation when the estimated coefficient for this variable is positive. The variable $sign(\Delta^{t-1}_{quality}) \times sign(\Delta^{t-1}_{profit})$ is a trial-and-error component whereby previous adjustments are gauged against the corresponding effect on profit, and it is equal to 1 if the signs of the two variations agree, -1 if they disagree and 0 whenever one of them is 0. A positive estimated coefficient signals that changes in payoff reinforce the adjustment pattern. We also distinguish the adjustment patterns of BM and DS students including in each regression the interaction term of each variable and the dummy DS, since we care for the existence (and sign) of possible differences between DS and BM. The other regressors have similar meaning.

Both heuristics are statistically significant for quality and markup adjustment in both C

[15] Actually, all the previous game history may affect subjects' choices at any specific round: we only considered the previous round for the sake of simplicity and because after each round players received information regarding that round only.

Table 6: Adjustments in choice variables over time

	Dependent variable:			
	$\Delta^t_{quality}$		Δ^t_{markup}	
	(1)	(2)	(3)	(4)
$d^{t-1}_{quality}$	31.553	46.643		
	(5.539)	(4.945)		
	p = 0.000	p = 0.000		
$d^{t-1}_{quality} \times DS$	6.163	−16.660		
	(7.582)	(6.592)		
	p = 0.417	p = 0.012		
$sign(\Delta^{t-1}_{quality}) \times sign(\Delta^{t-1}_{profit})$	4.943	14.384		
	(5.757)	(5.400)		
	p = 0.391	p = 0.008		
$sign(\Delta^{t-1}_{quality}) \times sign(\Delta^{t-1}_{profit}) \times DS$	5.836	−6.251		
	(7.784)	(7.243)		
	p = 0.454	p = 0.389		
d^{t-1}_{markup}			19.132	24.254
			(3.027)	(3.125)
			p = 0.000	p = 0.000
$d^{t-1}_{markup} \times DS$			0.063	−3.764
			(5.072)	(4.887)
			p = 0.991	p = 0.442
$sign(\Delta^{t-1}_{markup}) \times sign(\Delta^{t-1}_{profit})$			8.006	7.521
			(2.928)	(3.162)
			p = 0.007	p = 0.018
$sign(\Delta^{t-1}_{quality}) \times sign(\Delta^{t-1}_{profit}) \times DS$			1.526	0.321
			(4.811)	(5.139)
			p = 0.752	p = 0.951
Constant	−1.795	0.583	−1.265	−3.359
	(3.669)	(3.140)	(2.300)	(2.238)
	p = 0.625	p = 0.853	p = 0.583	p = 0.134
Observations	512	656	512	656
R^2	0.149	0.196	0.140	0.139
Adjusted R^2	0.143	0.191	0.134	0.134
Residual Std. Error	81.487 (df = 507)	79.082 (df = 651)	51.353 (df = 507)	57.320 (df = 651)
F Statistic	22.270*** (df = 4; 507)	39.654*** (df = 4; 651)	20.694*** (df = 4; 507)	26.360*** (df = 4; 651)

Note: Standard errors in parenthesis are clustered by subject ID. *p<0.1; **p<0.05; ***p<0.01

Table 7: Working aspirations

Where would you like to work in 10 years?	DS	BM
In the public administration (health or social sector)	12.3%	1.4%
In the public administration (other sectors)	16.4%	8.2%
As a freelance	9.6%	16.4%
In a private enterprise	8.2%	63%
In a nonprofit organization	43.8%	2.7%
I do not wish to answer	19.2%	9.6%

Note: larger than 100% sum due to multiple selections allowed.

and T (with the sole exception of the trial-and-error component in quality adjustment in C). In contrast no differences are observed between DS and BM, with one exception: in quality adjustment in T, DS mimic the rival less than BM (which does not happen in C). The results are also consistent with our findings of Section 4. Indeed, DS students making - in T - less pronounced adjustments in the direction of the rival is again suggestive of a difference in behaviour between DS and BM *in T only.*

In the following subsection we use data from the final questionnaire in order to validate the distinction between BM and DS students as a meaningful proxy of prosociality within our subject pool.

4.2 Evidence from the questionnaire on prosocial attitudes

The analyses carried out in this paper address the issue of whether subjects with different prosocial attitudes behave differently in our experimental setting. The specific subject pool studied here was selected assuming that the prosocial motivations were strongly associated with the field of study and specifically would differ starkly between students enrolled in Business and Management, and Development Studies. Such choice is supported by evidence from the literature showing that individual differences in motivation (which can be either prosocial or more achievement oriented) play a role in undergraduate degree choice (see e.g. Skatova and Ferguson, 2014). Besides, concerning the specific population from which our subject pool was sampled, in a survey administered just before graduation[16], students were asked to reveal the most important aspects while searching for a job. BM students mainly focus on earnings and career possibilities (68% and 81% respectively), whereas much less importance is attached to the social utility of their future job (23%). The opposite happens with DS students, for whom the social utility of their future job (65%) is most important, while placing less emphasis on earnings and career opportunities (38% and 46% respectively).

In light of these figures, we have assumed being a DS or BM student to be a good proxy for their prosocial attitude. In order to check the robustness of this assumption with regard to our specific sample, we included several questions in our post-experiment questionnaire.

Table 7 shows that the two groups of participants have different working aspirations: while BM students mainly hope to work in the private sector, DS students tend to be interested in working for nonprofit organizations and public administration (especially health and social sectors). Finally our questionnaire included questions related to relevant behavioural traits, several of which were inspired by the work of Falk et al. (2016) regarding preference survey modules to measure risk, time, and social preferences. Such questions solicited answers on a Likert scale from 0 to 10. We formulated an additional question that sought to measure the extent to which our participants thought of themselves as critical consumers (again on a 0 - 10

[16]See almalaurea.it/en/universita/profilo/, whose data we averaged over the years 2015 to 2019.

Table 8: Behavioural preference survey module - Questions

Questions	Label
How well does the statement "As long as I am not convinced otherwise I always assume that people have only the best intentions" describe you as a person?	Trust
How willing are you to give to good causes without expecting anything in return?	Altruism
How would you rate your willingness to return a favour to a stranger?	Trustworthiness
How well does the following statement describe you as a person: "If I am treated very unjustly, I will take revenge at the first opportunity, even if there is a cost to do so"?	Revenge
A critical consumer makes consumption choices based on predefined criteria, such as environmental and social sustainability, which have the same importance of price and quality of the products/services. Given this definition, define your own level of criticality as a consumer.	Critical consumer
Are you currently a voluntary member of an organisation or association?	Volunteer work

Table 9: Behavioural preference survey module - Results

	Median DS	Median BM	$p - value$
Trust	6	5	0.07075
Altruism	8	7	0.00213
Trustworthiness	9	8	0.001231
Revenge	3	4	0.03132
Critical consumer	7	6	0.05419
	Odds DS	Odds BM	
Volunteer work	0.54	0.23	0.02041

Note: p-values are for a one-tailed Fischer exact test for "Volunteer work", one-tailed Mann-Whitney U-test for the remaining variables

scale) and one that asked whether or not they were currently engaged in voluntary work (with a yes or no answer). Table 8 reports the exact wording of these specific questions and the labels which are then used in Table 9 to show test results on the differences between the two groups of students. Accordingly, DS students are more likely than BM students to donate to good causes, return a favour for a stranger (both p-values < 0.01) while they declare a lower willingness to take a revenge after being treated unfairly and are more likely to be involved in volunteer work in social organizations or cultural associations (p-values < 0.05). There is also a somewhat weaker evidence of DS students being more careful about their consumption choices and more trusting of other people. It is reasonable that these behavioral traits concur to outlining the prosocial attitudes of subjects.

In turn, Figure 4 provides an overview of the measures of association between the different variables of the preference survey module. In particular, the portion of the figure above the diagonal shows significant correlations with the expected sign (Spearman rank correlations) between the variables measured on a Likert scale, while the box plots on the right highlight the link between the dummies and the other variables, which are again as expected. Overall there is evidence that these variables seem to paint a fairly consistent picture of a general prosocial attitude.

