Social identity and implicit collusion in Cournot interactions

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A Dissertation by Qinjuan Wan*

April 10, 2019

Submitted in Partial Fulfillment of the

Requirements for the Degree of Philosophy

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Major Subject: Experimental Economics

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Curriculum Vitae

Qinjuan Wan was born on Jun 20, 1990, in Shanxi Province, China. She graduated from the University of East Anglia with a Bachelor's Degree of Business Economic in 2015, and she earned a Master's Degree of Econometric Economic at the University of Exeter in 2016. She pursued advanced studies at the University of Durham since 2016.

Acknowledgment

I would like to express my gratitude to all those who encouraged, supported and assisted me to complete this thesis. I want to thank the Business department of the University of Durham for granting me the permission to commence this thesis, to conduct the necessary research work and to use department resources. This thesis is the result of several years of work, during which I have been accompanied and supported by many people. It is a pleasure to express my gratitude to all of them.

First of all, I would like to thank my advisor, Jason, for providing constructive suggestions throughout the time of the research and encouraging me to pursue my research goal. I would like to thank the other members of my PhD committee who monitored my work and took time in reading and providing me with valuable comments on the earlier versions of this thesis. Thank you all.

A profound sense of gratitude also arises for my parents, who have always given me boundless love and supported me to realise my dream. I am grateful for my sister, Dongjuan, who encouraged me in the years.

Abstract

This research applies and extends the standard industrial organization models of repeated interaction between firms by incorporating group identity to evaluate the ability of group identity, thereby summarizing the theories of observed collusion. The model is used to outline circumstances under which collusion is easier to happen in a single market, and it will break down.

A general overview of literature based on laboratory experiments is presented to study the effects of social identity and study oligopoly markets. We construct lab experiments to test the effects of a single factor on collusion, i.e. whether the two players share the same group identity. University students were enrolled as research subjects in the laboratory experiments to test the validity of behaviour predictions. All experiments serve to answers two questions: a) How far is the market outcome away from the Standard Nash equilibrium? b) How good is the Nash prediction?

Study 1 investigates the effects of group identity on randomly rematches one-shot Cournot interactions. Study 2 describes the results of finitely repeated Cournot interactions that behaviour is more collusive when the players were from the same group than those from different groups or nogroup players. Study 3 concentrates on the indefinitely repeated interactions, finding that outgroup favouritism could be reflected in average quantity choices and collusion. Therefore, we determine that the effect of group identity on collusion is greater in repeated Cournot interactions than one-shot Cournot interactions, and that the repeated interaction devices enhance the difference between the players without group identity and players with primed group identity. The inspecting of individual behaviour indicated that the output adjustment is significantly correlated with the previous period's two-sides profit changes comparisons. In the group matchings (ingroup matchings and outgroup matchings), group identity further strengthens the role of enhancement for collusion.

Group identity can influence significantly the player's quantity choices. In this study we reassess the representation of group identity by applying group contingent other-regarding preferences. First, the influence of group identity varies unsympathetically across different devices of repeated Cournot interactions, so it cannot be explained through a well-behaved preference function. Second, this study suggests that group identity plays a key role in the preference over strategies of norms. Simulation results generated from a norm model estimated at the subject level provided insight into the repeated interactions and the group identity that motivate the collusion.

Keywords: Social Identity, Intergroup relations, Cournot interactions, Collusion, Lab experiments.

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INTRODUCTION

The core objective of all three projects is to predict the behaviour of duopolists under different market environments with different group assignments and Cournot interaction devices. According to Ledvina and Sircar (2012), the most prominent observations of game theory in industry organization are those concerning oligopolies' collusion. The causes of implicit collusion transversion are discussed, and the identity relationships of these three different group are induced. We are going to provide clear causality about the relationship by performing controlled laboratory studies.

Economists recognised that group identity plays a significant role in influencing colourful driving behaviour in critical actions. The prospects for various game theories have been argued on and on because people' preference must be taken into account when it comes to summarising the descriptive theories of observable behaviour. Experimental and field data suggest that group identity is generally conducted with a pro-social attitude towards the member of one's own group. To incorporate such non-pecuniary concerns into economic theory, economists proposed models of "social preference", which assume that in addition to maximizing utility, people also care about the kindness of their actions and other's actions. The weight of other-regarding based on the differential self-interested motives of ingroup and outgroup members might be shaped by different group identity. In a norm industrial situation, there will likely to multiple firms in organizations, firms of organization hope to get higher profits through collusion. Thus, most of the economists who have given their careers to studying the various effect on the likelihood of collusion. In the field data, many unobserved variables could modify the collusion, we assume group identity is one of them.

Our work shows that group identity does matter, yet it exerts its influence not in this predictable way from the standard game model in incorporating social preferences. One-shot predictions are intuitive, and ingroup identity leads to greater collusion than outgroup identity. Under finitely repeated interactions, these predictions can become counterintuitive. Outgroup identity leads to greater incidence and longer-sustained collusion. These predictions were tested in a series of laboratory experiments with induced group identity, and economically insignificant differences in one-shot interactions were discovered. Under indefinitely repeated interactions, ingroup identity leads to significantly higher collusion. Moreover, this feature increases within and across supergames. The results indicate that this behaviour is driven by duopolies' use of adjustment norms with group assignments. Furthermore, group identity affects implicit collusion by modifying the access to behavioural norms incongruent with the best response motivations of Nash equilibrium, but not through the shaping of social preferences. Not much difference was found in one-shot interactions, and this is the baseline to examine the social preference caused by different group identity. But we re-do interactions in repetition Cournot, and observe the predicted opposite direction. The repetition interactions lie upon outgroup bias is more effective in theory which meets the condition of Nash equilibrium (trigger grim). We observed the raising of ingroup matchings cooperation in supergames over periods.

Part I contains the qualitative literature review of lab experiments, which measure the psychology social group identity and the collusion in Cournot interactions. Part II traces the whole procedures of the experimental design and the details of the technique. The results of the experiments are elaborated in Part III with the Baseline experiment which answers the questions about how past transactions shape group identity preferences. Conclusions and discussions are presented in Part IV, along with the plan and suggestions for future researches.

Motivation: OPEC story

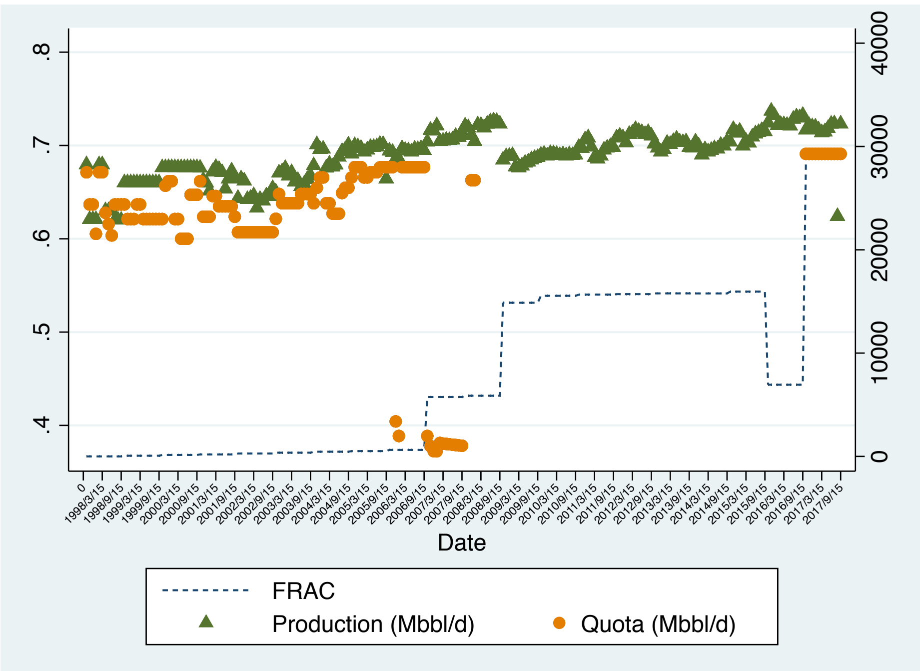
Our study is of practical research significance for organizations and institutions, such as the Organization of the Petroleum Exporting Counties (OPEC), an international organization of oil supply. OPEC is a cartel consisting of 12-14 countries, and it has been operating since the 1960s. The output quantity of OPEC exerts an adverse impact on the crude oil price. The role of OPEC in the adjustment of global crude supplies is a vital one. OPEC is, in essence, a quantity decision cartel to carry out oil production quotas system to ensure maximum oil revenue (The OPEC gave up quotas oil policy system after 2011, and re-adopted quotas after January, 2017.). The crude oil exportation of a member country of OPEC is a quantity decision game. OPEC could be regarded as a textbook cartel model, in spite of its controversy. As a matter of fact, we can often find the indication of interaction with cooperation throughout the history of OPEC, because the member has always over-fulfilled its quota. The "Prisoner Dilemma" theory disappeared in operation of OPEC. Besides, if OPEC agreed with a cut-output policy with non-OPEC countries (Russia), the OPEC members would obey the agreement. The question is, what factor would result in the break of the output degree?

The impetus for this research comes from the facts that deviations of OPEC members are based on the "freezing production" agreement. The quantity interactions are analysed and determined based on static/dynamic games model with complete information theory under non-cooperation games. From the perspective of economics, there are also some tricky problems to keep the integrity of a cartel, such as supervision, administration and implementation. All these problems would undermine the efficiency and validity of the production quota system. We further explain this problem by using the concept of sociology and psychology instead. Results of both experimental and non-experimental kinds of researches confirm the pervasiveness of evaluative biases in the judgment of group members in the event of salient ingroup/outgroup distinctions (membership identity to own group). Under this circumstance, we are concerned about how group identity impacts the whole process of quantity interaction with the inner members of OPEC. Notably, ethnicity and language were probably the most important characteristics of distinct social groups, and group norm is always a key element of the specific culture of one group. For example, Habyarimana, Humphreys, Posner, and Weinstein (2007) observed that co-ethnics play the part of cooperative equilibrium for the public good, whereas non-co-ethnics do not. In order to assess the importance of group identity and potential conflicts among the OPEC members, we could construct one primary measure of ethnic diversity (Alesina & Ferrara, 2005; Montalvo & Reynal-Querol, 2005). The index is fragmentation (FRAG), which indicates the probability of two randomly selected individuals belonging to different sub-ethnic categories. The index of fractionation, Tavares and Wacziarg (2001) examined the effect of democracy, and fragmentation could exert a negative effect on economic development.

$$FRAC = 1 - \sum_{i=1}^{N} \pi_i^2 \tag{1}$$

where π_i is the proportion of people affiliated to religion i in the OPEC. A higher religious diversity is associated with group identity and crude oil production. The frequency of deviations and stabilization reflects the signs of softening the punishment mechanism. In other words, the different group identity among OPEC members plays a detrimental role in collusion. The Figure 1 shows that the index of religious fragmentation, which is depicted on the left y–axis, implies lower group identity. The actual OPEC crude production and quota are shown on the right y-axis. The output agreement started in 1998 to 2011, and then the quota system was abandoned. A new price system started from 2012, and the quota system became effective again in 2016. Moreover, even some non-OPEC countries agreed to cut down output after January 2017 by 600,000 bbl/day. For example, Russia promised to decrease its production by 300,000bbl/day, and the agreement was implemented six months later. Conversely, Kuwait and Algeria over-fulfilled production cut quota.

Figure 1: OPEC



Quota: Total OPEC output quota (million of barrels per day) Ecuador reback and Angola jointed OPEC in 2007 Indonesia came back at 2016.
We aggregate the religious population sources of OPEC members based on national sources: The World Fackbook.

Part I

LITERATURE REVIEW

Introduction

The nature essentials of humanity, such as kindness, love, compassion, forgivingness, and contributing to the welfare, are constricted by parochialism and transitional economic assumptions. Due to the defects and limitations in the transitional self-interest economist models, the most anti/pro-social behaviours were not explained in a solid manner. Although many theoretical models provide reasonable explanations to the in/outgroup bias observations, the model of group identity is in agreement with practical situation. Thus, our examination of an oligopolistic market is hindered by the lack of a basic underlying model with which the social identity can be used to carry out the analysis.

In a specific community, the sense of belongingness of the members who share a common group identity could be enhanced, which may justify why people are prone to allocate more resources to their community. Such a parochial sense within the group, of courses, is not uncommon to observe in education activities and enterprises management. In the research of school education, each class or each study group could be regarded as a small group, in which the sense of belongingness and the collective feeling of honour can be used to stimulate healthy competition and to invest in education/training. These incentive pathways in the enterprises can spur the staff's enthusiasm and individual initiative, thereby improving efficiency and performance. In the enterprise, the leaders of the team are always entitled to allocate the vast majority of benefits and resources. During that process, the outgroup favouritism could be used to adjust and balance the allocation of resources, which makes the lower-benefited employees to accept and identify the inequality allocations. The outgroup favouritism can effectively alleviate intergroup contradictions and conflicts, especially, for major and minor groups, rich and poor groups.

Turner and Tajfel (1986) are the first ones that brought forward the theory of social identity.[1]

[1] The social identity theory of group study has involved many disciplines, such as anthropologists (Murphy, 1957), sociologists (Sumner, 2013) and political scientists (Miller, Gurin, Gurin, & Malanchuk, 1981) have explored group issues for decades.

[2] Compared with sociologists and social psychologists, the recognition of group membership can lead to potentially determinant motives are relatively late behaviour in economics. A growing number of literature in economics studies the effects of group identity on individual behaviour (Charness, Rigotti, & Rustichini, 2007; R. Chen & Chen, 2011; Y. Chen & Li, 2009; Goette, Huffman, & Meier, 2006; Goette, Huffman, Meier, & Sutter, 2010; Sutter, 2009).Byrne (1969) observed that people tend to like those who share similar attitudes and beliefs. By comparison, people dislike those with a different attitude and beliefs. Psychologists view group identity as a potentially detrimental factor of behaviour (Brewer, 1999; Johnston, Abdelal, Herrera, & McDemott, 2009).

In this section, we will go into further details about the effects of group identity on different economic behaviours. To advance a theory of decision making associated with the identity recognition, we also identify the concept of economic environment in a broad range. Social nature suggests that when people are making decisions, they tend to bring benefits to the members of the same group. This is in contrast with dominant rational choice models. Both lab and field experiments performed by economists have reviewed the question of how group identity affects human behaviours.

1 Group Identity

The concept of "Identity" indicates numerous connotations and it has a fairly long historical period of development in the research of sociology. "Identity" is associated with the particular role or major category, and it reveals the relationship among individuals in the society. The definition of social identity is dependent on one's opinion of oneself and others, including the realm of personal attribute and common features such as gender and race. Turner and Tajfel (1986) distinguished individual identity from group identity. The former usually means self-description of individual characteristics, whereas the latter depicts the common self-description of the members of a particular social category as a whole (e.g., organisation membership, religious affiliation, gender, and age cohort). The development of group identity profoundly effects, the research on the concept of group identity spans many fields of science, philosophy, sociology, and psychology. Because the development of group identity is of pro-

[2]The intergroup bias includes: ingroup favouritism, outgroup derogation, ingroup derogation, outgroup favouritism, it is easy to see in real life, from the viewpoint of development, the intergroup bias models have more excellent and more space for growth.

found effect, researches on the concept of group identity span many fields, including but not limited to science, philosophy, sociology, and psychology.

The formation of group identity experience involves three steps: social-categorisation, social comparison, and positive distinctiveness. Tajfel and Turner were the pioneers of studying the social identity of the minimal group paradigm, in which all participants were anonymously and randomly assigned into non-overlapping groups. They created "the tiny mass world" to facilitate the observation of the experimenters: (1) All subjects are randomly divided into non-overlapping groups, there are no interactions among subjects. (2) Group membership is anonymous. (3) Subjects' decisions do not affect their own payoffs. The above three conditions emphasise the importance of assigning subjects into different straightforward and meaningless categories, and the group orientation consciousness and actions of the participants were aroused.[3] Group identity can incentivize non-selfish preferences, Segal and Sobel (2007) provided an axiomatic foundation that can reflect individual preferences for reciprocity, inequity aversion, altruism as well as spitefulness. It was assumed that in addition to conventional preferences toward outcomes, the player in a strategic environment would also show preference toward strategy profiles. The interactions between ethnocentrism groups could be attributed to the difference in social identity, including intra-group behaviour (ingroup favouritism) and inter-group behaviour (outgroup derogation).[4] To ensure the simplicity and clarify of group bias, the "derogation" is by default the derogation against outgroup, and "outgroup favouritism" means the derogation against ingroup members (Brewer, 1999).

1.1 Priming Group Identity and Factors Affecting Saliency

Most people favour their shared group identity, regardless of how the groups were formed in the first place. Lab experiment results showed that the certain group identity of participants could be highlighted by labelling. Two main techniques are involved in the group identity experimental methodologies to induce group identity, including primed artificial group identity (Y. Chen & Li, 2009; Klor & Shayo, 2010; Li, Dogan, & Haruvy, 2011) and the enhanced naturally-existing group identity (Benjamin, Choi, & Fisher, 2010; Benjamin, Choi, & Strickland, 2007; Bernhard, Fehr, & Fischbacher, 2006; Goette et al., 2006; Goette, Huffman, Meier, &

[3]The bias assessed by traditional self-report including attribution of group cognition (stereotyping), group attitude (prejudice), and individual behaviour toward ingroup and outgroup targets (derogation) is explicit measures (Mackie & Smith, 1998; Stangor, Sullivan, & Ford, 1991; Wilder & Simon, 2001).