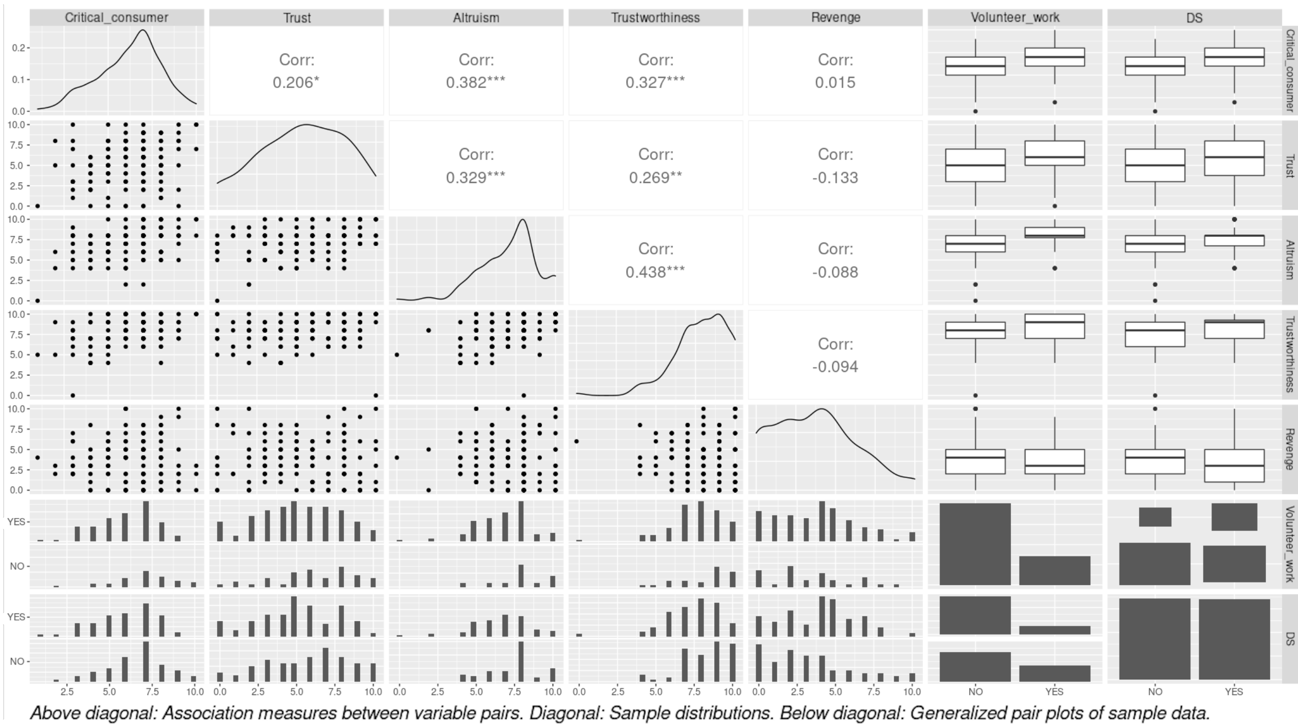

Figure 4: Measures of associations within questionnaire variables

5 Conclusions

The experimental design outlined in this paper presents producers having to make choices in terms of price and quality of a fictitious good or service within a duopoly. The role of producers is played by two different groups of students whose prosocial attitude is ex-ante different. The demand side of the market is artificial and is designed to reflect the characteristics of a population of consumers who have a heterogeneous willingness to pay for quality. In the control scenario different prosociality does not translate into different behavior of producers. In the treatment scenario selling high quality goods results in proportional payments to a charity (selected by each subject). The presence of such salient implication in terms of a positive social externality triggered a significantly different behavior, whereby more prosocial individuals produced higher quality goods than their counterparts. We can therefore extrapolate that individuals with different training and cultural backgrounds have different attitudes and motivations concerning CSR practices. However, strategic interactions between subjects with different degrees of prosociality are quite complex and the outcome of this type of competition cannot be taken for granted. In fact, there is only weak evidence that the presence of more producers with a higher degree of prosociality tends to generate a greater positive social impact: the market environment with its competitive pressure makes it difficult for the good deeds to be fully effective.

This paper's focus on the behavioral traits of individuals on the supply side of markets with social externalities could benefit greatly from the use of real entrepreneurs, rather than students, in the laboratory. Indeed, the results of this market experiment might be the outcome of an idealistic approach of subjects who most likely never had to develop effective strategies to survive in competitive markets. Further attempts to understand how different demand conditions might turn into different emerging behavior, could also provide an important test of the robustness of our main conclusions.

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Appendix A - Screenshots

Good deeds, business, and social responsibility in a market experiment

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March 23, 2021

Notice that the text highlighted in the following figures refers to the Treatment group only. In the Control group such text was not shown.

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Welcome

We are pleased to welcome you to this experiment. Please read the following instructions carefully. During the experiment it is forbidden to communicate with other participants. Questions should be addressed to the organisers only.

You can earn money by taking part in this experiment. The exact amount you will earn depends on your and the other participants' choices. At the end of the session, the amount will be paid to you in cash in private. During the experiment you may also contribute to the charity you have previously chosen. The corresponding amount, arising from your own and other participants' choices will be included in your invoice, but it will be immediately donated online to the charity of your choice at the end of the session. You will be asked to sign an invoice for your payment and charity donation.

The experiment includes various activities to be carried out on the computer and a brief final survey. The choices you make in each activity have no influence on either previous or subsequent activities in this experiment. The earnings accrued within each activity will be notified to each participant, only at the end of the experiment.

Each activity allows you to earn points which are converted to real money at the rate of 1€ for every 20 points.

It is important to be aware that all your decisions and earnings are strictly private and anonymous. The researchers will study the data from to the choices made without being able to link them to the identity of any participants. At the same time you will be paid by the administrative staff, who will have no access to the data concerning the choices that determined your earnings.

Next

Activity n.1

Instructions

You are about to participate in a market game, together with another participant who has been randomly associated with you. You represent two firms competing against each other. You produce a fictional good and you are responsible for choosing its **selling price** and its **social quality**, that is the external effect of its production. For example, you may think of choosing production inputs with a better environmental or social impact (e.g. materials that involve less pollution, no child labour, etc.). In this game more social quality implies greater production costs.

Each firm's **market share** is determined by the computer, using a mathematical algorithm which mimics the preferences of consumers with a particular degree of social consciousness. The higher a good's social quality and the lower its price the higher is the firm's market share. At the same time, the market share increases with the competitor's selling price and decreases with in its social quality. The following table summarizes these relations.

	Your quality	Your price	Competitor's quality	Competitor's price
Your market share	+	–	–	+
Competitor's market share	–	+	+	–

The quality can be any integer number between 0 and 400: higher numbers mean higher quality (and hence higher production costs). The price can be any integer number between the chosen quality and 400. The market share will be a percentage between 0% and 100%. The game will last for 10 consecutive rounds in which you will be facing the same competitor. The algorithm that determines the relative market shares remains the same throughout the whole game. At each round each firm's profit, earned by yourself and your competitor, will be equal to:

Profit = (Price - Quality) x Market share

The social contribution associated to your production at each round of the game will be equal to:

Social contribution = 1.5 x Quality x Market share

Notice that a unit increase in the good's quality generates an increase in social contribution which is proportionally higher than the cost increase (this is due to the coefficient equal to 1.5 in the formula).

Between each round players will be notified of both player's qualities and prices and their resulting market shares. Your profit and social contribution will also be shown. At the end of the game one round will be randomly selected and the points you earned in that period, both in terms of profit and social contribution, will be transformed into cash. The money corresponding to the social contribution for that period will be transferred to the charity of your choice.

For your convenience, these instructions (or a short version of them) will remain available to you on all subsequent screens of this activity.

Next

Please choose quality and price - Round 1 of 10

Choose a number between 0 and 400 as your quality.

points

Choose a number between quality (chosen above) and 400 as your price.

points

Next

Short Instructions

Your market share is higher the higher the quality and lower the price of the good you produce. At the same time, it is increasing in the competitor's selling price and decreasing in its social quality. The following table summarizes these relations.

	Your quality	Your price	Competitor's quality	Competitor's price
Your market share	+	–	–	+
Competitor's market share	–	+	+	–

In each round your profit will be equal to:

Profit = (Price - Quality) x Market share

The social contribution associated to your production at each round of the game will be equal to:

Social contribution = 1.5 x Quality x Market share

The points you earn in the paying period, both in terms of profit and social contribution, will be transformed in cash.

For your convenience these instructions will remain available to you on all subsequent screens of this activity.

Results

Time left to complete this page: 0:48

Round number	**1**
The price you chose	**133 points**
The quality you chose	**111 points**
The price chosen by the competitor	**231 points**
The quality chosen by the competitor	**226 points**
Your market share	**56.81%**
Your **payoff** if this is the paying period	**12 points**
The **social contribution arising from your choices** if this is the paying period	**95 points**

Next

Appendix B - Questionnaire

We are pleased to invite you and your organisation to participate in our survey. Participation in the survey is voluntary and you may decide to respond to the entire questionnaire or only to some questions. You may at any time withdraw your consent to participate. You do not have to give any reasons for withdrawing. If you withdraw your consent, all information about you and your organisation will be deleted. The information collected in this survey will be treated in an anonymous and aggregated manner and used for statistical and research purposes, in accordance to national laws on privacy and data collecting.

1. **Personal Code**: ____________________
2. **Sex**
   - ☐ Male
   - ☐ Female
   - ☐ Other
   - ☐ Do not wish to answer
3. **Date of birth(year)**: _______________
4. **I am...**
   - ☐ I year BA student
   - ☐ II year BA student
   - ☐ III year BA student
   - ☐ Other year BA

   - ☐ I year MSc student
   - ☐ II year MSc student
   - ☐ Other year MSc
5. **Do you have a full-time or part-time job?**
   - ☐ Full-time
   - ☐ Part-time
   - ☐ No, I have not
6. **Is /(has) anyone in your family (been) an entrepreneur?**
   - ☐ Yes
   - ☐ No
   - ☐ Do not know
   - ☐ Do not wish to answer
7. **Family status**
   - ☐ Single
   - ☐ Married
   - ☐ Co-habitating
   - ☐ Widowed
   - ☐ Separated
   - ☐ Divorced

- ☐ Do not wish to answer

8. **How many relatives do you have** *(Please, fill the box below with the number of your relatives)*

Parents	
Siblings	
Children	
Grandparents	
Grandchild	
Cousins	
Do not wish to answer	

9. **How many people are in your family?** *(Please, consider only the family members that are currently living with you)* ________________

10. **You are**
    - ☐ Catholic
    - ☐ Atheist
    - ☐ Agnostic
    - ☐ Other religion: ________________
    - ☐ Do not wish to answer

11. **How often do you attend religious services these days?**
    - ☐ More than once a week
    - ☐ Once a week
    - ☐ Once a month
    - ☐ Once a year
    - ☐ Practically never
    - ☐ Do not wish to answer

12. **Are you currently a voluntary member of an organisation or association?**
    - ☐ Yes
    - ☐ No

13. **If yes, could you please specify the name of the organisation/association?**

    ____

    ____

14. **How would you define your current financial situation?**
    - ☐ I live very comfortably
    - ☐ I live comfortably
    - ☐ I live in satisfactory conditions
    - ☐ I can barely afford to live
    - ☐ It goes bad
    - ☐ Do not wish to answer

15. **All in all, at the date you can state to be:**
    - ☐ Very satisfied
    - ☐ Satisfied

- ☐ Not really satisfied
- ☐ Not at all satisfied
- ☐ Do not wish to answer

16. Particularly, how satisfied are you concerning the following aspects:

	Not at all	A little	Sufficiently	Really	Do not wish to answer
Health					
Family relationship					
Friendship					
Professional life					
Free time					

17. Are you familiar with the game theory and prisoner's dilemma?

- ☐ Yes, I studied it during my university courses
- ☐ Yes, I heard about it but I did not study it
- ☐ I do not know what they are
- ☐ I do not wish to answer

18. Where would you like to work in 10 years?

- ☐ In the public administration (social, health or welfare sector)
- ☐ In the public administration (all other sectors)
- ☐ As a freelance
- ☐ In a private enterprise
- ☐ In a non-profit organisation
- ☐ I do not wish to answer

19. A critical consumer makes consumption choices based on predefined criteria, such as environmental and social sustainability, which have the same importance of price and quality of the products/services.
Given this definition, please use a scale from 0 to 10 to define your own level of criticality as a consumer, where 0 means you are not a critical consumer and 10 means you definitely are a critical consumer

0	1	2	3	4	5	6	7	8	9	10

20. Please tell me, in general, how willing or unwilling you are to take risks?
(Please use a scale from 0 to 10, where 0 means you are "completely unwilling to take risks" and a 10 means you are "very willing to take risks". You can also use any numbers between 0 and 10 to indicate where you fall on the scale, like 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.)

0	1	2	3	4	5	6	7	8	9	10

21. How well does the statement describe you as a person "I tend to postpone tasks even if I know it would be better to do them right away"?
(Please indicate your answer on a scale from 0 to 10, where 0 means "this does not describe me at all" and 10 means "this describes me perfectly")

0	1	2	3	4	5	6	7	8	9	10

22. How well does the statement describe you as a person "As long as I am not convinced otherwise, I always assume that people have only the best intentions"?
(Please indicate your answer on a scale from 0 to 10, where 0 means "this does not describe me at all" and 10 means "this describes me perfectly")

0	1	2	3	4	5	6	7	8	9	10

23. How willing are you to give to good causes without expecting anything in return?
(Please indicate your answer on a scale from 0 to 10, where 0 means you are "completely unwilling to do so" and 10 means you are "very willing to do so")

0	1	2	3	4	5	6	7	8	9	10

24. How would you asses your willingness to return a favour to a stranger?
(Please indicate your answer on a scale from 0 to 10, where 0 means you are "completely unwilling to do so" and 10 means you are "very willing to do so")

0	1	2	3	4	5	6	7	8	9	10

25. How well does the following statement describe you as a person: "if I am treated very unjustly I will take revenge at the first occasion even if there is a cost to do so?"
(Please indicate your answer on a scale from 0 to 10, where 0 means "this does not describe me at all" and 10 means "this describes me perfectly")

0	1	2	3	4	5	6	7	8	9	10

****

The information collected in this survey will be treated in an anonymous and aggregated manner and used for statistical and research purposes, in accordance to national laws on privacy and data collecting.
Thank you for taking the time to complete this questionnaire!

Appendix C

Here, we characterize the best reply functions of agents having *extreme* objective functions and look for possible game equilibria: in particular we focus on agents who are *pure profit maximizers* or *pure impact maximizers*.

C.1 Market shares

In our experiment the market shares are defined as follows. Letting p_i, q_i, the price and the quality chosen by subject $i = L, H$, we have:
if $q_L < q_H$

$$s_L(p_L, p_H, q_L, q_H) = \begin{cases} 1 & if \quad p_L < p_H - \frac{3}{2}(q_H - q_L) \\ \frac{2}{3}\frac{p_H - p_L}{q_H - q_L} & if \quad \frac{2}{3}\frac{p_H - p_L}{q_H - q_L} \in [0,1] \\ 0 & if \quad p_L > p_H \end{cases} \tag{1}$$

while if $q_L = q_H$

$$s_L(p_L, p_H, q_L, q_H) = \begin{cases} 1 & if \quad p_L < p_H \\ \frac{1}{2} & if \quad p_L = p_H \\ 0 & if \quad p_L > p_H \end{cases} \tag{2}$$

and in both cases

$$s_H(p_L, p_H, q_L, q_H) = 1 - s_L(p_L, p_H, q_L, q_H) \tag{3}$$

C.2 A methodological remark

Given the discontinuous nature of this optimization problem, in what follows it will be often necessary to parcel it out in sub-problems defined over non-compact sets where, technically, the optimal choice does not exist but where, practically, it is optimal *"to stay as close to the border as possible"*. Given that the objective functions involved are bounded, for the sake of simplicity, we will approximate the value of $\lim_{x \to x_0} f(x)$ with $f(x_0 \pm \varepsilon)$, with no consequence for the results.[1]

C.3 Case 1: Best reply function for an individual-impact-maximizing agent

Let's consider the case of an agent i willing to maximize his social impact under the non-negative profit constraint (implying $p_i \geq q_i$). The social impact of player i is given by $q_i s_i$. Then, the problem for i is

$$\arg\max_{p_i, q_i} I(p_i, q_i; p_j, q_j) = \arg\max_{p_i, q_i} q_i s_i(p_i, q_i; p_j, q_j) \qquad \text{subject to } 0 \leq q_i \leq p_i \leq 400$$

Observe that, in this case, p_i only plays a role in shaping s_i which is a non increasing function of it. Hence it is a weakly dominant strategy that of chosing $p_i = q_i$ and the problem can be simplified in

$$\arg\max_{q_i} q_i s_i(p_i = q_i; p_j, q_j) \qquad \text{subject to } 0 \leq q_i = p_i \leq 400$$

The following proposition holds.