[4]Lane (2016) summarised 77 experiments, 25 out of 77 showed ingroup favouritism, 46 out of 77 did not find any ingroup favouritism or outgroup derogation, and the rest experiments found outgroup favouritism.

Sutter, 2012; McLeish & Oxoby, 2011). Solow and Kirkwood (2002) use both two techniques to study the effects of group identity.

To study the basic characteristics of the artificial group identity, the participants were randomly assigned to receive a few pairs of stimulants (e.g., pieces of information, paintings, team-building task), and then they were encouraged to chat with people anonymously through non-face-to-face methods. A limitation of the above basic features ensures that there is no effect of group identity, other than the "labelling effect". In comparison, the "naturally-existing group identity" (such as ethnicity, nationality, religion, gender and social/geographical affiliation) gives people more than one "label" in real life.[5] For naturally created and arbitrarily induced group identity, the vast majority of economic studies demonstrated that ingroup favouritism was significantly consolidated and outgroup derogation was also improved (Fershtman & Gneezy, 2001; Glaeser, Laibson, Scheinkman, & Soutter, 2000). Group bias was stronger in terms of artificially primed identity than those of naturally identity.[6] The study which focused on the artificial group identity is easy to control and observe, compared with that of priming method which was used to adjust the different group identity (Bargh, Chen, & Burrows, 1996).

The bias varies with different modulatory factors, such as identity, role in games, and interactive environments. It is largely dependent upon the type of economic games. The audience, feedback, decision-making contexts, and payoff commonality interaction environments will inevitably cause different degrees of group identity saliency (Charness et al., 2007).[7] Eckel and Grossman (2005) conducted experiments consisting of six treatments, which are characterised by various degrees of group identification. It was found that "the enhanced identity leads higher levels of cooperation." For example, group discrimination in the third-party punishers was more apparent than the decision makers. Moreover, group size showed no effect on the various behaviours in the dilemma games, although large groups tend to invest more than in the individual that small groups in the public games (Brewer & Kramer, 1986).

[5] For example, the gender is the weakest group bias, even, there is opposite gender favouritism. Ingroup favouritism is more noticeable among participants in the U.S. participants than in China (Buchan, Croson, & Dawes, 2002).

[6] Two reasons why the level of bias between artificial groups is higher than various types of natural groups: 1) the experimental priming of an artificial identity confers experimenter demand effect; 2) the bias among natural identity groups is not to engage in socially unacceptable behaviour (politically incorrect).

[7] Other factors such as intergroup competition, similarity, and status differentials, could also enhance the intergroup distinctions.

1.2 Group Assignment Effects on Behaviours

Akerlof and Kranton (2002), who bridged the gap between sociology and economy, modified the standard economic models by taking social identity into the account of behaviours. Akerlof and Kranton (2005) and Ball, Eckel, Grossman, and Zame (2001) addressed the significant effects of group identity on market settings.[8] Individuals with disparate group identity possess various behaviours deviated from the theory of traditional standard hypotheses (Bolton & Qckenfels, 2000; Y. Chen & Li, 2009; Fehr, Gachter, & Kirchsteigeri, 1997; Fehr & Schmidt, 1999; Rabin, 1993).

Due to the limitation of self-interest in traditional economics, the amount of pro-social behaviours in individual game theory experiments is hard to explain merely by traditional economics theories. Recently, the thriving of behavioural and experimental economics observed the vast scale of behaviour that is derived in part from the groups. The results were not consistent with the assumptions of economists. The following studies and tests have validated this conclusion that group identity has penetrated into the economics fields of individual behaviour. For example, "minimal group" has been formed due to the preferences of subjects for the painters of Klee and Kandinsky. Group identity has exerted substantial effects on the behaviour of the allocators, who have been striving to maximise the profits for their own group, as well as the payoff of ingroup and outgroup.

It is well known that people tend to behave more prosocially when they interact with the members of their own group. Yet they might become less generous, less trusting, and less cooperative towards those who have a different group identity.[9] In real economic activities, the interactions of work-fellows, partners of firms, and managers of companies are repeated and can be fixed within the contract time. Two empirical studies demonstrated the effects of group identity on individual/group behaviour by Brewer and Kramer (1986) and Dawes, Van de Kragt, and Orbell (1988). Brewer and Kramer (1986) examined the choice behaviour in a public-good problem and determined a greater extent of self-restraint in the common-resource dilemma. The results of the public-goods problem are complex, and group identity promotes more contributions. In addition, in the second study, Dawes et al. (1988) stated that

[8] Socioeconomic phenomena, such as, gender discrimination and household division of labor (Akerlof & Kranton, 2000), trust (Basu, 2006; Buchan et al., 2002), public goods provision (Croson, Marks, & Snyder, 2008; Eckel & Grossman, 2005; Solow & Kirkwood, 2002), preferences over re distributive tax regimes (Klor & Shayo, 2010), cooperation (McLeish & Oxoby, 2011; Ruffle & Sosis, 2006)

[9] Bolton and Qckenfels (2000); Fehr and Gächter (2002b); Fehr and Schmidt (1999); Rabin (1993)

the effect of group identity can only be discovered when each and every member of the group promised to cooperate. In a number of economic experiments on group identity (Basu, 2010; Bénabou & Tirole, 2011; Fang & Loury, 2005); a higher willingness of the participants to adopt pro-social actions was observed (Goette et al., 2006; Yamagishi et al., 2013). On the contrary, the participants who belonged to different groups showed a certain extent of antisocial behaviour (Brewer, 1999, 2000; Levin & Sidanius, 1999; Mackie & Smith, 1998). This study discussed the social preference primed by group identity, which stimulated the different behaviour to occur under different game environments. In the next paragraphs, we measured the social preference based on previous literature and case study in labs. The Table A1 provided an analysis bases on the test of social preference for pro-social behaviours in the different games. More specifically, social preference is further divided into three sectors, including altruism (unconditional social preference), reciprocity and difference aversion (conditional social preference). Among these, two social preferences were significantly correlated with each other. For example, the decision of investors in the trust games can be influenced by reciprocity, and the returning action is determined by the combination of altruism preference and reciprocity. As a result, the different preference can be derived from the actions in the public goods.

Outgroup favouritism The theory of social identity has been criticised for its negligence of accounting adequately of the phenomenon of outgroup favouritism (Hewstone & Ward, 1985; Jost & Banaji, 1994). While this is often true, people have also shown other reactions to in/outgroups, particularly in the context of power and status. Studies on the natural existing group identity induce the outgroup favouritism, such as race (Fazio & Hilden, 2001), gender (Dasgupta & Rivera, 2004), and age (Mellott & Greenwald, 1999). Outgroup favouritism was revealed in the case of low-status groups, especially when people's attitudes and beliefs are assessed using indirect measures rather than self-report measures (Boldry & Kashy, 1999; Jost & Banaji, 1994; Moorman & Blakely, 1995; Sidanius & Pratto, 2001). These studies indicated that implicit prejudice and stereotypes have been influencing people's judgments, decisions and behaviours. As a social category, women are less powerful and they have a lower social status than men (Goodwin & Fiske, 2001). Consequently, women are inclined to attribute the more positive feeling to the members of an outgroup than men (Batalha, Akrami, & Ekehammar, 2007). At present, most of the studies on group identity are concentrated on significant ingroup favouritism, outgroup favouritism, especially economics behaviour is little studied.

Rabbie, Schot, and Visser (1989) hypothesised that "the greater the perceived outcome interdependence on the outgroup, the more outgroup favouritism will occur." In addition, Pan and Houser (2013) found that these interactions could influence group identity, and argued that the cooperative production process could often lead cooperation with the outside group (outgroup favouritism).

Punishment The punishment associated with group identity is of particular importance in the group's efficiency because it could enhance pro-social norm enforcement with groups (Fehr & Gachter, 2000; Fuster & Meier, 2010). It motivates individuals to cherish and uphold the value of group identity by punishing the violators. Akerlof and Kranton (2000); Bénabou and Tirole (2011) explained that the violations of the specific norms are tantamount to the undermining of the identity of the group. In the random assignment to groups, identity has been shown to motivate the differential punishment to ingroup and outgroup members. To date, work on second-party and third-party provided mixed support for this idea. In terms of the second-party punishment situations. Shinada, Yamagishi, and Ohmura (2004) found that ingroup members were punished severer than outgroup members in a gift-giving game when they violated certain rules. McLeish and Oxoby (2011) observed that the minimum acceptable offers of ingroup players are higher than outgroup players in the ultimatum games, and that the ingroup players were more likely to reject offers. Kubota, Li, Bar-David, Banaji, and Phelps (2013); Valenzuela and Srivastava (2012) found that ingroup members were more tolerant toward the marginally unfair offers in the ultimatum games. Group identity exerted enormous influences in cooperative behaviours and punishments of the defector (Y. Chen & Li, 2009; Goette et al., 2006; Goette, Huffman, & Meier, 2012) in the prisoner dilemma games. Punishment of defection was observed even though the punisher was in the position of the third-party observer, rather than a victim of defection (Fehr & Gächter, 2002b; Hoff & Pandey, 2006). Harris, Herrmann, and Kontoleon (2012) solved the problem about the close relationship between social norms (group norms) and punishment via one-shot dictator games with third-party punisher. Bernhard, Fehr, and Fischbacher (2006); Bernhard, Fischbacher, and Fehr (2006) summarised that if the third-party punisher and the victim were from the same group, the punisher was inclined to adopt severer punishment, compared with outgroup victim. In other words, the punisher's behaviour is affected by the victim's identity, and the third-party punishers had greater group discrimination than second-party players. The players favoured their shared group identity, yet they had not shown resentment toward outgroup members (Tajfel & Turner, 1979).[10] If the third-party punisher and the violator came from the same group, the violator had a better chance of being forgiven. In light of this, the punisher's behaviour was also affected by the violator's identity. Any ingroup member who did not respect group norms should be punished severely by other members within the same group (McLeish & Oxoby, 2007). Harris et al. (2012) found that the threat of ingroup punishment could slightly increase ingroup favouritism behaviour, and that outgroup punishment might enforce the "egalitarian sharing norms". Furthermore, spiteful punishment was often executed by an outside member of their own college fraternities in a prisoner's dilemma game (Kollock, 1998). Most of the previous studies showed that ingroup individuals preferred to punish ingroup members costly who violate group norms. Fehr and Gachter (2000); Fehr and Gächter (2002a); McCabe, Rigdon, and Smith (2003) found that the costly punishment could bring forward cooperation, although such punishment showed no such effect in the experiments of McLeish and Oxoby (2007).

1.3 Group Identity Models: Preference-based Model and Beliefs-based Model

Finding out the internal mechanism of group identity's effects on individual behaviour has been a research topic which requires the answers to hard questions. There are mainly two mechanisms to explain the effect of group identity on behaviour. Its effect may be exerted to change their social preferences directly and to stimulate the general pattern of outgroup derogation. This is achieved via the beliefs and expectations of group members. The former mechanism has attracted much attention and has been tested in a large number of experiments.

Preference-based Model The influence of group identity on social preference can be subdivided into three close preferences, including other-regarding preferences, pro-social preferences, and interdependent preference. The core of social preference indicates that economists care about their own material payoffs and others' material payoff. This is also an important part of economists' utility. In terms of social preference models which are extended to the utility functions with different social preferences, the basic analytical tools are characterised by game theory. Group identity is one important incentive ("intrinsic motivation") to pro-social

[10] The within-group interactions might determine the punishment differences between nature existing social groups and artificial groups, the historical interaction might be the key influence on nature and strength of group effects.

behaviours. Y. Chen and Li (2009) observed the effects of group identity on social preference through "minimal group paradigm", which was incorporated in the group identity with Charness and Rabin (2002)'s social preference model with utility functions. The optimal behaviour selection with identity parameter can be expressed by the following equation:

$$x^*(s) = (1 - \omega(s))x_o + \omega(s)x_c \tag{2}$$

, where x_o indicates that account identity is dismissed when players try to make decisions; x_c presents the ideal action of players with certain identity; $\omega(s)$ represents the weight of sensitivity to certain identity group; "s" indicates the degree of sense of belongingness to a certain identity. This utility function also allows the disutility from deviations for societal prescriptions. Charness and Rabin's model, also known as a two-person preferences-based model, indicates that an individual's utility is determined by a weighted average of monetary profits. Incorporating "social preferences" into the utility function was developed on the basis of this evidence, and had been tested in many experiments (Bolton & Qckenfels, 2000; Charness & Rabin, 2002; Cox & Sadiraj, 2012; Dufwenberg & Kirchsteiger, 2004; Engelmann & Strobel, 2004; Fehr & Schmidt, 1999; Rabin, 1993).[11] Using the tool of game theory analysis, various group identity theory models have brought about the rationality hypothesis to adjust the classical economic hypotheses. During that process, social parameters are injected and new equilibriums are constructive to explain the paradoxes in experimental economic behaviours.

Beliefs-based Model The alternative theory postulates that group identity can modify the players' belief that the opponent of the same group can be used as cooperative players. The players are engaged in the game, and all of them make their decisions based on their knowledge about the attitudes of the opponents. That is to say, the group identity could influence the expectations and beliefs, leading to an alteration in individual behaviours. Ockenfels and Werner (2014) found that the proposals transferred significantly more to ingroup recipients who had shared the knowledge about the proposal. In the minimal group paradigm, individual may change his or her behaviour by manipulating beliefs concerning the opponent's expectations. Bicchieri (2005); Gintis (2009) stated that individuals with an underlying preference for conditional cooperation should be able to ensure that their opponents are willing to cooperate. In that way, the group membership may be regarded as a signal that promotes individuals to

[11] A social prisoner's dilemma challenged this mechanism (Guala, Mittone, Ploner, et al., 2013).

adopt coordinative behaviours. Yamagishi et al. (2013) and Güth, Ploner, and Regner (2009), who have proved that the mutual beliefs can determinate the individual behaviour in the dictator games with the specific group identity. In Rabin's model (1993), the weight of a rival's monetary profits placed by the firm is dependent on the interpretation of the rival's intentions. Following Schelling (1980), who calls "a behavioural propensity [...] strategic if it influences others by affecting their expectations." The expectation of group reciprocity seems to serve as a heuristic purpose that shapes strategic decisions (Brewer, 1979; Yamagishi & Kiyonari, 2000). The expectation of reciprocity appears to be so great that it sometimes manifests itself even in the situations in which reciprocity is not logically possible.

2 Cournot Quantity Competition

It is no surprise in finding that Cournot's variation models are most popular in the literature about oligopoly. Many theories have been developed within this framework, along with the exploration of supergames of the Cournot model in the latest game theoretical literature. Herein, we focus on standard homogeneous Cournot duopoly interactions.

The growing body of experimental work which explores factors, such as leniency programs (Apesteguia, Dufwenberg, & Selten, 2007; Bigoni, Fridolfsson, Le Coq, & Spagnolo, 2012; Hinloopen & Soetevent, 2008), demand uncertainty (Aoyagi & Fréchette, 2009; List & Price, 2005; Rojas, 2012), and market structure (Davis & Holt, 1998; Isaac & Plott, 1981), can considerably impact the stability of cooperation in the marketplace Holt (1995). Friedman (1971); Holt (1993); Holt and Davis (1990); Huck, Normann, and Oechssler (2004); Potters and Suetens (2009); those experiments are associated with questions, such as the collusion found in the respective experimenters and the higher expectation of game theory. The different devices of Cournot quantity setting games are constantly applied in the industrial organisation. These simplified and brief models are tested by economists (Hoggatt, 1959; Sauermann & Selten, 1959), and their passion for the attractive environment of economic experiments remains insatiable. As a matter of fact, the Walrasian, the Cournot Nash equilibrium, and collusive quantity choices are the three benchmarks in oligopoly games. Here, we stress upon the characteristics of collusion in three different Cournot interaction frameworks, including one-shot games, finitely repeated games, and indefinitely repeated games. The aim of this section is to summarize the theory of implicit collusion within the framework of different Cournot interaction games, and to survey the comprehensive literature which showed that group identity factor tends to make collusion easier or more difficult to sustain.

2.1 Stage Game: One-shot Interactions with the Different Co-player

As pioneers in Cournot oligopolies, Fouraker and Siegel (1963) stated the early results to test the hypotheses on collusion in experiments. After that, Holt (1993); Huck et al. (2004); Stenborg (2004) conducted further experiments to enrich the results. Selten, Mitzkewitz, and Uhlich (1997) simulated outcomes in a duopoly market by providing full information of supply and demand parameters to the players, so that they can embed their strategies to beat other players in duopoly games. In the basic Cournot interaction, firms will take their expectations of an opponent's output decisions into account, yet they will act independently. The choice variable is output, the total market outputs determine the market-clearing price. No firm can improve its profit by unilaterally changing its strategy. When subjects are randomly re-matched with different subjects, the obtaining of tacit collusion through rewards and punishments seems rather difficult.[12] According to the theoretical prediction, the cooperation rate will be zero in the one-shot plays (Kreps, Milgrom, Roberts, & Wilson, 1982). As a result, the random matching in the Cournot Nash Equilibrium constitutes a reasonable prediction, because this system is consistent with theory. The convergence to the Cournot-Nash equilibrium is demonstrated (Fouraker & Siegel, 1963; Holt, 1985), given that the few attempts to collude had virtually ended up in failure. The participants' behaviour in a one-shot game remains constant over periods (Huck, Muller, & Normann, 2001). In the dynamic one-shot games, the mental stability properties of a Cournot Nash equilibrium could be regarded as actual refinement behaviour (Cox & Walker, 1998). Cooper, DeJong, Forsythe, and Ross (1996) observed that the rate of cooperation in the initial matchings is about 43%, higher than the rate of the later matchings (20%). Therefore, the experience of the one-shot repetition can not facilitate the collusion.

2.2 Repeated Games: Multi-period Repetition with the Same Co-player

Static formulation of Cournot interaction has been criticised due to ignorance of its participants and the absence of dynamic adjustment. Literature has focused on the dynamic behaviour of the firms in an oligopoly market. A dynamic model considers the firms from a multi-period

[12]In each sequence of one shot games, participants were randomly rematched into new pairings in each period, and participants will not meet again. No player knew the history behaviour of the current opponent.

planning horizon. The dynamic model is characterised by the effort of the firms to maximise the value of whole interaction procedures. Experimental markets are typically collusive if aggregate outcomes are less competitive than that in the static equilibrium (Holt, 1995). Here, we review some of the factors that may affect the incidence of tacit collusion with repeated interaction (fixed matching). Benson and Faminow (1988) who organised the duopoly price-choice markets with product differentiation and incomplete information, determining that the experienced subjects are more likely to cooperate. In general, the multiple-period experimental results showed that the average quantity choice always appears on both sides of the Cournot and that the outcomes might be competitive (Holt & Villamil, 1986).

2.2.1 Finitely Repeated Interactions

It is commonly known that all the players can interact with one another within a certain period. Now, a systematic review of repeated games has been conducted with perfect information. Subjects repeatedly interact with one another in fixed pairs, yet the communication between them is not allowed. The subjects have complete information about the market (their possible profits and costs). After each period, they receive feedback about the aggregate output, their own profits, the outputs and profits of the individual firms. In this game theory, the Nash Cournot equilibrium will be adopted by all rational participants in each stage.[13] The "backward induction" makes sure that the collusion cannot be sustained in finitely repeated games. Data of lab experiments suggest that the participants' quantity choice in multi-period duopoly always deviates systematically from a static Nash Equilibrium (F. T. Dolbear et al., 1968). In contrast to the one-shot findings repeated Cournot setting with fixed pairs of participants, the contradictive collusive outcome can appear (Holt, 1985). Fouraker and Siegel (1963); Hauk and Nagel (2001); Kreps et al. (1982); Selten and Stoecker (1986) observed that when people play finitely repeated interactions of prisoner's dilemma game, they often cooperate in the early periods. Nevertheless, this cooperation can break down by the end of the interactions (Andreoni & Miller, 2002; Selten & Stoecker, 1986). Most of the recent studies on the experimental Cournot markets summarized that the outcomes end up being close to Nash Equilibrium with the previous perfect information. If the same finitely repeated interactions

[13]Each firm will always choose the one period non-cooperation strategy in the last period and ignores, ignoring all the history choices. Actually, the history behaviour has nothing effects on the current behaviour, and there is no punish effect existence. The non-collusion strategy is the unique Sub-game Perfect Nash Equilibrium of the finitely repeated games.

are played by different opponents, the total market quantities will decrease over these finitely repeated interactions (Huck et al., 2001). The cooperation rate in these finitely repeated games generally declines (Cooper et al., 1996). The reputation building and altruism are the two leading theories to explain the collusion (Andreoni & Miller, 1993; Cooper et al., 1996).

2.2.2 Indefinitely Repeated Interactions

This subsection will review the indefinitely repeated games based on Friedman (1971) dynamic model. According to the definition, the indefinitely repeated stage games have no (predictable) last stage. However, the probability of indefinitely repeated interactions continuity is common knowledge for all participants. Tirole (1988) stated that there are several equilibria in the indefinitely repeated games. The maintenance of collusion must meet two conditions. First, firms must have the incentive to reach a collusion. Second, firms are more likely to keep the collusion strategy as long as the deviation is less than the loss of the discounted profits in the following non-collusion phase. Each firm may choose the collusion strategy when all firms choose to continue doing so. However, once a firm's best response strategy is flawed, the punishment will be triggered, that is, the credible non-cooperation punishment strategy of the stage games will be adopted forever. Base on the conclusion drawn through plenty of experiments, the collusion between the two companies is possible to some extent. However, it is very difficult to achieve perfect collusion, that is, the total output is closer to the Cournot Nash equilibrium output than to the monopoly output. Huck et al. (2001); Huck, Normann, and Oechssler (1999) found that players are eager to achieve the JPM achievement. In experimental praxis, an indefinite number of periods are not required to make cooperation possible (usually a few periods are sufficient). Feinberg and Husted (1993) reported how discount factors contribute to the collusion strategy in quantity choices duopoly. Under different random terminations, probabilities implement the varying discount factors, and the probability of collusion and future value increase simultaneously. Firms can sustain the collusion strategy if they are sufficiently patient. Meanwhile, firms can efficiently sustain collusion in quantity-choices settings if the individual discount factor is above the critical threshold.

Based on the past behavioural experiments of Cournot duopoly interactions, the vast majority of studies found the average between Nash and collusive outcomes for duopoly experiments (Huck et al., 1999). In the literature examining factors that facilitate or hinder collusion, three basic measures for collusion have emerged. In most cases, people are mostly concerned about the possibility of joint profit maximisation, and the ability to collude tacitly is measured by the length of horizons (finitely) and the critical discount factors (indefinitely). Collusion would be more difficult to sustain if the length of horizon factors for joint profit maximisation is lower (finitely), and the critical discount factors for joint profit maximisation is higher (i.e., the range of discount factors for collusive sustainability is smaller).

3 Group Identity Incorporates with Cournot Interactions

How can we explain the collusive behaviours in the Cournot interactions? Theories can be split into two main branches, that is, the complete self-interested players and not strictly self-interested players. The first types of theory, including Kreps et al., pointed out that the cooperation created for the motivation of maximizing self-profits is based on the small belief that their opponent is a cooperative player. Other types of theory mainly assume that players are not strictly self-interested, but benefit from cooperation in manner. Of course, in terms of self-interest, the collusive agreement is unsustainable since players would not like to collude. Thus, I am particularly interested in the collusion with players who are not strictly self-interested. Many empirical and experimental problems are incomprehensible without taking social preferences into account.[14] A considerable number of people show group identity, leading to heterogeneity with respect to group identity (Y. Chen & Li, 2009; Li & Liu, 2017). The cooperation occurs in fixed pairs of matching repeated actions, and the other-regarding cases induced by group identification. However, economic theory contributes little to understanding the factors of group identity and poses few effects on reaching an agreement. This study bridges these two research areas on group identity, and participants' actions and strategies in the Cournot interactions, through demonstrating the effects of group identity on collusion and strategies in different Cournot interaction devices. The potential strengths of group identity in determining the collusion in quantity setting games are explored in this study, which is still a relatively immature research area. In summary, through previous studies, we are able to investigate the impact of group identity and horizon parameters on collusion, as well as the interaction with experience. However, the understanding of behaviour combining these parameters is still not cleared in the Cournot interactions.

[14]e.g., Outcomes of competition markets, laws governing cooperation and collective actions, material incentives, optimal allocations, and social norms shaping

Part II

THEORY and EXPERIMENTAL STUDY

Introduction

When it comes to industrial organization, the most prominent contribution of game theory is in the oligopolistic market interaction. It is a vivid example of strategic interaction among the players in the market. Although these brief models have constantly been tested by economists (Hoggatt, 1959; Sauermann & Selten, 1959), and their passion for economic experiments remains insatiable. How public group assignment information impact duopoly market interactions? To answer that question, we conduct a new series of experiments studying oligopolies with same group match, different group match, or no group match in a unified frame. For starters, let us consider a market in which the two players sell identical products and compete against one another. The firms in this experiment feature simplified organization, with one-person and one decision unit. Their inverse demand function is subject only to the current quantities of human behaviour. Clearly, the purpose of our experiments is to study human behaviour, thereby deciphering the oligopolistic markets with group identity. A payoff table refers to the matrix of the possible amounts a player can earn under the restraint of market parameters and the output of the other player. Their behaviour can be explained, and the market outcome can be predicted by calculating the benefits of changes in their variables. In these experiments, the participants were not allowed to communicate so that the chance of explicit collusion could be eliminated by construction. That is to say, the cartel was built tacitly. To analyze how group identity affects the "collusion of Cournot interactions", our experiments were broadly divided into two sections, including an artificial group identity, and three different Duopoly Cournot interactions.

4 Theoretical Work

We adopt an evolutionary approach to investigate whether preference may evolve in human behaviour during the process of group assignment. Herein, the degree of group contingent other-regarding preference is expressed by a parameter which describes how much individual care for others. These economic behaviours in cooperation are consistent with standard economic theory. The theory holds that utility is above self-interest. A comparison of the interactions between players primed ingroup favouritism and that among players primed outgroup derogation reveals that ingroup players can achieve higher monetary profits than players from two different groups. Therefore, the group contingent preference parameters are composed of the following sections; where we just considering firms in the markets and ignoring the consumers' welfare: (1) pure other-regarding and altruism: the player hopes to maximize his or her rival's private monetary profits and minimize his or her own monetary profits; (2) other-regarding and maximization social welfare: in this special case the purpose of the player is to maximize joint profits by cooperating with others; (3) pure self-monetary-interest and indifference towards other: in this case the player cares only about his or her private monetary profits; (4) pure self-monetary-interest and advantage difference to others: the player not only considers his or her private maximization profit, but has a strong hand to play; (5) competitive antisocial: the player aims to minimize the monetary profits of all involved players.

We develop collusion solutions to the one-shot, finitely repeated, and indefinitely repeated Cournot duopoly interaction games, so as to identify how the group identity influences the quantity choices of the players. We consider a symmetric Cournot duopoly model with group identity in which each firm is entitled to a (common) concern about the profit earned by other firms. The models we discuss that collusion might be sustained as a non-collusive equilibrium among rival firms, what I want to stress is that cartel cannot. The signs (positive and negative) and values of fractions depend on group assignments. We cannot help asking whether the outcome of monopoly can be supported by collusion. An equilibrium out of a set of strategies can be achieved if each player implements the strategy which best suits other players' strategies. In this way, the combination of these strategies can help maximize the group contingent other-regarding preferences of the players. Notably, the economists are interested in the social preference of equilibrium as well, especially the evolution of players' strategies. These non-selfish observations are in agreement with the standard economic theory which postulates utility functions amongst members. Consequently, the group contingent other-regarding is positive for the group members, yet less positive and even harmful to the players outside the group. These facts made it necessary to compare the utility of players with different group contingent other-regarding preference parameters. To better understand the experimental results, the theoretical models which provide the framework are presented in Appendix C.

The study of collusion in duopoly market is entirely based on the following individual model, in which the inverse price demand function is linear, and the reaction functions are downward sloping (Huck et al., 2001).[15] The general form of the profit function for a $firm_i$ in a 2-person Cournot-competition game is expressed with the following equation, and each firm's monetary profits are dependent on the joint actions of (q_i, q_j)

$$\pi_i(q_i, q_j) \equiv q_i(Z - v(q_i + q_j)) - cq_i, \;\; \pi_j(q_i, q_j) \equiv q_j(Z - v(q_i + q_j)) - cq_j, \tag{3}$$

where Z, v and c are real, non-negative constant, We set $Z = 24$, $v = 1$, and $q_i \geq 0$ in the units produced by firm$_i$. To address the question and to achieve simplification, the study of collusion was entirely based on an individual model, and a common constant marginal cost of production has been set for each firm. This constant, without further loss of generality, is taken set as zero.

As a benchmark, a symmetric optimum is defined by quantity interaction $(\widehat{q}_i, \widehat{q}_j)$ that maximize the firms' joint profit, i.e.

$$(\widehat{q}_i, \widehat{q}_j) \in \underset{q_i, q_j}{\arg\max} = [\pi_i(q_i, q_j) + \pi_j(q_i, q_j)] \tag{4}$$

Therefore,

$$\widehat{q}_i = \widehat{q}_j = \frac{Z}{2 - 2(-v)}, \; and \; \pi_i(\widehat{q}_i, \widehat{q}_j) = \pi_j(\widehat{q}_i, \widehat{q}_j) = \frac{Z^2}{4(1 - (-v))} \tag{5}$$

The results of non-cooperative interactions $(\widetilde{q}_i, \widetilde{q}_j)$ can be expressed as:

$$\widetilde{q}_i \in \underset{q_i}{\arg\max}\, \pi_i(q_i, \widetilde{q}_j), \; \widetilde{q}_j \in \underset{q_j}{\arg\max}\, \pi_i(\widetilde{q}_i, q_j). \tag{6}$$

therefore, the best-response functions are

$$\widetilde{q}_i = \frac{Z - vq_j}{2}, \; \widetilde{q}_j = \frac{Z - vq_i}{2} \tag{7}$$

[15] For repeated games, the downward-sloping demand function implies that if the aggregate output is more significant than the joint profit maximization output, the individual output downwards adjustment tends to have a higher extent of cooperation, and vice versa. If one firm deviates the collusion but the other does not, then an upward quantity adjustment can be interpreted as an action of punishment.

The equilibrium actions and profits can be expressed as:

$$\widetilde{q}_i = \widetilde{q}_j = \frac{Z}{2-(-v)}, \; \pi_i(\widetilde{q}_i, \widetilde{q}_j) = \pi_j(\widetilde{q}_i, \widetilde{q}_j) = \frac{Z^2}{(2-(-v))^2} \tag{8}$$

In our setting, $\pi_i(\widetilde{q}_i, \widetilde{q}_j) < \pi_i(\widehat{q}_i, \widehat{q}_j)$, and $\widetilde{q}_i = \widetilde{q}_j > \widehat{q}_i = \widehat{q}_j$. The utility of complete self-interest $firm_i$ satisfies the condition of $u_i(q_i, q_j) = \pi_i(q_i, q_j), \pi_j$ (see Figure 2). The collusions in Cournot interactions analyzed in the paper should be assessed on three grounds. The first is about whether the collusive strategy is adaptive and whether the firms are able to collude. The second is the likelihood of a collusive strategy to reach an agreement. The third is about the sustainability of the collusion strategy, and how the collusion can remain effective for long.

4.1 One-shot Interactions: Nash Equilibrium

After group identity is primed, the group identity theory assumes that individuals directly care about the material profits of others. A parametric model of the group contingent other-regarding that determines the marginal rate of substitution between individuals and rivals' profits is introduced in this paper. Based on this model, it is demonstrated that the group contingent other-regarding preference depends on the group assignment. This model is the simplest game model, in which all players make the best choice without knowing other players' choices, so the profits of each player are simply determined by the combination of strategies selected by the players. In such one-shot interaction model, firms only meet once, starting with the effects of group identity on quantity choices, i.e., kindness and hostility without reciprocity. Market demand is obtained by the inverse demand function as $p = 24 - Q$, where $Q = q_i^g + q_j^g$, $g \in \{N, I, O\}$. 'N' represents that the two firms are completely independent, without the concept of the group (Nogroup). 'I' means that the two firms are from the same named group (Ingroup), while 'O' implies that the two firms are from the different named groups (Outgroup). With the existence of the group identity, the firms' economic behaviour under the best response function will inevitably develop with the group identity. Here, it is assumed that the rationality of firms' pursuit of maximum utility is the significant features of "group identity" rather than self-interest maximization.

$$u_i = \omega^g \pi_j + (1-\omega^g)\,\pi_i = \omega^g \left[\left(24 - q_i^g - q_j^g\right) q_j^g\right] + (1-\omega^g)\left[\left(24 - q_i^g - q_j^g\right) q_i^g\right], \quad \omega^g \in [-1, 1] \tag{9}$$

In the equation 9, where ω^g is the group contingent other-regarding parameter, which represents the concern that $firm_i$ expresses for the other firm's profits.[16] Based on the estimation of ω^g from Y. Chen and Li (2009), it is expected that $\omega^I > \omega^N = 0 > \omega^O$. Taking the group effect into account, the parameter of weight on the opponent changes the firm's optimal response, rather than the Nash Equilibrium of strategic substitute quantity competitions. Therefore, based on the equilibrium, each firm's monetary profits depend on the group contingent parameters of all firms in the market. Each firm pursues maximising subjective utility:

$$q_i^{*(g)} \in \arg\max_{q_i^g} u_i(q_i^g, q_j^{*(g)}),\ q_j^{*(g)} \in \arg\max_{q_j^g} u_i(q_i^{*(g)}, q_j^g) \tag{10}$$

Under the first-order conditions of utility maximization, the equilibrium of the game between two firms with symmetric ω^g is given as follows.