Proposition 1 *The best reply function for an impact maximizing agent is*

$$q_i^* = p_i^* = \begin{cases} 400 & if \quad q_j < \frac{400}{3} \text{ and } p_j > q_j \\ 400 & if \quad q_j \leq 200 \text{ and } p_j = q_j \\ q_j - \varepsilon & if \quad p_j = q_j \geq 200 \\ p_j & if \quad p_j > q_j \geq \frac{400}{3} \end{cases}$$

and the corresponding generated impact is

$$I^* = \begin{cases} 400\left(1 - \frac{2}{3}\frac{400 - p_j}{400 - q_j}\right) & if \quad q_j < \frac{400}{3} \text{ and } p_j > q_j \\ \frac{400}{3} & if \quad q_j \leq 200 \text{ and } p_j = q_j \\ \frac{2}{3}(q_j - \varepsilon) & if \quad p_j = q_j \geq 200 \\ p_j & if \quad p_j > q_j \geq \frac{400}{3} \end{cases}$$

[1] This choice, could also be explained as the result of optimization with respect to a non continuous variable, which indeed was the case in the experiment. Unfortunately, this argument would be at odds with the usual analytical approach followed throughout this Appendix.

Proof.

1. Consider first the case $p_j = q_j$.
   Player i's market share will be equal to 2/3, 1/2 or 1/3 (refer to equations 1 - 3) if q_i is smaller, equal or greater than q_j respectively. Hence, it is

$$I_i = \begin{cases} \frac{2}{3}q_i & \text{if} \quad q_i < q_j \\ \frac{q_i}{2} & \text{if} \quad q_i = q_j \\ \frac{q_i}{3} & \text{if} \quad q_i > q_j \end{cases} \Rightarrow q_i^* = \begin{cases} q_j - \varepsilon & \text{if} \quad q_i < q_j \\ q_j & \text{if} \quad q_i = q_j \\ 400 & \text{if} \quad q_i > q_j \end{cases}$$

   and the optimal solution is

$$q_i^* = \begin{cases} 400 & \text{if} \quad q_j < 200 \\ q_j - \varepsilon & \text{if} \quad q_j \geq 200 \end{cases} \text{ with } I_i^* = \begin{cases} \frac{400}{3} & \text{if} \quad q_j < 200 \\ \frac{2}{3}(q_j - \varepsilon) & \text{if} \quad q_j \geq 200 \end{cases} \tag{4}$$

2. Let's consider now the case $p_j > q_j$.
   Observe that $q_j < q_i = p_i = p_j$ implies $s_i = 1$ (eqn. 1 - 3), so there is no reason to choose $q_i < p_j$ as this would necessarily yield a smaller impact. At the same time, for $q_j < p_j < q_i = p_i$ the impact function is convex given that

$$\frac{\partial_2 (I_i)}{\partial q_i^2} = \frac{\partial_2 \left(q_i \left(1 - \frac{2}{3} \frac{q_i - p_j}{q_i - q_j} \right) \right)}{\partial q_i^2} = \frac{4}{3} q_j \frac{p_j - q_j}{(q_i - q_j)^3} > 0$$

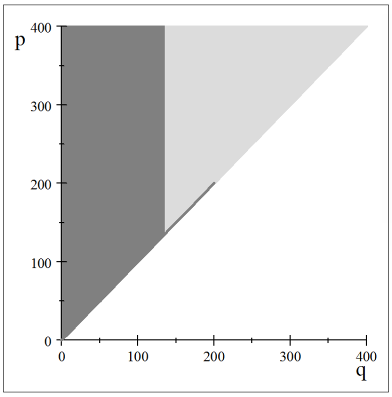
   As a consequence, the solution to the problem has to be either $q_i = p_j$ or $q_i = 400$. Evaluating player i's impact we get

$$I_i (q_i = p_i = p_j, q_j < p_j) = p_j$$
$$I_i (q_i = p_i = 400, q_j < p_j) = 400 \left(1 - \frac{2}{3} \frac{400 - p_j}{400 - q_j} \right)$$

   and $p_j \geq 400 \left(1 - \frac{2}{3} \frac{400 - p_j}{400 - q_j} \right)$ if and only if $q_j \geq \frac{400}{3}$, so the solution (given $p_j > q_j$) is

$$q_i^* = \begin{cases} 400 & \text{if} \quad q_j < \frac{400}{3} \\ p_j & \text{if} \quad q_j \geq \frac{400}{3} \end{cases} \text{ with } I_i^* = \begin{cases} 400 \left(1 - \frac{2}{3} \frac{400 - p_j}{400 - q_j} \right) & \text{if} \quad q_j < \frac{400}{3} \\ p_j & \text{if} \quad q_j \geq \frac{400}{3} \end{cases} \tag{5}$$

Putting equations (4) and (5) together we get the desired result. ■
The following figure illustrates the findings.



Best reply of agent i when (q_j, p_j) belongs to the dark grey region is $q_i^* = p_i^* = 400$ while for (q_j, p_j) in the light grey region it is $q_i^* = p_i^* = p_j$.

C.3.1 Best reply function for an aggregate-impact-maximizing agent

What if the agent also includes the impact generated by the competitor in his own objective function? In this case the solution simplifies as follows. The problem for i is now

$$\arg\max_{q_i} q_i s_i + q_j s_j \qquad \text{subject to } 0 \leq q_i = p_i \leq 400$$

The following proposition holds.

Proposition 2 *The best reply function for an aggregate-impact-maximizing agent is*

$$q_i^* = 400$$

and the corresponding generated impact is

$$I^* = \frac{400 + 2p_j}{3}$$

Proof. When $p_j = q_j$ it is

$$I_i = \begin{cases} \frac{2q_i+q_j}{3} & \text{if} \quad q_i < q_j \\ \frac{q_i+q_j}{2} & \text{if} \quad q_i = q_j \\ \frac{q_i+2q_j}{3} & \text{if} \quad q_i > q_j \end{cases} \Rightarrow q_i^* = \begin{cases} q_j - \varepsilon & \text{if} \quad q_i < q_j \\ q_j & \text{if} \quad q_i = q_j \\ 400 & \text{if} \quad q_i > q_j \end{cases}$$

and the optimal solution is

$$q_i^* = 400 \text{ with } I_i^* = \frac{400 + 2q_j}{3} \tag{6}$$

Instead, when $p_j > q_j$, following the same reasoning as in the proof of Proposition 1 we get

$$I_i = \begin{cases} q_i \frac{2}{3} \frac{p_j - q_i}{q_j - q_i} + q_j \left(1 - \frac{2}{3} \frac{p_j - q_i}{q_j - q_i}\right) = \frac{2}{3} q_i - \frac{2}{3} p_j + q_j & \text{if} \quad q_i < \min\{q_j; 3q_j - 2p_j\} \\ q_i & \text{if} \quad \min\{q_j; 3q_j - 2p_j\} \leq q_i \leq p_j \\ q_i \left(1 - \frac{2}{3} \frac{q_i - p_j}{q_i - q_j}\right) + q_j \frac{2}{3} \frac{q_i - p_j}{q_i - q_j} = \frac{2}{3} p_j + \frac{1}{3} q_i & \text{if} \quad q_i > p_j \end{cases} \Rightarrow$$

$$\Rightarrow \quad q_i^* = \begin{cases} \min\{q_j; 3q_j - 2p_j\} & \text{if} \quad q_i < \min\{q_j; 3q_j - 2p_j\} \\ p_j & \text{if} \quad \min\{q_j; 3q_j - 2p_j\} < q_i \leq p_j \\ 400 & \text{if} \quad q_i > p_j \end{cases}$$

and the optimal solution is

$$q_i^* = 400 \text{ with } I_i^* = \frac{400 + 2p_j}{3} \tag{7}$$

■

C.4 Case 2: Best reply function for a profit-maximizing agent

Let's consider now the case of an agent i willing to maximize his own payoff. Differently from the previous case, there is no reason to restrict to $p_i = q_i$ (in fact, only the case $p_i > q_i$ deserves now some attention given that profits would be null otherwise). The problem for i is now

$$\arg\max_{p_i, q_i} \Pi(p_i, q_i; p_j, q_j) = \arg\max_{p_i, q_i} (p_i - q_i) \cdot s_i(p_i, q_i; p_j, q_j) \qquad \text{subject to } 0 \leq q_i \leq p_i \leq 400$$

The following proposition holds.