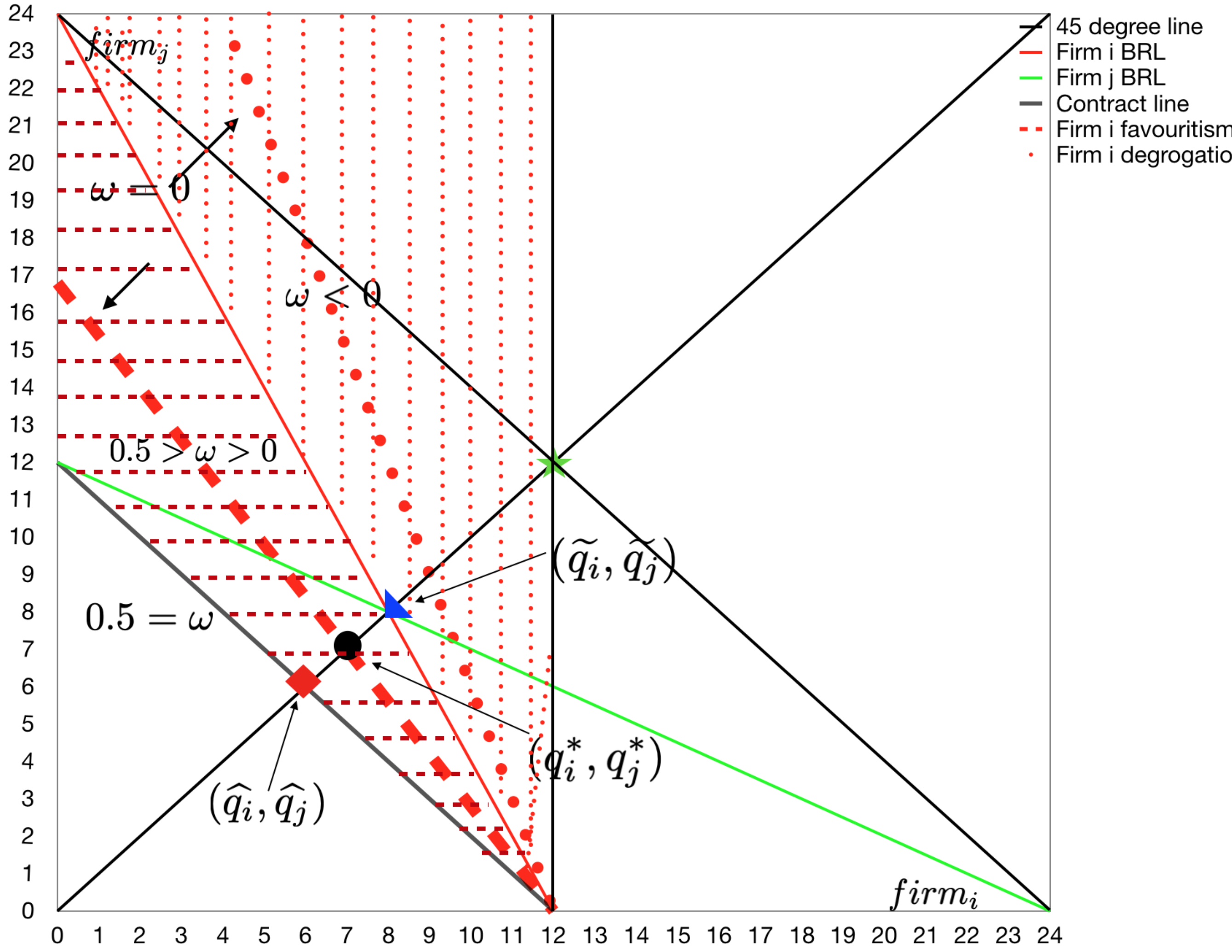
$$q_i^{*(g)}(\omega^g) = q_i^{*(g)} = q_j^{*(g)} = \frac{24(1-\omega^g)}{3-2\omega^g} \tag{11}$$

If the $\omega^g \in (0, 0.5)$, the larger ω^g is, the lower the outcome is to the optimum$(\widehat{q}_i, \widehat{q}_j)$ than the Cournot Nash equilibrium $(\widetilde{q}_i, \widetilde{q}_j)$. It is assumed that all participants in a given session have the same ω^g, where, the market-clearing price is

$$p^{*(g)} = 24 - q_i^{*(g)} - q_j^{*(g)} = \frac{24}{3-2\omega^g}. \tag{12}$$

[16] Basu (2006); Y. Chen and Li (2009); McLeish and Oxoby (2007) used this similar group contingent social preference model, in which the individual maximizes the weighted sum of material profits of his/her own and the others, with weighting dependent on the opponent's group category.

Figure 2: The pure-strategy Nash Equilibria of the Cournot interactions



The red dots shaded part: $\omega < 0$. The red dashes shaded part: $0 < \omega < 0.5$. Red square: Collusive quantity choices. Blue triangle: Standard Cournot Nash Equilibrium quantity choices. Green star: Competitive quantity choices.

Figure 2 illustrates the dynamic movement of the best response with the ω^g determined by the group assignment and enhancement. In this example, there is a one-to-one correspondence between specific equilibria and specific group contingent other-regarding parameters. We describe preference by the equation 9, and the weights ω^g represents the concern that $firm_i$ expresses for other firms' monetary profits. The positive other-regarding preference firms possess $0 < \omega^g \leq 1$, posing an indirect impact on the firm's monetary profits to increase the opponent's monetary profits based on the parameter ω^g. In Figure 2, the equilibrium is determined as the intersection of the firms' best response function.[17] Here, we take $firm_i$ as an

[17]Based on the Meta-analysis of social dilemma, the effect size of the relationship between cooperation and other

example (red lines). With the value of "ω^g" increasing (the sign is positive), the best response line of the $firm_i$ rotates counter-clockwise with a center, which is reflected as the red long-dots line. The intersection of the two firms' Cournot Nash Equilibrium quantity decisions (blue triangle point) moves to the black circle intersection. The response curve is much flatter than predicted by standard theory. The intersections of the two symmetric response lines always fall on the 45-degree line, and each has its corresponding ω^g characteristics. A comparison of the different preferences between two firms with identical group contingent other-regarding parameters is expressed as follows.

$$\widetilde{q}_i = \widetilde{q}_j > q_i^{*(g)} = q_j^{*(g)} > \widehat{q}_i = \widehat{q}_j. \tag{13}$$

When $\omega^g = 1/2$, the firms' equilibrium actions fall at the optimum point of collusion. In the context of the one-shot Cournot oligopoly, if $\omega^g \in [0, 0.5]$, as the value of ω^g among rivals increases, the equilibrium in the market becomes less competitive, that is, the aggregate output falls toward the monopoly level. Thus, increasing ω^g among rivals would result in a more profitable non-cooperative equilibrium. Similarly, another conjecture is that increasing ω^g would lead to a greater similarity of profits, which in turn would facilitate collusion among rivals.[18] Under the one-shot Cournot interaction, as the degree of group contingent other-regarding preference increases, the equilibrium in the market becomes less competitive while the market quantities tend to be the tacit collusion level. Thus, increasing group contingent other-regarding among rivals results in a more profitable non-collusive equilibrium.

For repeated games: a simultaneous stage game is repeated during the experimental periods, and the outcome of each stage game is revealed before the next stage game is played. If the game has a finite number of players who implement finite strategies, there exists at least one

regarding is 0.30(Balliet, Parks, & Joireman, 2009).

[18]For example, if a randomly particular average weighted value ω^g causes the change of the two firms' best response line, it interacts at a new equilibrium point on the 45-degree line.

- Optimal other-regarding parameter points: $\omega^g = 0.5$; Pure other-regarding parameter points: $\omega^g > 0.5$; Impure other-regarding parameter points: $0 < \omega^g < 0.5$; Negative other-regarding parameter points (spiteful): $\omega^g < 0$. There is little evidence of pure other-regarding models in empirically (Clotfelter, 1985) and in experiments (Andreoni, 1993).
- $\widehat{q}(\omega^g = 0.5) < q_i(\omega^\bullet) < \widetilde{q}(\omega^g = 0)$
- $\widetilde{p}(\omega^g = 0) < p(\omega^\bullet) < \widehat{p}(\omega^g = 0.5)$
- $\widetilde{\pi}(\omega^g = 0) < \pi(\omega^\bullet) < \widehat{\pi}(\omega^g = 0.5)$

Where price with positive $\omega^\bullet$ is bigger than $\widetilde{p}(\omega^g = 0)$, and $q(\omega^\bullet) = q(\omega^\bullet) = \frac{24(1-\omega^\bullet)}{3-2\omega^\bullet}$ are smaller than $\widetilde{q}(\omega^g = 0) = \frac{24}{3}$; then $\pi(\omega^\bullet)$ are larger than $\widetilde{\pi}(\omega^g = 0) = 64$. We suppose that the quantity q function is differentiable, which we want to optimize by choosing ω^g.

Nash Equilibrium (NE). NE may contain mixed strategies, and we will discuss this question later. The tricky issue here is how to make the right decision in the set of multi-equilibrium. In the non-cooperative sub-game perfect equilibrium of repeated games, firms could achieve higher monetary profits than the Cournot Nash monetary profits in the one-shot game. The perfect collusion is a situation in which the firms manage to maximize their joint utility, which is greater the sum of Nash utility of the stage games. We present the alternative derivation of Nash equilibrium in the finitely repeated games and the Sub-game Perfect Nash Equilibrium in the indefinitely repeated games to identify the role of group identity role in other-regarding preferences.

The standard approach to study collusion in repeated games assumes that firms would use grim trigger strategies to punish any deviation from collusion. When the rival firm sticks to collusion, the firm is tempted to cheat by playing its one-period best response. Under this circumstance, a deviation utility of $u_i^D(R_i^g\ (\widehat{q}_j))\ (> u_i(\widehat{q}_i))$ is yield, where $u_i(\widehat{q}_i)$ denotes firm i's per period utility in the collusive outcome. In modelling the possibilities of collusion, we use the standard model in which the firms follow trigger strategies that employ reversion to the static non-cooperative equilibrium if any firm deviates from monopoly. Yet the deviation from monopoly would trigger punishment, and $firm_i$ would earn the profit of the Cournot-Nash equilibrium in all future periods. This can be denoted in this equation: $u_i^{p(g)}\ (u_i^{p(g)} = u_i^{*(g)})$, and $u_i^{p(I)} > u_i^{p(N)} > u_i^{p(O)}$. Group identity can affect the difference between collusion utility and the utility after the first deviation. The positive group identity leads to decreased $u_i(\widehat{q}_i) - u_i(q^{p(g)})$ and vice versa. ω^g displays two effects. Firstly, it reduces the gain from cheating on a collusive agreement. Secondly, it softens the punishment for cheating and makes collusion less sustainable. These two effects work in opposite directions.[19] (see Appendix C)

4.2 Finitely Repeated Interactions: Perfect Nash Equilibrium

If the firms know the final period in advance, the backward induction incentives that firms will not collude in the penultimate period, which implies that they will play the Cournot Nash of the stage game in the final period. By that analogy, the only subgame-perfect Cournot Nash is the unique dominant-strategy $q^{*(g)}$ in each period ($q^{*(I)} < q^{*(N)} < q^{*(O)}$).

There may be an equilibrium in which the players collude with one another at the early peri-

[19] $u_i(\widehat{q}_i)$ designates the utility for collusion, $u_i^D(R_i^g\ (\widehat{q}_j))$ the temptation to collude, $u_i^{p(g)}\ (u_i^{p(g)} = u_i^{*(g)})$ the punishment for mutual Nash equilibrium choices.

ods to obtain utilities from the (collusion, collusion) outcome. Collusion appears at the early periods if the long-run cost exceeds the long-run deviation gains. After the first deviation, the players' equilibrium strategy went back to the Cournot equilibrium. In our model with group contingent other-regarding preference in a finitely repeated interactions version of Cournot game, we compare the path of the game with that of the predictions of the equilibrium of Kreps et al. To understand that comparison, we present an equilibrium path for the interactions in which the players with other-regarding concerns respond to their opponent. The best response to $firm_j$'s collusion strategy in term of short-run deviation gains can be expressed as:

$$R_i^g(\widehat{q}_j) = \frac{24(1-\omega^g) - \widehat{q}_j}{2(1-\omega^g)} \tag{14}$$

The function R(.) of the group contingent other-regarding parameters defines a symmetric evolutionary game.[20] However, the deviation would trigger the punishment, and $firm_i$ would earn the profit of Cournot-Nash equilibrium in all future periods. This situation can be denoted as: $\pi_i^{p(g)}$ ($\pi_i^{p(g)} = \pi_i^{*(g)}$), and $\pi_i^{p(I)} > \pi_i^{p(N)} > \pi_i^{p(O)}$. The disparate group identity would affect the difference between collusion utility and the utility after the first deviation. The positive group identity leads to decreased $\pi_i(\widetilde{q}_j) - \pi_i(q_i^{p(g)})$, and vice versa. The two effects of ω^g are that it reduces the gain from cheating on a collusive agreement and it softens the punishment following the cheating. Obviously, these two effects work in opposite directions. The gains from quantity choices were adjusted upward. $R_i^g(\widehat{q}_j)$ are lower for the pairs in the ingroup matching, compared with other scenarios. The profits π^p are higher in the ingroup matching even when the collusion agreements were broken down, compared with that in outgroup or nogroup matching.

Firms are able to sustain collusion when the utility from collusion is no less than the utility from deviation. A commonly known last period is that the collusion behaviour could be determined by threshold strategies.[21] Firms follow trigger strategies that employ reversion to the static non-cooperative equilibrium forever if either firm deviates from monopoly. The sum utility of

[20] Assuming that the rival firm sticks to collusion, the firm is tempted to cheat by playing its one-period best response, yielding a deviation utility of $\pi_i(R_i^g(\widehat{q}_j)) > \pi_i(\widehat{q}_i)$. $\pi_i(\widehat{q}_i)$ denotes firm i's per period utility in the collusive outcome considered.

[21] Strategies that conditionally colluded until a threshold period before switching to the always Cournot Nash equilibrium with group contingent other-regarding preference. Despite threshold strategies' initial differences, the evolution of behavior is consistent with the unraveling logic of backward induction (Embrey, Fréchette, & Yuksel, 2015).

T periods could be represented as:

$$U_i = \sum_{t=1}^{T} u_{i,t} \tag{15}$$

Thus, the collusive equilibrium (the no deviation utility overall repeated game in $T-1$) is:

$$u_i(\widehat{q}_i) + u_i(\widehat{q}_i) + \cdots + u_i(\widehat{q}_i) + u_i(q^{*(g)}) \tag{16}$$

If at the t^{th} period, the total current utility is no different between deviations and collusion (there is always punishment for deviation), this period is known as the threshold deviation period, t^c ($t^c < T$). Thenceforth, the competition between the two firms enters the punishment stage. The utility of firms goes to the u^p at $t^c + 1$ period, until the end of the game. The collusion equilibrium requirement is:

$$\begin{aligned} u_i(\widehat{q}_i) + u_i(\widehat{q}_i) + \cdots + u_i(\widehat{q}_i) + u_i(q_i^{*(g)}) \geq \\ u_i(\widehat{q}_i) + u_i(\widehat{q}_i) + \cdots + u_i(\widehat{q}_i) + u_i(R_i^g(\widehat{q}_j)) + u_i(q_i^{p(g)}) + \cdots u_i(q_i^{p(g)}) \end{aligned} \tag{17}$$

which means:

$$t^c \leq T - \frac{u_i(R_i^g(\widehat{q}_j)) - u_i(q_i^{*(g)})}{u_i(\widehat{q}_i) - u_i(q_i^{p(g)})} \tag{18}$$

[22]

4.3 Indefinitely Repeated Interactions: Sub-game Perfect Nash Equilibrium

Economists consider the theories are useful, since a large number of equilibria are mathematically possible in indefinitely repeated games. A crucial assumption of the collusion in theory is that the interactions will continue indefinitely. In the indefinitely repeated games, each supergame consists of an indefinite repetition of the same stage game with the same cohort. t=0,1,2,... indexed the periods in the supergame. All firms have the same discount future utility with the factor $0 < \delta_i^g < 1$. No theory could provide sharp predictions since there may be multiple equilibriums. We consider whether each firm is playing the Sub-game Perfect Nash Equilibrium in the indefinitely repeated games. Regarding the monopoly quantities in each

[22]This observation, though it is evident in the given context, has an intriguing implication, that Shapiro (1989) (page 365) suggested the principle of supergame theory: "Any underlying market condition that makes very competitive behaviour possible and credible can, by lowering $\pi_i^{p(g)}$, actually promote collusion." In the abstract, $u_i^{p(I)} > u_i^{p(N)} > u_i^{p(O)}$ is the rank of punishment phases profits in the three treatments, it is obvious that $t^{c(I)} < t^{c(N)} < t^{c(O)}$. (see Figure C22)

period, once this "tacit collusion" is broken, both firms would be equal to one-shot Nash equilibrium with group contingent other-regarding preference after choosing their quantity. If both firms choose quantity level $\widehat{q}$ at each period, the present discounted value of each firm's utility can be expressed as $\widehat{U} = \widehat{u}/(1-\delta^g)$. A firm's best deviation against the opponent who will choose q^* in all sequent cycles. The discounted utility resulting from this optimal deviation is $U^D = u_i(R_i^g(\widehat{q}_j), \widehat{q}_i, \omega_i^g) + \frac{\delta^{c(g)}}{1-\delta^{c(g)}} u_i(q^*, \omega_i^g)$ Thus, each $firm_i$ is more inclined to adopt the collusive strategy if the utility from collusion is not less than that from defection, which consists of one cyclical benefit from defection plus the discounted utility of inducing Nash reversion forever, that is,

$$\frac{1}{1-\delta^{c(g)}} u_i((\widehat{q}_i), \omega_i^g) \geq u_i(R_i^g(\widehat{q}_j), \widehat{q}_i, \omega_i^g) + \frac{\delta^{c(g)}}{1-\delta^{c(g)}} u_i(q^*, \omega_i^g) \tag{19}$$

where $\widehat{q}_i \equiv (\widehat{q}_i, \widehat{q}_j)$ is the vector of collusive quantity choices resulting from the joint profit maximization. It can be said that the group identity facilitates collusion if the collusion quantity profile can be sustained at a lower critical discount factor when firms are altruistic than when they are no group assignment. If the opposite happens, group identity makes collusion harder. By solving $\delta^{c(g)}$, we obtain the critical discount factor above which collusion can be sustained by firms:

$$\delta_i^g \geq \delta^{c(g)} = \frac{u_i(R_i^g(\widehat{q}_j)) - u_i(\widehat{q}_i)}{u_i(R_i^g(\widehat{q}_j)) - u_i(q^{*(g)})} \tag{20}$$

where $u_i(q^{*(g)}) = u_i(q^{p(g)})$. In other words, the increase of the group contingent other-regarding may actually affect the collusion sustainability by changing the critical discount factor. Figure C23 shows that $\delta^{c(g)}$ decreases until approximately $\omega^g = 0.5$, and then increases after $\omega^g = 0.5$. The higher levels of group contingent other-regarding with the increasing group contingent other-regarding preference may actually decrease the likelihood that collusion can be sustained. As discussed above, increasing group contingent other-regarding can weaken the effect of the punishment phase. However, this also reduces the utility gains from collusion deviation. The tradeoff between the two effects determines whether group contingent other-regarding makes tactic collusion more or less likely.

4.4 Summary

In summary, the main results of the theory with group identifications are as follows. First, when firms are paired within the same group, collusion outcomes can appear in a one-shot game. Second, collusion becomes easier as the group contingent other-regarding preference increases. Third, when firms meet repeatedly, collusive outcomes can be sustained in Subgame Perfect Nash Equilibrium, especially, when firms are from the different groups in the finitely repeated games and when firms are from the same group in the indefinitely repeated games. Fourth, many collusive outcomes can be sustained in equilibrium, and different punishment strategies vary from group assignments. Fifth, group assignments produce different quantity choice adjustment norms. Sixth, when firms can fully understand the decisions of a certain period and history, there may be collusion, but it is less likely to be collusion compared to the uncertain period and fixed pairing.

5 Experimental Design

Our experiments have three main features. The artificial group identity could be primed and enhanced by painting study tasks (Li & Liu, 2017). Second, we consider the group effect on the player's quantity choices. Third, we vary the Cournot competitions of the repetition devices to examine whether group identity features are different. A Supplementary Appendix B contains the full experimental design, instructions, payoff table, and some screen-shots.

To summarise, we conducted a 3*3 experimental design, (ingroup assignment, outgroup assignment, or nogroup assignment)*(one-shot or finitely repeated, indefinitely repeated); the nine treatments and the order of events are summarised in Appendix D. The experiments were programmed in O-tree. Each experiment was conducted using cohorts of players recruited from the undergraduate, or above degree at the University of Wuhan. We collected data at the university, covering 360 students in the age range from 18 to 25 years. In the experiments, 120 players participated and 3 sessions in each Cournot interactions (Oneshot, Finitely, Indefinitely). In other words, 40 players recruited in each session. For the group sessions, 20 players were randomly assigned to a Luojiashan group and a Donghu group. Players were seated at separate computer terminals and given a copy of the instructions. Since these instructions were also read aloud, we assume that the information contained in them is common knowledge. In each condition of both the one-shot games and the repeated games, the players' payoffs in each period were represented on them by the matrix on the screen.

In our experimental conditions for one-shot interactions, players participated in 70 Cournot competition stage games each against anonymous opponents changing from period to period. The participants just have their own history quantity and profits, but have no idea about current opponent history quantity and profits. For ten periods of repeated interactions, it is common knowledge that players played seven fixed pair ten-period Cournot competition with different partners, with perfect monitoring of the current opponent's actions in each supergame.[23] In terms of the indefinitely repeated games, each player played seven random stop supergames with 0.9 continuation probability, and without repeating a pair, the opponents' actions can be perfectly observed by current participants. The number of periods in a supergame is randomly determined with discount factor (δ). We used between-subject design, participants were always paired with another person from the same group in the ingroup treatment, and were always paired with someone from the other group in the outgroup treatment.

Table 1: Experimental design

	Treatments	Group Assignment	Problem Solving	Number Questions	Number of Participants	Number of Super-games (sessions)	Number of Periods
One-shot	Nogroup	None	Self	2	40	- (1)	70
	Ingroup	Random	Chat	2	40	- (2)	70
	Outgroup	Random	Chat	2	40	- (1)	70
Finitely	Nogroup	None	Self	2	40	7 (1)	70
	Ingroup	Random	Chat	2	40	7 (2)	70
	Outgroup	Random	Chat	2	40	7 (1)	70
Indefinitely	Nogroup	None	Self	2	40	7 (1)	72
	Ingroup	Random	Chat	2	40	7 (2)	72
	Outgroup	Random	Chat	2	40	7 (1)	72

Table 1 presents our experimental design. This table summarises the features of experimental sessions, including treatments, group assignments, how a treatment to solve problems, the number of players in each treatment, the number of suspergames, and the total periods in the whole Cournot games.

5.1 Part One-Manipulation of Categories

As participants arrived at the laboratory, each randomly drawn an ID card or an ID envelope. ID cards are printed with experiment number for non-group sessions. A piece of paper is printed with group a name and experiment number in the ID envelope for group sessions. The players with ID envelop were told that the experiment required two groups of players; they were asked to identify themselves by these ID envelopes; their personal identity would be

[23]we preferred a commonly known finite horizon for both one-shot interactions and ten periods of finitely repeated interactions.

completely unknown to the experimenter. They were reminded not to show their ID characters to the other participants, nor to the experimenter.

5.1.1 Step One (Randomly Group Assignment)

Just ingroup and outgroup treatments contain the group assignment step, where we adopted the artificial group assignment method. From this side, the group manipulation references the design of the Random Between treatment by R. Chen and Chen (2011). The strength of group identity implemented by nearly minimal group paradigm (players are randomly assigned to groups; players do not interact before; group membership is anonymous) based on the random choice of an envelope with a specific group card inside. Two artificial groups are called Luojiashan group and Donghu group, those two attractions of the most representative, likely the primary colours of the university in the UK.

5.1.2 Step Two (Team Building Task)

The second step is a collective problem-solving task using an online chat program. All participants have to be an independent learner and study three pairs of paintings by Kandinsky and Klee for three minutes in the front of the lab screen. Then every participant judges each of the two new paintings made by the artists in eight minutes, the same assigned group members could express ideas through the online chat program (Only participants assigned to the named groups could experience the online chat). Each correct answer is worth 50 experiment points. There existence the first questionnaire for the group assigned players, including three questions, i.e., their own group name and concerning their belongingness to own group and the other group respectively.

There are three types of group identity primed for the treatment variables. In one treatment, the participants did not experience group classification. In the one treatment participants after group classification, and then played Cournot games with the other participants who are from the same group. The third treatment participants experienced group classification, in which, who played Cournot games with the other participants who are from the different group. The players only read the instructions for part two after the first part has ended (see Appendix B).

5.2 Part Two-Cournot Interactions

We have operationalized a version of the Cournot oligopoly models of output choice for experiments. The experiments involved both sellers make a simultaneous quantity choice to how much boxes they wish to sell, and the market then determines the prices. The outputs are the six potential integer value in experiments, and a market price is determined by an inverse demand function. Players' profits depend on these output choices. In each subsequent period, players chose the output quantity and got paid the profit before the beginning of the next period.

5.2.1 One-shot Interactions

The stage games are strategic substitutes, and re-derived from linear symmetric duopoly games, normal-form games in which both players have six quantity choices to choose from. Each player participated in a sequence of one-shot games against different anonymous opponents. The participants were told, in any of the experiments, how many market periods there would be. There were 70 market periods, and the players were randomly re-matching into new pairings in each period. For group treatments, players knew the identity of the player with whom he/she was currently paired. Furthermore, each player knew the history quantity decisions of paired players. In these games, we employed a matching design in which reputation effects were not feasible (The reputation effects from repeated play against a fixed opponent could not arise.).

5.2.2 Ten Periods Repeated Interactions

To explore the effects of repeated play on collusion, 40 players, in two separate cohorts, each played seven 10-fold repetitions of Cournot interactions. Each subject played the same opponent 10 times as either a row or column player. Players were then anonymously matched with new opponents and play continued for 10 more periods. Moreover, so on, till seventh rematches finished. Nogroup players randomly paired seven times, and they could not meet twice. Players of ingroup treatment randomly paired seven times with ingroup members; the same pair happened once. Players of outgroup treatment would pair seven different outgroup members. In each supergame, the current current supergame pair's history quantity decisions and history profits are the common public information for paired two players. However, when players were re-matched, they were not told anything about the history of play of their new opponent in the previous supergames.

5.2.3 Indefinitely Periods Repeated Interactions

The indefinite horizon supergame was constructed as follows. Following play of the stage game, a random draw was made from a uniform distribution over the range [1,100]. The draw was made by the computer program that was used to experiment. If the draw was less than or equal to 90, players were matched according to the given protocol, and the stage game was repeated. If the random draw exceeded 90, the supergame was ended. Thus, the probability, p, that a supergame continues is 0.90 and the expected number of future rounds to be played from the perspective of any period reached is always $\frac{1}{1-p}$ or 10. This is equivalent to an indefinite horizon where the discount factor attached to future payoffs is 0.90 per period. Each subject played the same opponent randomly determined times as either a row or column player. Players were then anonymously matched with new opponents and play continued for randomly determined periods. Moreover, so on, till seventh rematches finished. Nogroup players randomly paired seven times, and they could not meet twice. Players of ingroup treatment randomly paired seven times with ingroup members, the same pair happened once. Players of outgroup treatment would pair seven different outgroup members. In each supergame, the current pair's previous quantity decisions and previous profits are the common information for current paired two players. However, when players were rematched, they were not told anything about the history of play of their new opponent. The length of each indefinitely repeated game (supergame) should average 10 periods, our goal of 70 periods per session was satisfied by playing an average of 7 indefinitely repeated games per session. Of course, due to the random end of each indefinitely repeated game, there is some variation in the periods.[24]

5.3 Payoffs

The profits were presented in a payoff matrix (Figure 3), the participant's profits in each market for any combination of the participant's quantity choice and quantity choice by the opponent in that market. The demand systems and quantity choices sets are chosen to that the resulting payoff matrices are as close as possible: we have identical diagonal elements, which including

[24]The lengths of the finitely repeated game were chosen to coincide with the expected lengths of the indefinitely repeated ones.

collusion, Nash, identical temptation and sucker payoffs, as well as altruistic outcomes and perfect competition outcomes. The game has Nash equilibrium $q_i = q_j = 8$ and an optimal collusion outcome, the symmetric Joint payoff maximum (JPM) $q_i = q_j = 6$. With no loss of theoretical generality, the table normalizes the "collusion" payoff at 81 and the "sucker" payoff at 54. The sucker temptation profile (6, 9) and (9, 6) also yield a lower payoff sum than the collusion profile (6, 6). Thus, the dilemma: the equilibrium is inefficient. The player i is the research subject, Table 2 shows the feature details of the Cournot interactions. The slop of -1, which means that the product is perfect substitute. The players' own quantity choices and profits in the previous are basic information to player i. The additional information in the repeated games, the current paired player j's history quantity choice and profits. And, 'T' is the total periods in each supergame interactions, δ is the probability of game continuity at this period. ω is the parameter of the group identity.

Figure 3: Payoff matrix

	0	6	7	8	9	12
0	(0,0)	(0,108)	(0,119)	(0,128)	(0,135)	(0,144)
6	(108,0)	(72,72)	(66,77)	(60,80)	(54,81)	(36,72)
7	(119,0)	(77,66)	(70,70)	(63,72)	(56,72)	(35,60)
8	(128,0)	(80,60)	(72,63)	(64,64)	(56,63)	(32,48)
9	(135,0)	(81,54)	(72,56)	(63,56)	(54,54)	(27,36)
12	(144,0)	(72,36)	(60,35)	(48,32)	(36,27)	(0,0)

Table 2: Parameters of the Cournot interactions

Cournot	Quantity choices			Profits			Information			Other-regarding
	Nash	JPM	Defect	Nash	JPM	Defect	Slope	Baseline	Addition	
One-shot	8	6	9	64	72	81	-1	$q_{i,history}$ $\pi_{i,history}$		$\omega \in [-1, 1]$
Finitely	8	6	9	64	72	81	-1	$q_{i,history}$ $\pi_{i,history}$ T=10	$q_{j,history}$ $\pi_{j,history}$	$\omega \in [-1, 1]$
Indefinitely	8	6	9	64	72	81	-1	$q_{i,history}$ $\pi_{i,history}$ $\delta = 0.9$	$q_{j,history}$ $\pi_{j,history}$	$\omega \in [-1, 1]$

5.4 Procedures

All sessions were programmed and conducted using the O-Tree (D. L. Chen, Schonger, & Wickens, 2016) experimental software at the laboratory of Wuhan University, a university of approximately 85800 students. Participants were randomly recruited through Wechat software, who were allocated to computer terminals programmed in O-tree in the laboratory such that they could not infer with whom they would interact. In each session, there were 40 participants, and every participant is allowed to take part in only one session. Before the beginning of a session, instructions were read aloud to all participants. Participants were also given a written copy of the instructions with the payoff tables. The experiment began after all players make sure the experimental details are understood correctly. All substantive questions about the instructions were answered out loud to ensure common knowledge. Participants completed this procedure within 90 minutes. The individual total monetary return equals to the sum of self-cumulative earnings in all periods, the correct answers to the paintings, and the 15 yuan show up fee. The exchange rate was 100 points for 1.5 yuan. The average earnings were over 60 yuan per person in different nine experiments. Experimental instructions are included in Appendix B. Participants simultaneously and independently choose a quantity q_i for the production of homogeneous boxes. A table with payoffs and quantity choices from all previous periods was displayed whenever the payoff matrix was displayed except at the wait pages. A post-experiment survey was conducted to collect information on demographics and participants' experiences with the tasks during the experiment. For the group treatments, the questions in the questionnaire of step 2 of Part one will be asked again at the end of the experiments.

Our study involves the development and application of a tool: a simple measure of group identity designed to summarize the sense of belongingness that exist to any groups. We examined the effectiveness of inducing artificial group identity in the two experimental questionnaires. In the experimental design, players were not only classified into two different groups, and then communication was allowed within the group to share information on paintings guessing in the group treatments. Following the group membership assignment discussion, members were asked privately to given their own personal recommendation for paintings' questions, which might or might not differ from the group discussion. Once groups are identified, then the strength of their identities can be measured as the mean of the degree of the identification of individual members with the group, adjusted for the degree of variation. Players were asked to give several evaluative ratings (on a scale of 1 (not at all) to 10 (very much)) if in/outgroup members), before and after the Cournot competitions. "What is your group name?" "The sense of belongingness to the Donghu group?" "The sense of belongingness to the Luojiashan group?"

6 Hypothesis

The experiment design and the unique set of subjects enable use to develop behaviour hypotheses on how the group identity might affect quantity choices, collusion and punishment behaviour in the Cournot interactions environment. If individuals do not experience group assignment, they will always choose Cournot Nash quantity ($\widetilde{q} = 8$) in the one-shot interactions and finitely repeated interactions, because this is a dominant strategy (Fouraker & Siegel, 1963; Holt, 1993; Huck et al., 2004). Especially, the punishment will not induce collusion in the one-shot interactions. Similarly, for the punishment phases in the repeated interactions, a selfish individual would never choose costly punishment choices ($q > 8$). Let us briefly summarize our predictions. First, the interaction between other-regarding preference and group identification is expected in quantity choices. If the goal transformation hypothesis is correct, then the behaviour of individualism should be affected by the group assignment that is different (nogroup versus ingroup versus outgroup). Second, the interaction between other-regarding preference and group identification is expected in collusion and JPM. When a group succeeds, the group identity plays different degree roles in the three different repeated Cournot interactions. Finally, the interaction between identification, collusion, and the other-regarding preference in the one-shot games (unconditional preference) and in the repeated games (conditional preference) are intriguing.

6.1 Hypotheses I

How do individuals' quantity choices vary depending on whether group membership has been assigned or not? Does the group contingent other-regarding preference determine the Equilibrium quantity choices? The determinant of the group identity impacts on the Nash equilibrium in three different Cournot interaction devices.

Hypothesis 1. *All else being equal, the quantity choices of ingroup players are lower than nogroup players' and outgroup players' in the one-shot Cournot interactions.*

Hypothesis 2. *All else being equal, the quantity choices of ingroup players are lower than nogroup players' and outgroup players' in the ten-periods finitely repeated Cournot interactions.*

Hypothesis 3. *All else being equal, the quantity choices of ingroup players are lower than nogroup players' and outgroup players' in the indefinitely repeated Cournot interactions.*

6.2 Hypotheses II

How frequently are quantity choices optimal? Does the group identity determine the likelihood of individual collusion and JPM? Group identity varies the one-period deviation temptations, the utility gains from collusion deviation in ingroup matchings are lower than outgroup matchings and nogroup matchings. The ingroup matching participants are more likely to choose collusion quantity choices ($q_i = 6$), compared with the other two matchings.

Hypothesis 4. *The group identity changes an individual's (pair's) chances of reaching collusion in the finitely repeated interactions.* $Pr(\widehat{q}_i^{\,I} = 6) > Pr(\widehat{q}_i^{\,N} = 6) > Pr(\widehat{q}_i^{\,O} = 6)$*, and* $Pr(\widehat{q}_i^{\,I} = \widehat{q}_j^{\,I} = 6) > Pr(\widehat{q}_i^{\,N} = \widehat{q}_j^{\,N} = 6) > Pr(\widehat{q}_i^{\,O} = \widehat{q}_j^{\,O} = 6)$

Hypothesis 5. *The group identity changes an individual's (pair's) chances of reaching collusion for the indefinitely repeated interactions.* $Pr(\widehat{q}_i^{\,I} = 6) > Pr(\widehat{q}_i^{\,N} = 6) > Pr(\widehat{q}_i^{\,O} = 6)$*, and* $Pr(\widehat{q}_i^{\,I} = \widehat{q}_j^{\,I} = 6) > Pr(\widehat{q}_i^{\,N} = \widehat{q}_j^{\,N} = 6) > Pr(\widehat{q}_i^{\,O} = \widehat{q}_j^{\,O} = 6)$

6.3 Hypotheses III

Once joint profit maximization achieved, does the group identity determine the deviation degree and punishment degree?[25] Bernhard, Fehr, and Fischbacher (2006) find individuals were more willing to punish those who had harmed members of their own group. Similarly, Y. Chen and Li (2009) and Kollock (1998) find that individuals are more willing to punish outgroup members in response to actions considered unfair.