Proposition 3 *The best reply function for a profit maximizing agent is*

$$(q_i^*, p_i^*) = \begin{cases} (q_j + \varepsilon, p_j) \;\; or \;\; \left(q_j - \varepsilon, p_j - \frac{3}{2}\varepsilon\right) & if \quad (q_j, p_j) \in I \\ \left(q_j + \frac{\sqrt{6(400-p_j)(400-q_j)}}{3}, 400\right) & if \quad (q_j, p_j) \in II \\ \left(0, \frac{p_j}{2}\right) & if \quad (q_j, p_j) \in III \end{cases}$$

and the corresponding generated profit is

$$\Pi^* = \begin{cases} p_j - q_j - \varepsilon & \textit{if} \quad (q_j, p_j) \in I \\ \frac{\left(1200 - 3q_j - \sqrt{6(400-p_j)(400-q_j)}\right)^2}{3600 - 9q_j} & \textit{if} \quad (q_j, p_j) \in II \\ \frac{p_j^2}{6q_j} & \textit{if} \quad (q_j, p_j) \in III \end{cases}$$

where, given the constraints $0 \le q_j \le p_j \le 400$*, it is*

$$\begin{aligned} I &= \left\{ (q_j, p_j) : p_j \ge \max\left\{ \left(3 - \sqrt{3}\right) q_j, 16 + \frac{24}{25} q_j \right\} \right\} \\ II &= \left\{ (q_j, p_j) : p_j \le 16 + \frac{24}{25} q_j \wedge \left(3\left(400 - q_j\right) + 2\left(400 - p_j\right) - \frac{p_j^2}{2q_j} \right)^2 \ge 24\left(400 - p_j\right)\left(400 - q_j\right) \right\} \\ III &= \left\{ (q_j, p_j) : p_j \le \left(3 - \sqrt{3}\right) q_j \wedge \left(3\left(400 - q_j\right) + 2\left(400 - p_j\right) - \frac{p_j^2}{2q_j} \right)^2 \le 24\left(400 - p_j\right)\left(400 - q_j\right) \right\} \end{aligned}$$

Proof.

1. As before, let's consider first the case $p_j = q_j$. We can distinguish three alternatives depending on whether q_i is equal, smaller or greater than q_j.

   (a) For $i = L$, that is $q_i < q_j$, the problem is

   $$\arg\max_{p_i, q_i} \Pi = \arg\max_{p_i, q_i} \begin{cases} (p_i - q_i) & \text{if} \quad \frac{2}{3}\frac{q_j - p_i}{q_j - q_i} > 1 \\ (p_i - q_i) \cdot \frac{2}{3}\frac{q_j - p_i}{q_j - q_i} & \text{if} \quad \frac{2}{3}\frac{q_j - p_i}{q_j - q_i} \in [0,1] \\ 0 & \text{if} \quad \frac{2}{3}\frac{q_j - p_i}{q_j - q_i} < 0 \end{cases}$$

   If $\frac{2}{3}\frac{q_j - p_i}{q_j - q_i} \in [0,1]$ holds, first order conditions are

   $$FOC \rightarrow \begin{cases} \frac{\partial \Pi}{\partial p_i} = \frac{2}{3}\left(\frac{q_j - p_i}{q_j - q_i} - (p_i - q_i)\frac{1}{q_j - q_i} \right) = \frac{2}{3}\frac{q_j + q_i - 2p_i}{q_j - q_i} = 0 \rightarrow p_i = \frac{q_j + q_i}{2} \\ \frac{\partial \Pi}{\partial q_i} = -\frac{2}{3}\frac{q_j - p_i}{q_j - q_i} + (p_i - q_i)\frac{2}{3}\frac{q_j - p_i}{(q_j - q_i)^2} = -\frac{2}{3}\frac{(p_i - q_j)^2}{(q_i - q_j)^2} < 0 \end{cases}$$

   and $\frac{\partial_2 \Pi}{\partial p_i^2} = -\frac{4}{3(q_j - q_i)} < 0$. Hence $q_i^* = 0$, $p_i^* = \frac{q_j}{2}$ and $\Pi_{p_j = q_j > q_i} = \frac{q_j}{6}$. Observe that for these values, condition $\frac{2}{3}\frac{q_j - p_i}{q_j - q_i} \in [0,1]$ becomes $q_j \ge 0$ which always holds.

   (b) For $i = H$, that is $q_i > q_j$, the problem is

   $$\arg\max_{p_i, q_i} \Pi = \arg\max_{p_i, q_i} \begin{cases} (p_i - q_i) & \text{if} \quad 1 - \frac{2}{3}\frac{p_i - q_j}{q_i - q_j} > 1 \\ (p_i - q_i) \cdot \left(1 - \frac{2}{3}\frac{p_i - q_j}{q_i - q_j}\right) & \text{if} \quad 1 - \frac{2}{3}\frac{p_i - q_j}{q_i - q_j} \in [0,1] \\ 0 & \text{if} \quad 1 - \frac{2}{3}\frac{p_i - q_j}{q_i - q_j} < 0 \end{cases}$$

   If $1 - \frac{2}{3}\frac{p_i - q_j}{q_i - q_j} \in [0,1]$ holds, first order conditions are

   $$FOC \rightarrow \begin{cases} \frac{\partial \Pi}{\partial p_i} = \left(1 - \frac{2}{3}\frac{p_i - q_j}{q_i - q_j}\right) - \frac{2}{3}(p_i - q_i)\frac{1}{q_i - q_j} = \frac{5q_i - 4p_i - q_j}{3(q_i - q_j)} = 0 \\ \frac{\partial \Pi}{\partial q_i} = -\left(1 - \frac{2}{3}\frac{p_i - q_j}{q_i - q_j}\right) + (p_i - q_i)\left(-\frac{2}{3}\right)\frac{q_j - p_i}{(q_i - q_j)^2} = \frac{2p_i^2 - 4p_i q_j - g3q_i^2 + 6q_i q_j - q_j^2}{3(q_i - q_j)^2} = 0 \end{cases}$$

   Solving the second equation and considering second order conditions (as well as condition $q_i > q_j$) we see that there is a candidate solution for $q_i^* = q_j + \frac{\sqrt{6}}{3}(p_i - q_j)$. By substitution in $\frac{\partial \Pi}{\partial p_i}$ we get

   $$\left.\frac{\partial \Pi}{\partial p_i}\right|_{q_i = q_i^*} = \frac{5 - 2\sqrt{6}}{3} > 0$$

   Hence it is $p_i^* = 400$, $q_i^* = \frac{3 - \sqrt{6}}{3} q_j + \frac{400\sqrt{6}}{3}$ and $\Pi_{q_i > q_j = p_j} = \frac{5 - 2\sqrt{6}}{3}(400 - q_j)$. It's easy to see that $q_i^* \in (q_j, 400)$ and that condition $1 - \frac{2}{3}\frac{p_i - q_j}{q_i - q_j} \in [0,1]$ becomes $q_j \le 400$ which always holds.

(c) The case $q_i = q_j = p_j$ is uninteresting due to either i's market share or i's mark-up (and hence profits) going down to zero.

A comparison between profits obtained in *(a)*, *(b)* and *(c)* shows that

$$\Pi_{p_j=q_j>q_i} = \frac{q_j}{6} \geq \frac{5-2\sqrt{6}}{3}(400-q_j) = \Pi_{q_i>q_j=p_j} \Leftrightarrow q_j \geq 224-64\sqrt{6}$$

meaning that i's optimal choice when $p_j = q_j$ is

$$q_i^* = \begin{cases} \frac{3-\sqrt{6}}{3}q_j + \frac{400\sqrt{6}}{3} & \text{and} \quad p_i^* = 400 \quad \text{if} \quad q_j \leq 224-64\sqrt{6} \\ 0 & \text{and} \quad p_i^* = \frac{q_j}{2} \quad \text{if} \quad q_j \geq 224-64\sqrt{6} \end{cases}$$

resulting in

$$\Pi^* = \begin{cases} \frac{5-2\sqrt{6}}{3}(400-q_j) & \text{if} \quad q_j \leq 224-64\sqrt{6} \quad \text{with} \quad q_i^* = \frac{3-\sqrt{6}}{3}q_j + \frac{400\sqrt{6}}{3}, p_i^* = 400 \\ \frac{q_j}{6} & \text{if} \quad q_j \geq 224-64\sqrt{6} \quad \text{with} \quad q_i^* = 0, p_i^* = \frac{q_j}{2} \end{cases} \tag{8}$$

2. Let's now consider the case $p_j > q_j$. Again, we separately analyze $q_i \lesseqgtr q_j$.

(a) For $i = L$, that is $q_i < q_j$, the problem is

$$\arg\max_{p_i,q_i} \Pi = \arg\max_{p_i,q_i} \begin{cases} (p_i - q_i) & \text{if} \quad \frac{2}{3}\frac{p_j-p_i}{q_j-q_i} > 1 \\ (p_i - q_i)\cdot\frac{2}{3}\frac{p_j-p_i}{q_j-q_i} & \text{if} \quad \frac{2}{3}\frac{p_j-p_i}{q_j-q_i} \in [0,1] \\ 0 & \text{if} \quad \frac{2}{3}\frac{p_j-p_i}{q_j-q_i} < 0 \end{cases}$$

If $\frac{2}{3}\frac{p_j-p_i}{q_j-q_i} \in [0,1]$ holds, the Hessian determinant, $\det H_\Pi = -\frac{4}{9}\frac{(p_j-q_j)^2}{(q_j-q_i)^4}$, is always negative. This implies either a border solution with $q_i = 0$ or no solution at all if $q_i = q_j - \varepsilon$ proves to be a better choice when $\varepsilon \to 0$ (whereas $p_i = q_i$ or $p_i = 400$ can be excluded as they would imply zero profits). Given that

$$\frac{\partial \Pi}{\partial p_i} = \frac{2}{3}\left(\frac{p_j-p_i}{q_j-q_i} - (p_i-q_i)\frac{1}{q_j-q_i}\right) = \frac{2}{3}\frac{p_j+q_i-2p_i}{q_j-q_i} = 0 \Rightarrow p_i = \frac{p_j+q_i}{2}$$

using $q_i = 0$, and checking for condition $\frac{2}{3}\frac{p_j-p_i}{q_j-q_i} \in [0,1]$ we find that a candidate solution is $(q_i, p_i) = \begin{cases} \left(0, \frac{p_j}{2}\right) & \text{if} \quad p_j < 3q_j \\ \left(0, p_j - \frac{3}{2}q_j\right) & \text{if} \quad p_j \geq 3q_j \end{cases}$. Instead, when $q_i = q_j - \varepsilon$ (and using $p_j > q_j$), we have that $p_i = \frac{p_j+q_i}{2}$ always implies $\frac{2}{3}\frac{p_j-p_i}{q_j-q_i} > 1$. Hence, by forcing $\frac{2}{3}\frac{p_j-p_i}{q_j-q_i} = 1$ we get $\left(q_j - \varepsilon, p_j - \frac{3}{2}\varepsilon\right)$. Substituting in the profit function we get

$$\Pi\left(q_i = 0, p_i = \frac{p_j}{2}\right) = \frac{p_j^2}{6q_j} \quad \text{if} \quad p_j < 3q_j$$

$$\Pi\left(q_i = 0, p_i = p_j - \frac{3}{2}q_j\right) = p_j - \frac{3}{2}q_j \quad \text{if} \quad p_j \geq 3q_j$$

$$\Pi\left(q_i = q_j - \varepsilon, p_i = p_j - \frac{3}{2}\varepsilon\right) = p_j - q_j - \frac{\varepsilon}{2}$$

and comparing the profits we see that the best reply (q_i^*, p_i^*) is $\left(q_j - \varepsilon, p_j - \frac{3}{2}\varepsilon\right)$ if $p_j \geq q_j\left(3-\sqrt{3}\right)$, and $\left(0, \frac{p_j}{2}\right)$ otherwise. Hence, under the constraint $q_i < q_j < p_j$, it is

$$\Pi_{p_j>q_j>q_i} = \begin{cases} p_j - q_j - \frac{\varepsilon}{2} & \text{if} \quad p_j \geq q_j\left(3-\sqrt{3}\right) \quad \text{with} \quad q_i = q_j - \varepsilon, p_i = p_j - \frac{3}{2}\varepsilon \\ \frac{p_j^2}{6q_j} & \text{if} \quad p_j < q_j\left(3-\sqrt{3}\right) \quad \text{with} \quad q_i = 0, p_i = \frac{p_j}{2} \end{cases}$$

(b) For $i = H$, that is $q_i > q_j$, the problem is

$$\arg\max_{p_i,q_i} \Pi = \arg\max_{p_i,q_i} \begin{cases} (p_i - q_i) & \text{if } \; 1 - \frac{2}{3}\frac{p_i-p_j}{q_i-q_j} > 1 \\ (p_i - q_i) \cdot \left(1 - \frac{2}{3}\frac{p_i-p_j}{q_i-q_j}\right) & \text{if } \; 1 - \frac{2}{3}\frac{p_i-p_j}{q_i-q_j} \in [0,1] \\ 0 & \text{if } \; 1 - \frac{2}{3}\frac{p_i-p_j}{q_i-q_j} < 0 \end{cases}$$

If $1 - \frac{2}{3}\frac{p_i-p_j}{q_i-q_j} \in [0,1]$ holds then the Hessian determinant, $\det H_\Pi = -\frac{4}{9}\frac{(p_j-q_j)^2}{(q_i-q_j)^4}$, is the same as in the previous case and is always negative. Again, this implies either a border solution with $p_i = 400$ or no solution at all if $q_i = q_j + \varepsilon$ proves to be a better choice when $\varepsilon \to 0$ (whereas $p_i = q_i$ or $q_i = 400$ can be excluded as they would imply no profits). From

$$\frac{\partial \Pi}{\partial q_i} = \frac{2p_i^2 - 2p_i q_j - 2p_j p_i - 3q_i^2 + 6q_i q_j - 3q_j^2 + 2p_j q_j}{3\,(q_i - q_j)^2} = 0$$

considering the constraint $q_i > q_j$, and substituting for $p_i = 400$ we get the solution[2]

$$q_i = q_j + \frac{\sqrt{6\,(400 - p_j)\,(400 - q_j)}}{3}$$

We shall now check whether conditions $q_i \in (q_j, 400)$ and $1 - \frac{2}{3}\frac{p_i-p_j}{q_i-q_j} \in [0,1]$ are satisfied.
The inequality $q_j + \frac{\sqrt{6(400-p_j)(400-q_j)}}{3} > q_j$ is always satisfied (exception made for the uninteresting case $p_j = 400$ or $q_j = 400$) while $q_j + \frac{\sqrt{6(400-p_j)(400-q_j)}}{3} < 400$ is satisfied if and only if

$$p_j > \frac{3}{2}q_j - 200$$

which is always met for $p_j > q_j$ and $q_j < 400$. As for $1 - \frac{2}{3}\frac{p_i-p_j}{q_i-q_j} \in [0,1]$, by substitution we obtain

$$1 - \frac{2}{3}\frac{p_i - p_j}{q_i - q_j}\bigg|_{q_i = q_j + \frac{\sqrt{6(400-p_j)(400-q_j)}}{3},\, p_i = 400} = \frac{1200 - 3q_j - \sqrt{6\,(400 - p_j)\,(400 - q_j)}}{1200 - 3q_j}$$

which is trivially smaller than 1 in the relevant region. Furthermore

$$\begin{aligned} &1200 - 3q_j - \sqrt{6\,(400 - p_j)\,(400 - q_j)} \geq 0 \Leftrightarrow (1200 - 3q_j)^2 \geq 6\,(400 - p_j)\,(400 - q_j) \Leftrightarrow \\ &480000 + 9q_j^2 - 4800q_j + 6p_j\,(400 - q_j) \geq 0 \Leftrightarrow 6p_j\,(400 - q_j) \geq -480000 - 9q_j^2 + 4800q_j \Leftrightarrow \\ &p_j \geq \frac{-480000 - 9q_j^2 + 4800q_j}{6\,(400 - q_j)} \Leftrightarrow p_j \geq \frac{3}{2}q_j - 200 \end{aligned}$$

so $1 - \frac{2}{3}\frac{p_i-p_j}{q_i-q_j} \geq 0$ is always true when $q_j, p_j \in [0, 400]$ and $p_j > q_j$.
Let's consider now the case $q_i = q_j + \varepsilon$. Using the first order condition

$$\frac{\partial \Pi}{\partial p_i} = \frac{2p_j - 3q_j - 4p_i + 5q_i}{3\,(q_i - q_j)} = 0 \Leftrightarrow p_i = \frac{2p_j - 3q_j + 5q_i}{4}$$

we have

$$1 - \frac{2}{3}\frac{p_i - p_j}{q_i - q_j}\bigg|_{p_i = \frac{2p_j - 3q_j + 5q_i}{4}}\bigg|_{q_i = q_j + \varepsilon} = \frac{2p_j - 2q_j + \varepsilon}{6\varepsilon}$$