Hypothesis 6. *The quantity choices upward adjustments of ingroup matchings are lower than the outgroup matchings and nogroup matchings.*[26]

Hypothesis 7. *The reaction to a deviation from the collusive path,* $q^*(I) < q^*(N) < q^*(O)$.[27]

6.4 Hypotheses IV

Does the group identity determine the duration of collusion and JPM? The threat that competition (punishment phases) and gains from deviation determine the actually stabilizes collusion. (Kreps et al., 1982).

Hypothesis 8. *Severe threats of penalties lead that collusion quantity choice will be more sustained in the outgroup matching than in other two matchings. Ingroup matching decreases the duration of JPM,* $t^{c(I)}$*, compared to outgroup* $t^{c(O)}$*, or nogroup matching* $t^{c(N)}$ *in the finitely repeated interactions.*

The different group identity also changes the critical discount rate at which collusion can be sustained ($\delta^{c(I)}, \delta^{c(N)}, \delta^{c(O)}$). For example, the high critical discount factor decreases the range of firms' discount factors, and then lower the collusion sustainability.

Hypothesis 9. *The group identity varies the range of the critical discount rate at which collusion can be sustained. For example, if* $\omega_i^g \in [-1, 0.5]$*, for the high levels of group contingent other-regarding of the firms, it is easier to sustain collusion. However, the opposite happens if firms' group contingent other regarding are above the 0.5.*

[25]The determinants of group identity impact on the punishment policy and punishment degree. Defection in public good or prisoner's dilemma games creates strong negative emotions. These negative emotions are particularly strong toward group members who contribute less than average (Fehr & Gachter, 2000; Fehr & Gächter, 2002b; Gächter, Herrmann, & Thöni, 2004)

[26]The gains from quantity choices were adjusted upwards ($R_i^g(\hat{q}_j)$) (see Figure C19)) are lower for the pairs who are in the ingroup matchings, compared with nogroup matchings.

[27] The material profits π^p in punishment phases are higher in the ingroup matchings when the collusion agreements were broken down, compared to outgroup or nogroup matching. Furthermore, a more salient group contingent other-regarding increases $\pi_i(q^{p(g)})$, the ingroup matching players will be more likely to forgive the defectors.

6.5 Hypotheses V

Does the group identity determine the strategies and impact on the quantity choice adjustment paths? The possibility of punishment appears to be a powerful tool for sustaining social capital (Fehr & Gächter, 2002b). Group identity introduces a condition that ensures that the concerns on the opponent's payoff increase if the opponent chooses a nicer strategy. Players are marginally more likely to choose tit-for-tat with the ingroup matchings than with the outgroup matchings (Li & Liu, 2017). McLeish and Oxoby (2007) find that individuals punished members of their own group in response to the violation of tacit norms. Similarly, Stroebe, Lodewijkx, and Spears (2005) document that, under certain conditions, the ingroup members created ingroup interactions higher rates of cooperation and more negative punishment between ingroup members has seven been proposed by the theoretical literature: Bénabou and Tirole (2006) and Akerlof and Kranton (2005) propose that the violation of ingroup norms by ingroup members can been seen as threat to the identity of the group, as such, individuals are motivated to buoy up the value of the group identity by punishing the offender.

Hypothesis 10. *If own material profits increased between two previous periods, but the opponent's material profits did not; the ingroup matchings will be more likely to cut down the quantity to cooperate at the current period, caused by the quantity choice adjustment norms enhanced by the group identity.*

6.6 Hypotheses VI

Does the group identity determine identical effects in three different repeated devices?

Hypothesis 11. *Adding repeated competition within groups cause even stronger ingroup favouritism, but also a qualitative change in punishment.* $q_i^I(One-shot) > q_i^I(Finitely) > q_i^I(Indefinitely)$

Part III

RESULTS

Introduction

In this chapter, the impact of group identity on players' quantity choices in Cournot interactions on collusion is investigated. Herein, a fundamental question that must be dealt with at the outset is whether group identity primed would alter their behaviour? Will the explicit awareness of mutual interdependence alter their behaviour? The chapter reports the results of the experiment which was designed to determine whether group assignment subjects can learn to play Cournot duopoly strategies and whether their out-off equilibrium play is consistent with the predictions of models.

There are several ways to test the impact of primed group identity. For example, to determine whether there is a difference in the number of duopolies who reach the collusive outcome in the three different Cournot interaction devices, and to find whether the lengths of periods are different to reach a collusive outcome are effective methods. Moreover, the difference in the types of equilibrium behaviour among three cases is another indicator.

The main result of this chapter is that the players' behaviour depends on group membership and on the Cournot repeated devices. The initial level of group identification determines whether group members are likely to set themselves apart from the rest of their group. In that case, the intra-group and inter-group evaluations would be different. The experimental results are summarized as follows: the aggregate treatment effects of group identity on outputs were presented. Afterwards, the effects of group identity on individual collusion selection and joint payoff maximization were analyzed. Group identity plays two opposite effects on collusion. In these three different repetition interactions of Cournot competitions, different roles are played by the group identity based on individual quantity choices. Section 7 presents the results of one-shot games with group identity considered. Section 8 reports the results of finitely repeated games influenced by group identity. Section 9 discusses the analysis results of indefinitely repeated games. In section 10, the conclusion is reached, and further discussion is performed.

Several standard features are applicable throughout our analysis and discussion. Firstly, the standard errors in the regressions are clustered at the session level as the control for the potential dependency of decisions across individual within a session. Second, a 5% statistical significance level is set as the threshold (unless stated otherwise) to establish statistical significance.

Manipulation Check (Group Identity Analysis)

The strong primed group identity is the premise for result analysis. In this experiment, the subjects were divided into two groups, and communication was only allowed within the group. Once the groups were identified, the strength of their identities can be measured by the mean of the identification of individual members with the group, adjusted for variation. Subjects were asked to give several evaluative ratings, on a scale from 1 (not at all) to 10 (very much). Moreover, the same questions were asked twice, one after the painting-question task was completed and the second at the end of the Cournot interaction. The two questions are: (1) "The sense of belongingness to Luojiashan group?" (2) "The sense of belongingness to the Donghu group?"

The Table 3 shows the self-reported measures of the sense of belongingness to x_{group} (own_{group}, $other_{group}$).

Table 3: Self-reported the sense of belongingness to $own/other_{group}$

	Obs.	Rating				t-tests			
		Own group		Other group		Before vs After		Own vs Oth	
		Before	After	Before	After	Own	Other	Before	Afte
One-shot									
Ingroup	40	5.78 (0.04) [5.70,5.85]	5.65 (0.04) [5.57,5.74]	2.08 (0.04) [2.00,2.15]	2.10 (0.04) [2.03, 2.17]	0.00	0.02	0.00	0.00
Outgroup	40	7.30 (0.04) [7.21,7.38]	7.20 (0.04) [7.11,7.28]	3.06 (0.06) [2.95,3.17]	2.73 (0.05) [2.63,2.83]	0.00	0.00	0.00	0.00
Finitely									
Ingroup	40	7.63 (0.03) [7.56,7.69]	6.23 (0.04) [6.15,6.30]	1.85 (0.04) [1.78,1.92]	1.70 (0.03) [1.64,1.76]	0.00	0.00	0.00	0.00
Outgroup	40	6.63 (0.04) [6.54,6.71]	6.45 (0.04) [6.37,6.53]	1.68 (0.03) [1.62,1.73]	2.20 (0.03) [2.13,2.27]	0.00	0.00	0.00	0.00
Indefinitely									
Ingroup	40	7.13 (0.04) [7.05,7.20]	6.58 (0.03) [6.51,6.64]	2.43 (0.04) [2.34,2.51]	2.10 (0.03) [2.34,2.51]	0.00	0.00	0.00	0.00
Outgroup	40	7.20 (0.03) [7.14,7.26]	6.80 (0.03) [6.74,6.87]	2.50 (0.05) [2.41,2.59]	2.35 (0.04) [2.27,2.43]	0.00	0.00	0.00	0.00

Notes: I report the average the sense of belongingness by treatments in three different interacted repeated devices.
The number of the participants in each treatment is noted in the second column (the observations).
From the third column to the sixth column, I report the average of the ratings to own group and the other group,which include the sense of belongingness to x_{group} before and after Cournot interactions.
Two-sided p-values of the t-test are reported in the last four columns: The differences of the sense of belongingness to own/other group between before and after Cournot interactions.
Standard deviations in the parentheses; 95% confidence intervals in the square brackets.
The preferences of individuals facing the same quantity choices at different period are same.[28]

The first column contains the group treatments and the different devices of the repeated Cournot interactions. Across the treatments, the mean ratings of the sense of belongingness to own group before and after Cournot interactions are listed in the column (3). The ratings of the sense of belongingness to the other group before and after Cournot interactions are illustrated in the column (4). The players display the naturally positive valued distinctiveness for their own group with which can be identified from the other group (Ingroup favouritism). The left numbers of column (3) and (4) are the ratings of the sense of belongingness before Cournot interactions, and the numbers in the right are the ratings of the sense of belongingness after Cournot interactions. The mean ratings of own group are significantly higher than those of the other group beyond the 0.000 level, regardless of the timing of Cournot interactions. The table also shows that the mean rating differences of own-group and the other-group are significant before and after Cournot interactions at 0.02 level. The group identity has been primed successfully, showing a significant bias in favour of ingroup members. The sense of group identity is entirely lower after Cournot interactions than that before the quantity interactions, implying the social identity vanishes with interactions.[29][30]

The results in this study show that quantity choice is dependent on group identity and Cournot repeated devices (one-shot, finitely repeated, and indefinitely repeated). When the player makes quantity decision in the one-shot, the difference of individual quantity choices is insignificant. Group effect is present in the repeated interactions no matter the outcome is finite or indefinite. Differences were found in these two cases.

7 Study I: One-shot Interactions

First of all, we examined the effects of group identity on individual quantity choice distributions of one-shot interactions. The pairs were re-matched randomly before a period (there are no conjectures on coplayer play from the last period).[31] One participant made quantity choice decisions in one of three pair-matchings (nogroup matching, ingroup matching and outgroup matching). In the nongroup matching (Nogroup treatment), no group identities were induced among players, so that we could measure the quantity choices in our Cournot interactions in the absence of group identity effect. The impact of (homogeneous and heterogeneous) group identities was then analysed by comparing quantity choices in the ingroup matchings (Ingroup treatment) and outgroup matchings (Outgroup treatment). No solid evidence was found to show that group identity could provide the incentive to the higher degree of collusion in the

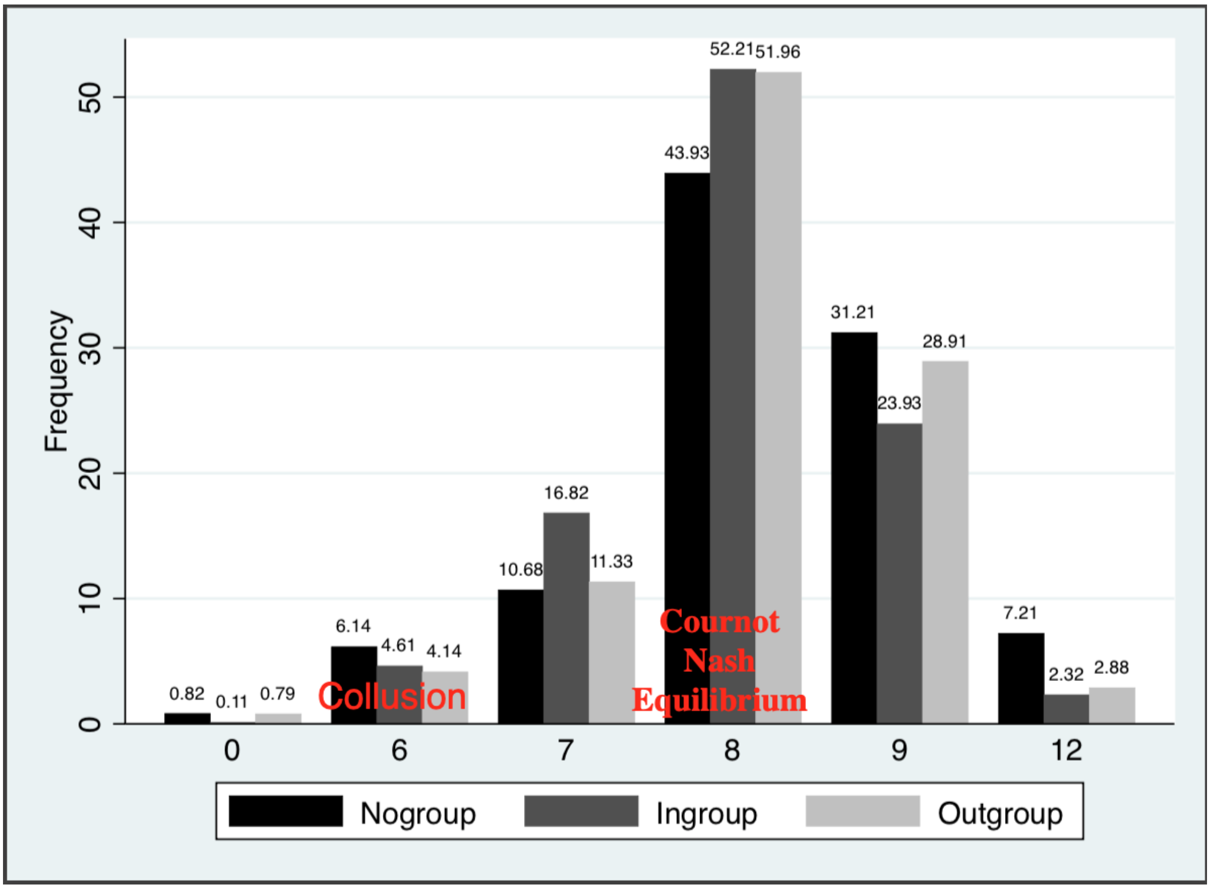
[29] The analysis of communication during the group identity formation stage indicates that asking and receiving help during this stage does not affect the quantity choice decisions significantly in all nine treatments during the game. The correlation between chat program help in the group identity assignment and the sense of belongingness to own group implies that general reciprocity is a driving factor for the difference between the identity and the no identity treatments.

[30] In addition, the difference in the sense of the belongingness to own (the other) group among three Cournot interactions are not significant ($p > 0.1$).

[31] We pool all players quantity choices by treatment, and calculate the Pearson correlation coefficient. Nogroup treatment: Pearson correlation was 0.004; t-test is 0.834 (The correlation coefficent is not significantly different from zero. We thus do not find strong evidence in favor of best-response play for nogroup matchings.). Ingroup treatment: Pearson correlation was 0.050; t-test is 0.009. Outgroup treatment: Pearson correlation was 0.073; t-test is 0.001. The results for In/Outgroup duopolies are with the Pearson correlation coefficient being positive. The t-test comparision suggests that the coefficient is statistically different from zero. In other words, the strategic substitutability relation does not hold, and instead output choice corresponds to strategic complementarity for ingroup and outgroup matchings. The ingroup matchings and outgroup matchings are trying to achieve collusion by adjusting their quantity choices in the same direction, even if the collusion is difficult to sustain successfully.

ingroup matchings, compared with that in the nogroup matchings and outgroup matchings in the one-shot Cournot interactions.

Figure 4: One-shot interactions: Quantity choices distributions over different treatment



H_0: There are no quantity choices distribution differences between nogroup matching and ingroup matching; there are no quantity choices distribution differences between nogroup matching and outgroup matching; there are no quantity choices distribution differences between ingroup matching and outgroup matching.

As showed in Figure 4, the histograms of quantity choices in each treatment are illustrated. Each player made quantity choice decisions over six possible choices (0, 6, 7, 8, 9, 12) during a total of 70 periods. For example, in the nogroup matching, the implications of 6.14% ($\frac{172}{2800}$) indicate that there are 172 collusive observations ($q_i = 6$) out of the total observations (2800) in the one-shot interactions. As seen in the graph, the quantity choices are almost identical in all three matchings. For all treatments, the choice of non-cooperation ($q_i = 8$) is the most dominant one. Kolmogorov-Smirnov test was used to analyse the quantity choice of distributions. The null hypothesis is that there is no difference on distributions among three different treatments: nogroup≠ingroup (p<0.001, two-sided); nogroup≠outgroup (p<0.001, two-sided); ingroup≠outgroup (p<0.001, two-sided). Although, the test results reject the null hypotheses, and the pairwise comparative results are significantly different. The shapes of quantity choice distributions among three group treatments are very similarly, those marginal differences can be ignored.

7.1 The Impact of Group Identity on Quantity Choices

In an effort to further analyse the group identity effects on the individual decisions, the mean quantity choices by the three different treatments are listed in Table 4.