[2] Observe that

$$\frac{\partial_2 \Pi}{\partial q_i^2} = -\frac{4}{3}\,(p_i - p_j)\,\frac{p_i - q_j}{(q_i - q_j)^3}$$

which is always negative with $p_i = 400$ and $q_i > q_j$.

which, given $p_j > q_j$, implies $1 - \frac{2}{3}\frac{p_j - p_i}{q_j - q_i} > 1$ for ε small enough. Hence, by forcing $1 - \frac{2}{3}\frac{p_j - p_i}{q_j - q_i} = 1$ we get $(q_i, p_i) = (q_j - \varepsilon, p_j)$.[3]
Substituting in the profit function we obtain

$$\Pi\left(q_i = q_j + \frac{\sqrt{6(400-p_j)(400-q_j)}}{3}, p_i = 400\right) = \frac{\left(1200 - 3q_j - \sqrt{6(400-p_j)(400-q_j)}\right)^2}{3600 - 9q_j}$$
$$\Pi(q_i = q_j + \varepsilon, p_i = p_j) = p_j - q_j - \varepsilon$$

and comparing the profits we get

$$\begin{aligned}
&p_j - q_j > \frac{\left(1200 - 3q_j - \sqrt{6(400-p_j)(400-q_j)}\right)^2}{3600 - 9q_j} \Leftrightarrow \\
&(p_j - q_j)(3600 - 9q_j) > \left(1200 - 3q_j - \sqrt{6(400-p_j)(400-q_j)}\right)^2 \Leftrightarrow \\
&6(400 - q_j)\sqrt{6(400-p_j)(400-q_j)} > 15(400-p_j)(400-q_j) \Leftrightarrow \\
&36(400-q_j)^2\, 6(400-p_j)(400-q_j) > 225(400-p_j)^2(400-q_j)^2 \Leftrightarrow \\
&24(400-q_j) > 25(400-p_j) \Leftrightarrow p_j > 16 + \frac{24}{25}q_j
\end{aligned}$$

showing that the best reply (q_i^*, p_i^*) is $(q_j + \varepsilon, p_j)$ if $p_j > 16 + \frac{24}{25}q_j$, and $\left(q_j + \frac{\sqrt{6(400-p_j)(400-q_j)}}{3}, 400\right)$ otherwise. Hence, under the constraint $p_j > q_j \wedge q_i > q_j$, it is

$$\Pi_{p_j > q_j \wedge q_i > q_j} = \\ = \begin{cases} p_j - q_j - \varepsilon & \text{if} \quad p_j > 16 + \frac{24}{25}q_j \quad \text{with} \quad q_i = q_j + \varepsilon, p_i = p_j \\ \frac{\left(1200 - 3q_j - \sqrt{6(400-p_j)(400-q_j)}\right)^2}{3600 - 9q_j} & \text{if} \quad p_j \leq 16 + \frac{24}{25}q_j \quad \text{with} \quad q_i = q_j + \frac{\sqrt{6(400-p_j)(400-q_j)}}{3}, p_i = 400 \end{cases}$$

(c) Finally, for $q_i = q_j$ it will also be optimal to choose $p_i = p_j - \varepsilon$. In this case profits are $\Pi_{p_j > q_j = q_i} = p_j - q_j - \varepsilon$.

Summarizing, if $p_j > q_j$ the best we can get is

$$\Pi_{p_j > q_j > q_i} = \begin{cases} p_j - q_j - \frac{\varepsilon}{2} & \text{if} \quad p_j \geq q_j\left(3 - \sqrt{3}\right) \quad \text{with} \quad q_i = q_j - \varepsilon, p_i = p_j - \frac{3}{2}\varepsilon \\ \frac{p_j^2}{6q_j} & \text{if} \quad p_j < q_j\left(3 - \sqrt{3}\right) \quad \text{with} \quad q_i = 0, p_i = \frac{p_j}{2} \end{cases}$$

with $q_i < q_j$ while with $q_i > q_j$ it is

$$\Pi_{p_j > q_j \wedge q_i > q_j} = \begin{cases} p_j - q_j - \varepsilon & \text{if} \quad p_j > 16 + \frac{24}{25}q_j \quad \text{with} \quad q_i = q_j + \varepsilon, p_i = p_j \\ \frac{\left(1200 - 3q_j - \sqrt{6(400-p_j)(400-q_j)}\right)^2}{3600 - 9q_j} & \text{if} \quad p_j \leq 16 + \frac{24}{25}q_j \quad \text{with} \quad q_i = q_j + \frac{\sqrt{6(400-p_j)(400-q_j)}}{3}, p_i = 400 \end{cases}$$

and with $q_i = q_j$

$$\Pi_{p_j > q_j = q_i} = \quad p_j - q_j - \varepsilon \quad \text{with} \quad q_i = q_j, p_i = p_j - \varepsilon$$

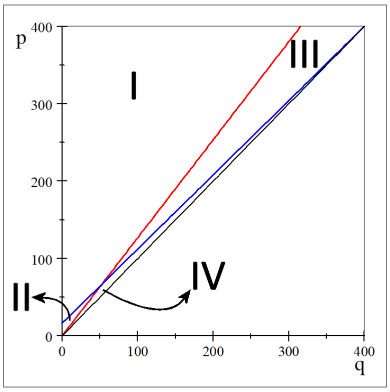
The alternative is between *staying close* to the competitor's quality and price or to move away and differentiate the product by *staying low* ($q_i = 0$, in the first case) or *staying high* ($p_i = 400$, in the second). We can distinguish

[3] Another argument is the following.
The partial derivative $\frac{\partial \Pi}{\partial p_i}$ evaluated in $q_i = q_j + \varepsilon$ is

$$\frac{5\varepsilon - 4p_i + 2p_j + 2q_j}{3\varepsilon} < \frac{5\varepsilon - 4p_i + 4p_j}{3\varepsilon} = \frac{5\varepsilon - 4(p_i - p_j)}{3\varepsilon}$$

which is negative for $p_i > p_j$ and $\varepsilon \to 0$. Hence a candidate optimal solution is $\left(q_i^*, p_i^*\right) = (q_j + \varepsilon, p_j)$.

four different regions depending on the previous results (see figure below).



It's easy to see that the best choice is *staying close* in region **I**, *staying high* in region **II**, and *staying low* in region **III**. As for region **IV** we must compare the *high/low* alternatives. It is

$$\frac{\left(1200-3q_j-\sqrt{6\left(400-p_j\right)\left(400-q_j\right)}\right)^2}{3600-9q_j} > \frac{p_j^2}{6q_j} \Leftrightarrow$$

$$\left(1200-3q_j-\sqrt{6\left(400-p_j\right)\left(400-q_j\right)}\right)^2 > \frac{3p_j^2\left(400-q_j\right)}{2q_j} \Leftrightarrow$$

$$9\left(400-q_j\right)^2+6\left(400-p_j\right)\left(400-q_j\right)-6\left(400-q_j\right)\sqrt{6\left(400-p_j\right)\left(400-q_j\right)} > \frac{3p_j^2\left(400-q_j\right)}{2q_j} \Leftrightarrow$$

$$3\left(400-q_j\right)+2\left(400-p_j\right)-\frac{p_j^2}{2q_j} > 2\sqrt{6\left(400-p_j\right)\left(400-q_j\right)}$$