Result 1. *Group identity affects the distribution of quantity choices in the one-shot game, but not briefly. Most players choose the standard Nash equilibrium quantity choice in all three different matchings. The test results illustrate that players with group assignment have slightly, but light significantly less average quantity choices than those without group assignment in duopoly interactions.*

Table 4: One-shot interactions: Individual average quantity choice by treatment

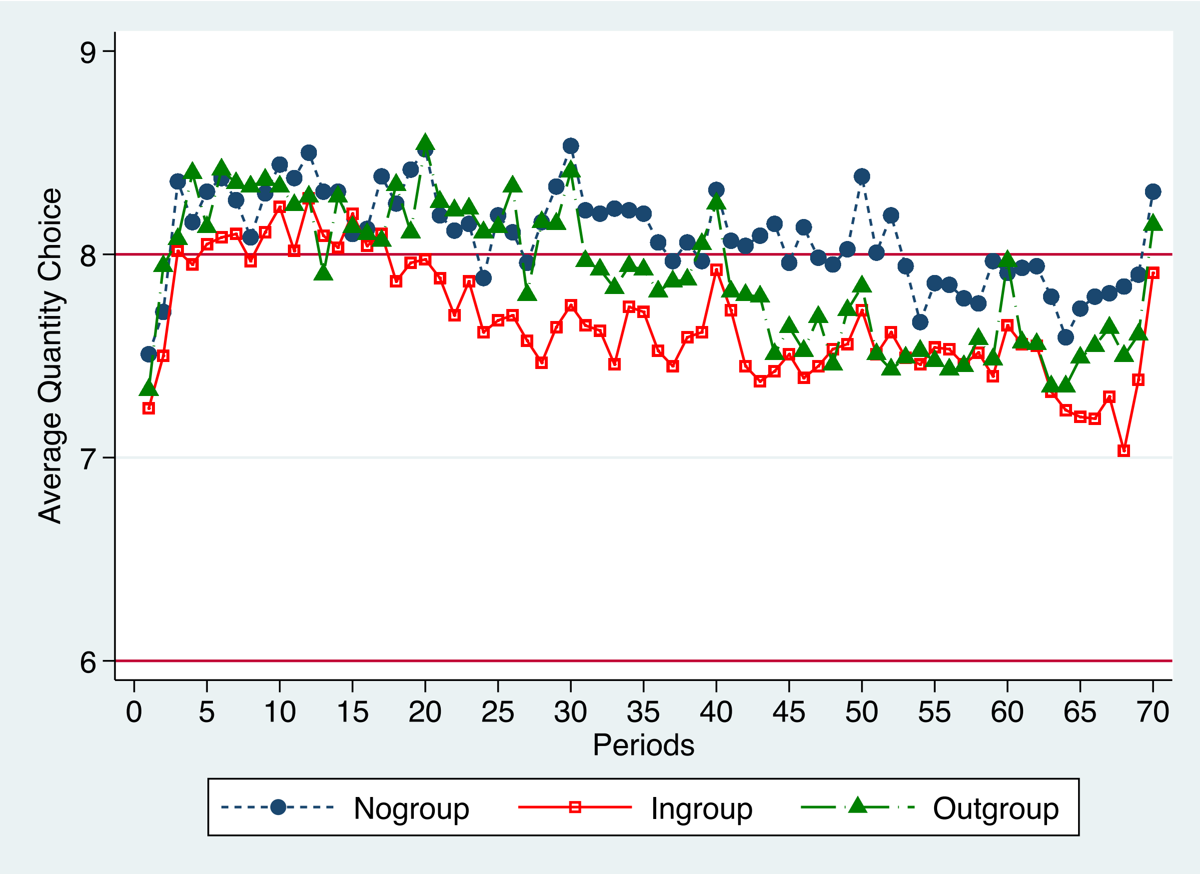
Periods	Obs.	No Mean (SD)	In Mean (SD)	Out Mean (SD)	p-values (t-test) No vs In	No vs Out	In vs Out	p-values (ranksum) No vs In	No vs Out	In vs Out
All Periods	8400	8.31 (1.50)	8.06 (1.01)	8.09 (1.40)	0.00	0.00	0.42	0.00	0.00	0.00
1-35 Periods	4200	8.28 (1.61)	8.12 (1.16)	8.33 (1.42)	0.00	0.47	0.00	0.00	0.02	0.00
36-70 Periods	4181	8.33 (1.37)	8.01 (0.84)	7.96 (0.97)	0.00	0.00	0.00	0.00	0.00	0.60

I report the average quantity choices by individuals.
The number of observations in each situation is noted in the second column.
This table also provides the t-test and Mann-Whitney U test.
Unless otherwise indicated, all p-values are based on the two-side test applied to group averages.
All statistical test reported in the paper is applied to 40 independent players per treatment.
Due to the network failures, some players could not choice quantity in the limited time (45 seconds) after 63^{rd} period.

Was the effect of discrimination on group identity positive or negative? Table 4 and Figure 5 provide econometric and graphics results which summarize the statistic details of average quantity choices of individual players for all periods combined (1-70), and for the separation in the first half (1-35), and the second half (36-70) of the experiment. The third, fourth and fifth columns list the mean value and its standard deviation of the individual quantity choices for nogroup treatment, ingroup treatment and the outgroup treatment; respectively. The differences in average individual quantity choices for different treatments were tested using two-sided t-test and non-parametric Mann-Whitney U-test (please refer to the last six columns).

The null hypotheses were overall rejected in favour of the alternative hypothesis that the individual quantity choices are significantly different between ingroup treatment and outgroup treatment. In all cases, the average quantity choices is close to the Nash equilibrium quantity ($q_i = 8$), and the trend became stabilized gradually.

Figure 5: One-shot interactions: The average of quantity choices by treatment



The Cournot Nash Equilibrium level of quantity choice is at 8. The Collusion level of quantity choice is at 6.

In the nogroup matching condition, the average of quantity choices was 8.31, and the quantity choices were fairly stable across all periods, averaging 8.28 in the first half periods of experiment and 8.33 in the last half periods. The players had significantly lower value in the ingroup matching, averaging 8.12 in the first half of the experiment and 8.01 in the last half. Across all periods, the quantity choices were 0.25 higher in Nogroup than those in Ingroup (8.31 versus 8.06), and the difference is statistically significant ($p<0.01$). Therefore, the two players shared a common group identity, and they were inclined to cut quantity choices relative to the nogroup matching. In regard to the players' quantity choices in the outgroup matchings, the averages across all periods were lower than players' quantity choices in the nogroup matching (two-sided t-test: $p<0.01$; two-sided Wilcoxon signed rank tests: $p<0.01$). No significant difference was found between the average quantity choices in the ingroup matchings and those in the outgroup matchings across all periods (8.06 versus 8.09 and $p<0.01$).

7.2 Regression Analysis of Quantity Choices

As shown in Table 5, in the one-shot Cournot interactions, where the quantity decisions chosen across periods are independent. The players in the different treatments chose different quantity levels. A simple OLS regression model was used to analyse how group identity influences individual quantity choices and how this impact evolves over periods, with robust standard errors estimated with clustering at the session. The dependent variable for those three regressions is the individual quantity, while the independent variables for regression include dummy variables which describe whether the player participated in an ingroup or an outgroup session. The case of nogroup was omitted. Two other independent variables in both regressions were the interaction terms between matching groups and a dummy variable for the periods in each session. Ingroup (Outgroup) is a dummy variable that takes the value i for players of ingroup (outgroup) matchings or 0 otherwise scenario. Periods∗Ingroup and Periods∗Outgroup are the interactions of periods and treatments. Columns (2) and (3) control for the periods' trend. In the Table 5, the coefficient for the ingroup treatment dummies (p=0.242 for (1) and (2), and p=0.674 for (3)). As for the outgroup dummies (p=0.108 for (1), and p=0.106 for (2), and p= 0.207 for (3)) are not significant. The significant negative coefficients for the Periods∗Ingroup and Periods∗Outgroup interaction ($p<0.05$) reveal that the players' reduction quantity choices more than those of no group assignment players. In the One-shot Cournot interactions, the players in different sessions had slightly different quantity choices throughout the experiment. While the players in the ingroup treatment showed a slightly lower level of quantity choices than players in the nogroup treatment.[32]

[32] R. Chen and Chen (2011) did not find outgroup derogation in minimum effort games, while Deaux (1993) observed the negative behavior towards outsiders.

Table 5: One-shot interactions: Treatment effects on the individual quantity choices

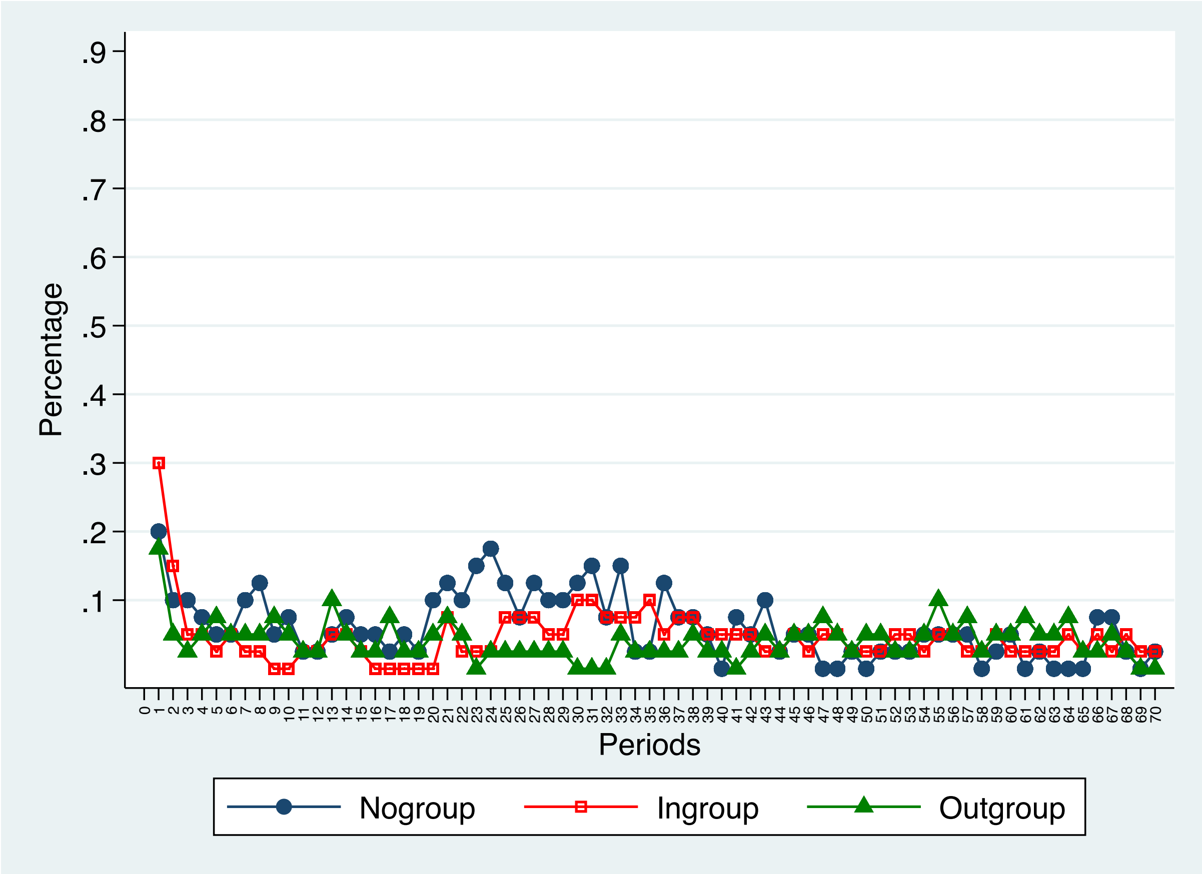
	(1)	(2)	(3)
Constants	8.305***	8.429***	8.256***
	(0.00)	(0.09)	(0.00)
Ingroup	-0.242*	-0.242*	-0.063
	(0.09)	(0.09)	(0.11)
Outgroup	-0.160***	-0.161***	0.182***
	(0.00)	(0.00)	(0.00)
Periods		-0.003	0.001***
		(0.00)	(0.00)
Periods$*$Ingroup			-0.005***
			(0.00)
Periods$*$Outgroup			-0.010***
			(0.00)
Observations	8381	8381	8381
r^2	0.006	0.009	0.013
r^2 Adjusted	0.006	0.009	0.013

Standard errors in parentheses * $p<0.1$, ** $p<0.05$,*** $p<0.01$

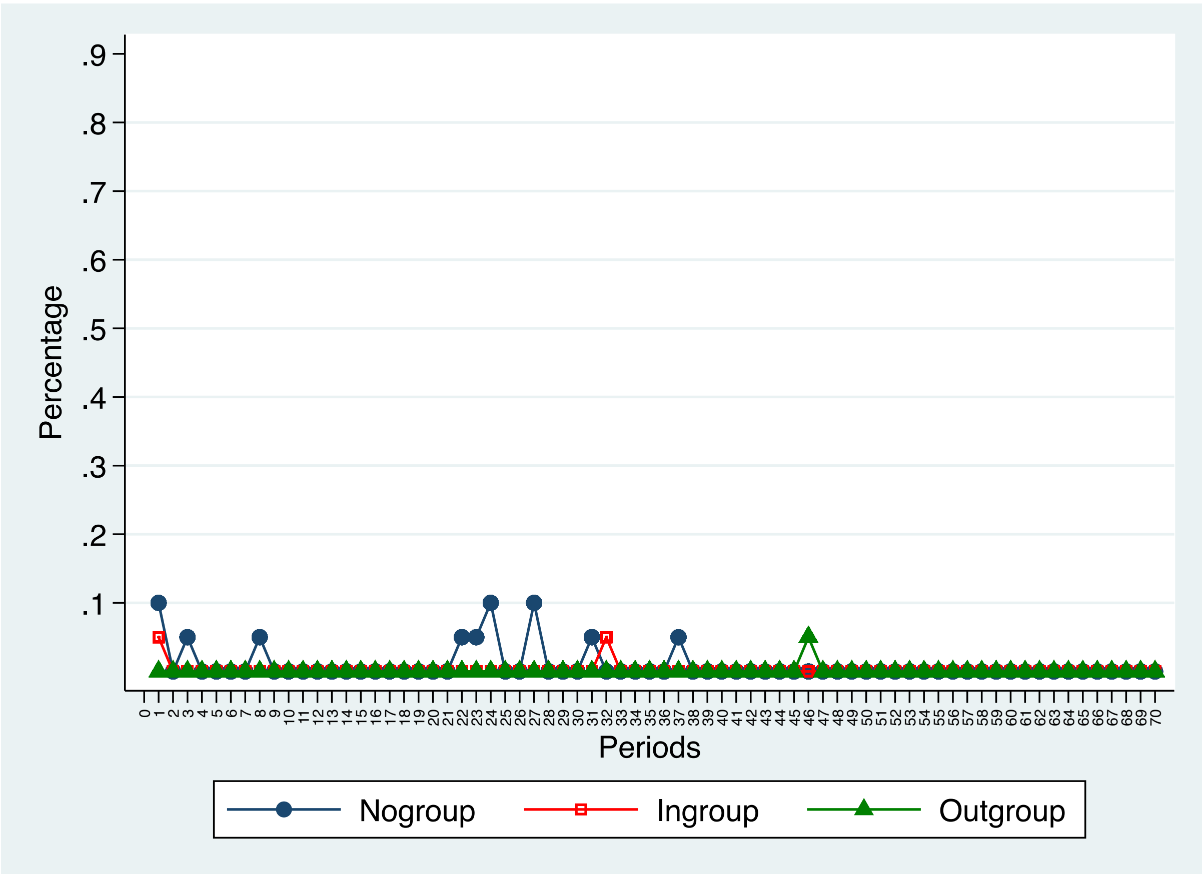
In the one-shot interactions, the effects of the treatments were negligible, especially for the individual collusion strategies. As seen in the Figure 6a and Figure 6b, the low percentage of individual collusion strategy and market JPM chosen among players and pairs are apparent.

Result 2. *The successful primed Group identity could not modify the individuals' dominant quantity choice decisions across all group treatments through group contingent other-regarding preferences hypotheses.*

Figure 6: One-shot interactions: Rate of choice of collusion over periods by treatment



(a) One-shot interactions: $q_i = 6$



(b) One-shot interactions: $q_i = q_j = 6$

In summary, in the repeated games which allowed for re-matching, collusion tended to vanish with prolonged periods, and most quantity choices shifted back to the Cournot level. Our results suggest that no special treatment is needed in our one-shot experiment to induce the distinction between the ingroup and the outgroup collusion.

8 Study II: Finitely Repeated Interactions

What is commonly observed in the experiments involving finitely repeated Cournot interactions is that players do not always play the dominant Cournot Nash strategies Huck, Normann, and Oechssler (2002); Huck et al. (2004). Instead, they seek to achieve a certain extent of collusion. In the one-shot games, we find that the number of collusive play increases when players interact for a finite number of plays, yet the pattern of individual play is not consistent with the prediction of Kreps et al.[33] Further, the dynamic pattern of collusion predicted by the theory does not agree with the observed aggregate pattern of play, because the collusion rates do not decline as quickly as predicted in the theory. For the multi-periods repeated games, the analysis consist of the following aspects, the average quantity choices, the percentage of individual collusion quantity choices ($q_{i,t} = 6$), the percentage of market joint payoff maximization ($q_{i,t} = q_{j,t} = 6$), the punishment explanations, the impacts of other group identity on the quantity choices (e.g., inequality aversion, reciprocity, and so on).