To solve the inequality first observe that

$$3\left(400-q_j\right)+2\left(400-q_j\right)-\frac{p_j^2}{2q_j} < 3\left(400-q_j\right)+2\left(400-q_j\right)-\frac{q_j}{2}$$

that

$$2\sqrt{6\left(400-p_j\right)\left(400-q_j\right)} > 2\sqrt{6}\left(400-q_j\right)$$

and that

$$3\left(400-q_j\right)+2\left(400-q_j\right)-\frac{q_j}{2} < 2\sqrt{6}\left(400-q_j\right)$$

is always true for all $q_j > 224-64\sqrt{6} \simeq 67.233$. Hence the inequality can be studied, without loss of generality, under the constraint $q_j < 224-64\sqrt{6}$. Now observe that we shall compare the inequality subject to $p_j < \left(3-\sqrt{3}\right)q_j$. Because

$$3\left(400-q_j\right)+2\left(400-q_j\right)-\frac{p_j^2}{2q_j} > 3\left(400-q_j\right)+2\left(400-q_j\right)-\frac{\left(\left(3-\sqrt{3}\right)q_j\right)^2}{2q_j} > 0$$

for all $q_j < 224-64\sqrt{6}$, we can write

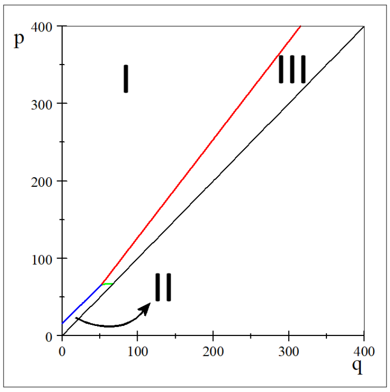
$$\begin{aligned} 3\left(400-q_j\right)+2\left(400-p_j\right)-\frac{p_j^2}{2q_j} &> 2\sqrt{6\left(400-p_j\right)\left(400-q_j\right)} \Leftrightarrow \\ \left(3\left(400-q_j\right)+2\left(400-p_j\right)-\frac{p_j^2}{2q_j}\right)^2 &> 24\left(400-p_j\right)\left(400-q_j\right) \end{aligned}$$

to obtain a fourth degree inequality in p_j. To understand some qualitative properties of the solution, consider *(i)* the intersection[4] between the lines $p_j = \left(3-\sqrt{3}\right) q_j$ and $p_j = 16+\frac{24}{25}q_j$, $(q_j, p_j) = \left(\frac{10200+5000\sqrt{3}}{363}, \frac{5200+1600\sqrt{3}}{121}\right)$, and *(ii)* the point discriminating between the *low/high* optimal strategies when $q_j = p_j$, $(q_j, p_j) = \left(224-64\sqrt{6}, 224-64\sqrt{6}\right)$. Also observe that, consistently with continuity, it is

$$\left(3\left(400-q_j\right)+2\left(400-p_j\right)-\frac{p_j^2}{2q_j}\right)^2 - 24\left(400-p_j\right)\left(400-q_j\right)\Bigg|_{q_j=\frac{10200+5000\sqrt{3}}{363}, p_j=\frac{5200+1600\sqrt{3}}{121}} = 0$$

$$\left(3\left(400-q_j\right)+2\left(400-p_j\right)-\frac{p_j^2}{2q_j}\right)^2 - 24\left(400-p_j\right)\left(400-q_j\right)\Bigg|_{q_j=p_j=224-64\sqrt{6}} = 0$$

The complete curve is numerically plotted and the three relevant regions are depicted in the figure below



where best reply and profits are

$$\Pi^* = \begin{cases} p_j - q_j - \varepsilon & \text{if} \quad (q_j, p_j) \in I \quad \text{with} \quad q_i^* = q_j + \varepsilon, p_i^* = p_j \text{ or } q_i^* = q_j - \varepsilon, p_i^* = p_j - \frac{3}{2}\varepsilon \\ \frac{\left(1200-3q_j-\sqrt{6(400-p_j)(400-q_j)}\right)^2}{3600-9q_j} & \text{if} \quad (q_j, p_j) \in II \quad \text{with} \quad q_i^* = q_j + \frac{\sqrt{6(400-p_j)(400-q_j)}}{3}, p_i^* = 400 \\ \frac{p_j^2}{6q_j} & \text{if} \quad (q_j, p_j) \in III \quad \text{with} \quad q_i^* = 0, p_i^* = \frac{p_j}{2} \end{cases} \tag{9}$$

Finally, remark that these results extends to the line $p_j = q_j$, corresponding to those in eqn. (8). ∎

C.5 Market equilibrium

We now want to check whether a dynamic equilibrium is possible in a market populated with 2 agents.

C.5.1 Both agents are individual-impact maximizers

In this case both players will play $p_i = q_i$, $i = 1, 2$, so both optimal strategies are described by equation (4). It's easy to understand that no equilibrium exists under this setting. If player 1 offers a quality $q_1 < 200$ then the best reply is $q_2 = 400$. Then, a sequence of quality choices such that $q_i = q_j - \varepsilon$ will emerge until one of the two competitors' quality will fall under 200, starting again an analogous path. The dynamics for any other possible initial condition is described by the same argument.

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[4] It is

$$\left(3-\sqrt{3}\right) q_j = 16 + \frac{24}{25} q_j \Leftrightarrow q_j = \frac{16}{\frac{51}{25}-\sqrt{3}} = \frac{10200+5000\sqrt{3}}{363} \simeq 51.957$$

and $p_j = 16 + \frac{24}{25}\frac{10200+5000\sqrt{3}}{363} = \frac{5200+1600\sqrt{3}}{121}$.

C.5.2 Both agents are profit maximizers

In this case both players will play $p_i > q_i$, $i = 1, 2$, so both optimal strategies are described by equation (9). Again, no equilibrium exists under this setting. This is a very well known result. To understand why this is true, first observe that no equilibrium is possible having both competitors inside region **I**. Indeed, if player 1 plays a strategy in region **I** then the best reply for player 2 is to *stay close* generating a non-stationary sequence which could (after a possibly long time) exit the region. On the other hand, if player 1 plays a strategy in region **II** then the best reply for player 2 is to *stay high* (hence in region **III**) as well as the best reply to a strategy in region **III** is to *stay low* (hence in region **II**): so no equilibrium having both players in the same region is possible. What if player 1 is in region **II** and player 2 is in region **III**? From equations (9) we have that the candidate equilibrium shall assume the form

$$\begin{cases} q_1^* = 0, p_1^* = 200 \\ q_2^* = \frac{400\sqrt{3}}{3}, p_2^* = 400 \end{cases}$$

which is not compatible with the constraints $p_1^* < 16$ and $q_2^* > \frac{600+200\sqrt{3}}{3}$.

C.5.3 One agent is individual-impact maximizer and the other is profit maximizer

Now let's consider the mixed case. The strategies of the impact maximizing player 1 are described by equation (5) while for the profit maximizing player 2 the strategies are described by equation (8). It is:

$$I_1^* = \begin{cases} 400\left(1 - \frac{2}{3}\frac{400-p_2}{400-q_2}\right) & \text{if} \quad q_2 < \frac{400}{3} \quad \text{with} \quad q_1^* = 400 \\ p_2 & \text{if} \quad q_2 \geq \frac{400}{3} \quad \text{with} \quad q_1^* = p_2 \end{cases}$$

$$\Pi_2^* = \begin{cases} \frac{5-2\sqrt{6}}{3}(400 - q_1) & \text{if} \quad q_1 \leq 224 - 64\sqrt{6} \quad \text{with} \quad q_2^* = \frac{3-\sqrt{6}}{3}q_1 + \frac{400\sqrt{6}}{3}, p_2^* = 400 \\ \frac{q_1}{6} & \text{if} \quad q_1 \geq 224 - 64\sqrt{6} \quad \text{with} \quad q_2^* = 0, p_2^* = \frac{q_1}{2} \end{cases}$$

In this case an equilibrium exists. If we assume $q_2 < \frac{400}{3}$ then player 1 best reply is $q_1^* = p_1^* = 400$ implying player 2 best reply $q_2^* = 0, p_2^* = 200$ which is compatible with the initial assumption. Hence

$$\begin{aligned} (q_1^*, p_1^*) &= (400, 400) \\ (q_2^*, p_2^*) &= (0, 200) \end{aligned}$$

is a Nash Equilibrium. No other equilibria exist. Indeed, assume by contradiction that $q_2 > \frac{400}{3}$, then player 1 best reply is $q_1^* = p_1^* = p_2 > q_2 > \frac{400}{3}$. In turn this implies that player 2 best reply is $q_2^* = 0, p_2^* = \frac{p_1}{2}$ which is at odds with the initial assumption.

C.5.4 One agent is aggregate-impact maximizer

To conclude, let's consider the case with at least one aggregate-impact-maximizing agent. By Proposition 2, this kind of agent has an optimal strategy irrespective of the competitor's choice. This implies that there will always be a unique Nash equilibrium.

Indeed, when the competitor is another impact-maximizing agent (individual or aggregate) the Nash equilibrium implies that both agents will choose $q^* = p^* = 400$ (see Proposition 1).

Instead, when the competitor is a profit-maximizing agent, the Nash equilibrium implies $q_1^* = p_1^* = 400$ for the aggregate-impact maximizer and (from Proposition 3) $q_2^* = 0$, $p_2^* = 200$ for the profit maximizer.