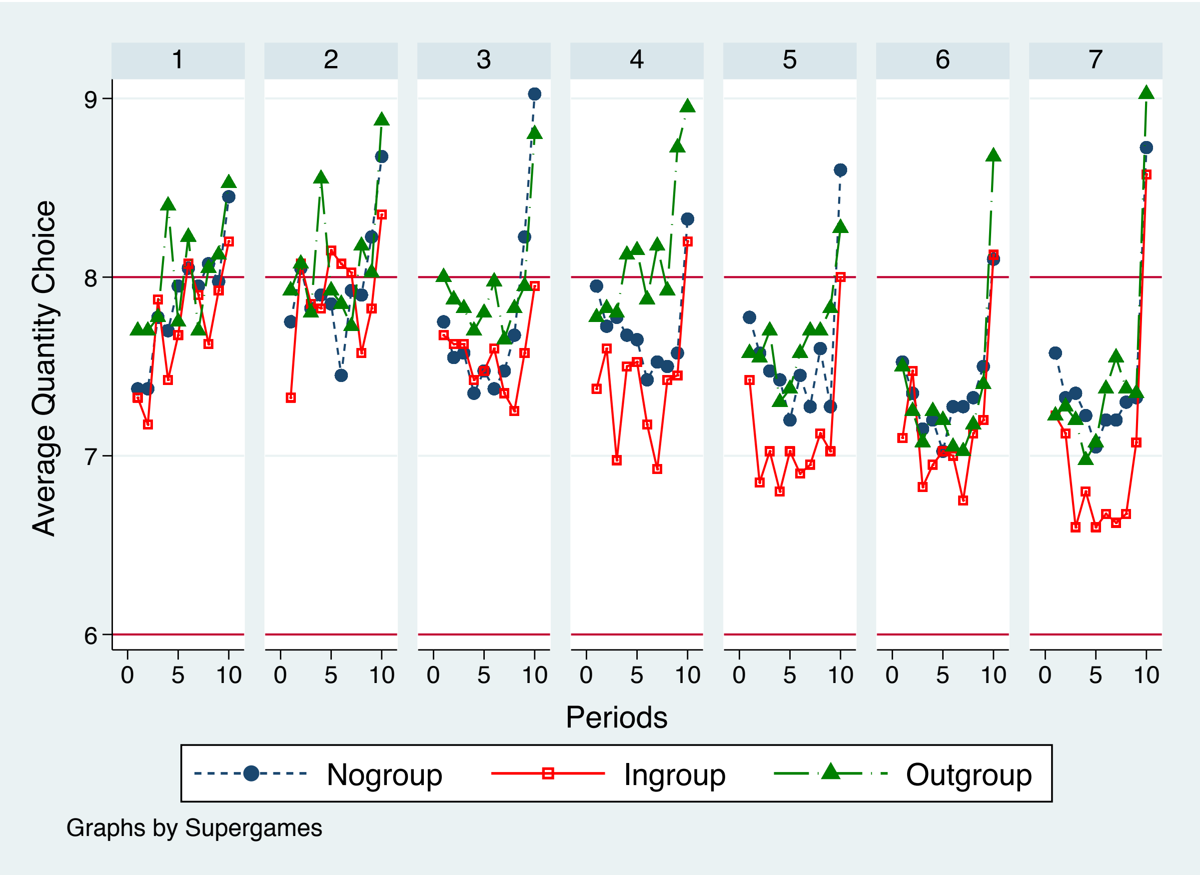
In a market with fixed matching, we observe that the ingroup favouritism tend to increase overtime slightly, and outgroup derogation decreases overtime slightly. This could be reflected in the decreased quantities overtime, and it could be attributed to the increased number of successfully colluding pairs. This observation is crucial for the understanding why experiments suggest contradictory patterns with respect to backward induction.[34] We find that the level of cooperation in the final round of the finitely repeated games is similar to that in one-shot games.

[33] Ferreira. J and Kujal. P who find that the quantity choices of experienced duopolies are more closer to the monopolistic outcome than quantity choices of inexperienced duopolies. Our treatments are very similar with the inexperienced duopolies treatments.

[34] The lengths of the finitely repeated games are chosen to coincide with the expected periods of the indefinitely repeated ones.

8.1 The Impact of Group Identity on Quantity Choices

Figure 7: Finitely repeated interactions: Average quantity choices over supergames and periods



The Cournot Nash Equilibrium level of quantity choice is at 8. The Collusion level of quantity choice is at 6.

Result 3. *There exists the obvious ingroup favouritism. The ingroup effects increase over experiments. The following relationship between the three treatments satisfies:* $q_i^I < q_i^N < q_i^O$. *The ingroup (outgroup) matching promotes declined (increased) quantity choices. Group assignment leads participants to cut down their output and obtain higher payoffs.*

We observe ten-periods of Cournot interactions under the condition of three different group identities. As illustrated in Figure 7, the horizontal axis is the number of supergames and the number of the periods in each supergame, while the vertical axis is the quantity choices. The navy (dot), the red (solid) and the green (dash) connecting the lines represent the time series of the average quantity choices over all periods in the nogroup treatment, ingroup treatment and outgroup treatment; respectively. The decreasing trend over the whole finite repeated games is obvious. Beyond the downward trend in individual quantities, the crucial differences among the three treatments appeared an apparent "end game effect" in different intercepts and slopes. After the second supergame, the differences among the three treatments enlarged. From an overall perspective, individual quantity choices are lower in the ingroup than in the nogroup and outgroup treatments. The end period of each supergame is no exception.

Similarly, in Table 6, the differences in average individual quantity choices and non-parametric tests across different group matching conditions are greater with more detailed distribution information. The whole periods in all seven supergames include the first half supergames (1-4), the second half supergames (5-7), and the 10^{th} periods of all seven supergames, the all seven supergames without the 10^{th} periods. The second column includes observations, and the following three columns show the average of quantity choices and standard deviation in the nogroup treatment, ingroup treatment and outgroup treatment; respectively. The p-values of the pair t-tests and Mann-Whitney U test between the treatments are listed in the sixth and seventh columns. Besides, the differences in average quantity choice among different treatments are significant at a 5% level. It appears that the average quantities selected by the individuals are lower than those of the same group. For example, averaging across all periods, the quantity choices are 0.25 units higher in nogroup matchings than those in the ingroup matchings (7.66 vs 7.41 units), and the difference is statistically significant (p<0.001). Therefore, when the players share one common group identity, they are prone to cut down quantity choices. The ingroup matchings and outgroup matchings allow us to examine whether this effect exists in heterogeneous groups. The difference is also statistically significant at a 10% level (ingroup matchings vs outgroup matchings: p<0.001; outgroup matchings vs nogroup matchings: p<0.100). Although group identity could not completely eliminate the "endgame effect", the average quantities in all three matching treatments are greater than Nash Equilibrium quantity (q_i=8), and $\bar{q_i^I} < \bar{q_i^N}$ and $\bar{q_i^I} < \bar{q_i^O}$ cannot be rejected at the 5% level.

Table 6: Finitely repeated interactions: Individual quantity choices by treatment

	Obs.	No Mean (SD)	In Mean (SD)	Out Mean (SD)	p-values (test) No vs In	No vs Out	In vs Out	p-values (ranksum) No vs In	No vs Out	In vs Out
All periods (1/7)	8400	7.66 (1.66)	7.41 (1.83)	7.80 (1.81)	0.00	0.00	0.00	0.00	0.08	0.00
Supergames (1/4)	4800	7.82 (1.77)	7.65 (2.04)	8.04 (1.94)	0.011	0.00	0.00	0.07	0.01	0.00
Supergames (5/7)	3600	7.46 (1.47)	7.09 (1.47)	7.49 (1.55)	0.00	0.61	0.00	0.00	0.86	0.00
10^{th} periods	820	8.56 (1.69)	8.2 (1.75)	8.73 (1.84)	0.02	0.24	0.00	0.01	0.51	0.00
No 10^{th} periods	7560	7.57 (1.63)	7.32 (1.81)	7.70 (1.77)	0.00	0.01	0.00	0.00	0.09	0.00

We report the average quantity choices by individuals.
The number of the observations in each situation is noted in the second column.
This table also provides the t-test and Mann-Whitney U test.

8.2 Regression Analysis of Quantity Choices

It is assumed that quantity choices correspond to different levels of ω^g. Ordinary least squares regression was used to investigate the treatment effects on individual quantity choices, and how this impact evolves over supergames. We estimated that the dependent variable is the current individual quantity choice in the OLS models. As shown in Table 7, the first column contains the independent variables, whereas the ingroup and the outgroup treatment dummies with the nogroup treatment are omitted. The following columns contain the interactive variable between supergames and group assignment dummies (Supergame$*$Ingroup, Supergame$*$Outgroup). Therefore, we conducted further analysis on the 10^{th}period (end game effect) dummy variable, interactive variable and group assignment dummies (10^{th}period$*$Ingroup, 10^{th}period$*$Outgroup), which were included as additional models. As shown in column (1), the individual quantity choices in the outgroup matchings are significantly higher than those in the nogroup matchings (0.139, p<0.001). Besides, the average individual quantity choices are significantly lower in the ingroup matching than those in the nogroup matchings (0.255, p<0.05). Column (2) - (5), illustrate that the coefficients of Supergame$*$Ingroup are -0.052 (p=0.012). Therefore, it is obvious that ingroup pairwise significantly reduces individual quantity choices over supergame, in comparison with nogroup treatment. The results of group treatments versus nogroup comparisons in the 10^{th} periods of supergames are shown in Column (4) and (5). The coefficients of the 10^{th}period$*$Ingroup and 10^{th}period$*$outgroup illustrate that the ingroup matchings could relieve the "end-game effect", whereas the outgroup matchings might consolidate the "end-game effects".

Table 7: Finitely repeated interactions OLS regressions: Treatment effects on individual quantity choices

	(1)	(2)	(3)	(4)	(5)
Constant	7.664*** (0.00)	8.149*** (0.06)	8.045*** (0.00)	7.948*** (0.00)	7.946*** (0.00)
Ingroup	-0.255** (0.06)	-0.255** (0.06)	-0.0490 (0.14)	-0.0490 (0.14)	-0.037 (0.15)
Outgroup	0.139*** (0.00)	0.139*** (0.00)	0.244*** (0.00)	0.244*** (0.00)	0.240*** 0.00
Supergame		-0.121*** (0.01)	-0.095*** (0.00)	-0.095*** (0.00)	-0.095*** (0.00)
Supergame$*$Ingroup			-0.052* (0.02)	-0.052* (0.02)	-0.052* (0.02)
Supergame$*$Outgroup			-0.026*** (0.00)	-0.026*** (0.00)	-0.026*** (0.00)
10^{th}period				0.968*** (0.04)	0.992*** (0.00)
10^{th}period$*$Ingroup					-0.114*** (0.02)
10^{th}period$*$Outgroup					0.040*** (0.00)
Observations	8400	8400	8400	8400	8400
r^2	0.008	0.027	0.028	0.055	0.054
r^2Adjusted	0.008	0.027	0.027	0.054	0.054

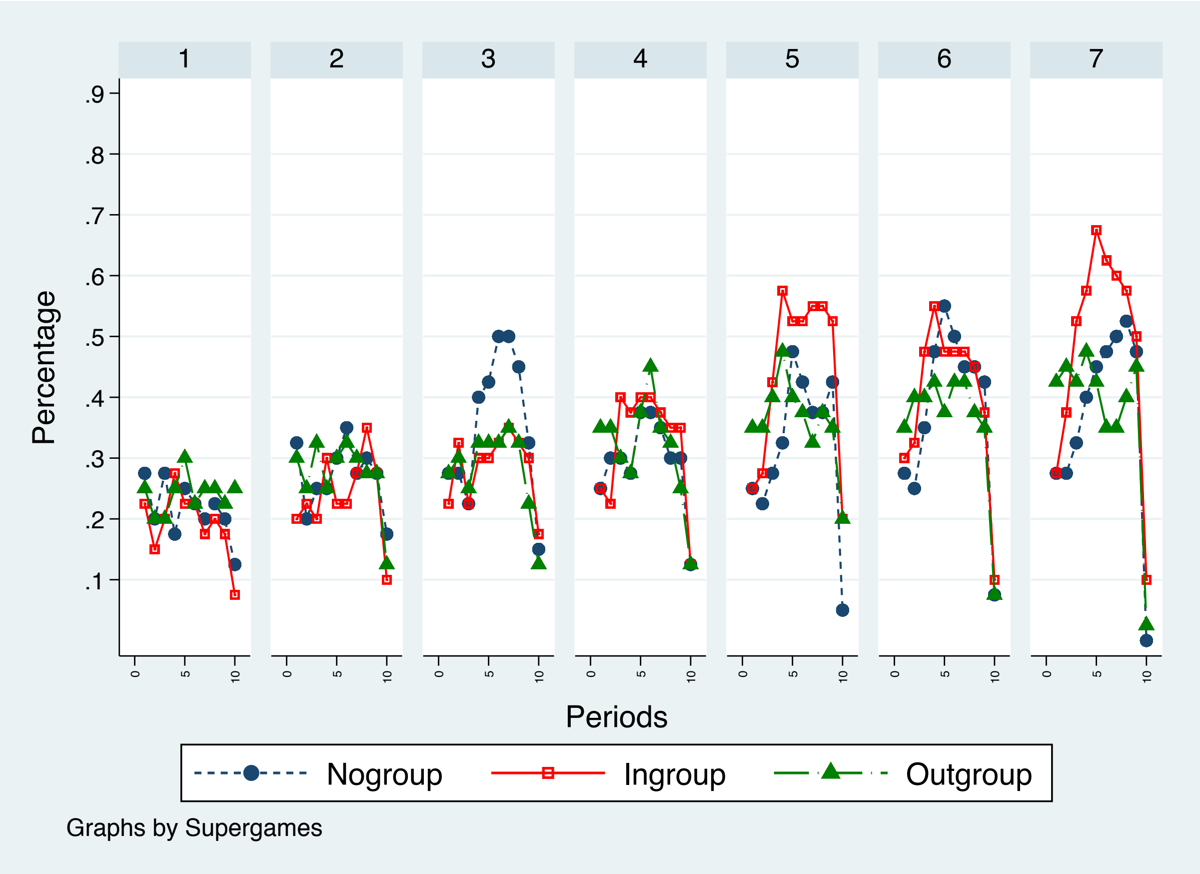
Standard errors in parentheses * p<0.1, ** p<0.05,*** p<0.01

8.3 The Impact of Group Identity on Collusion and JPM

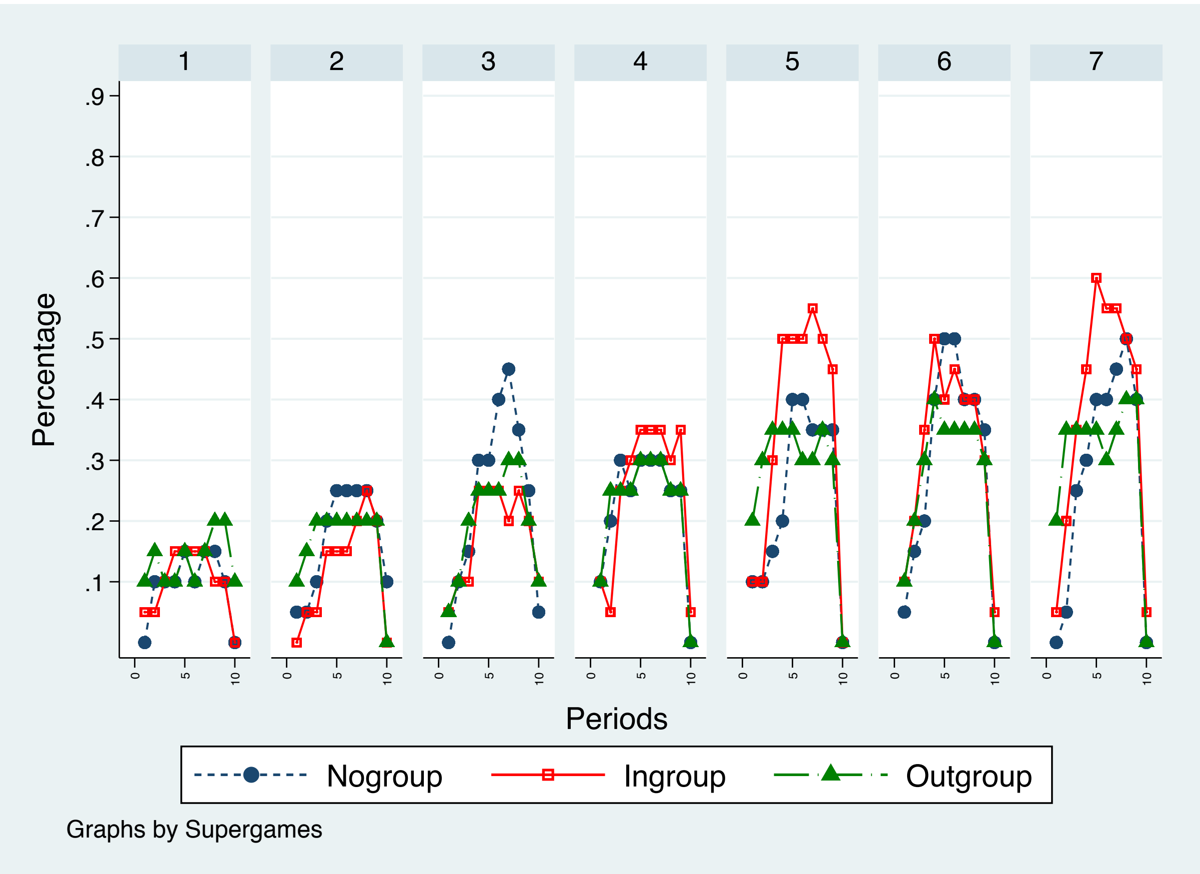
Result 4. *Compared with nogroup matchings, ingroup matching participants are more likely to choose collusive behaviour and easier to achieve JPM.*

Figure 8 reports the rate of successful individual and collective market collusion, indicating that ingroup favouritism promotes the percentage of collusive strategies. The connected lines shown in Figure 8a concur with the notion of Table 8. Moreover, the collusive strategies are more sustainable in outgroup treatments.

Figure 8: Finitely repeated interactions: Rate of choice of collusion over supergames and periods by treatment



(a) Finitely repeated interactions: $q_i = 6$



(b) Finitely repeated interactions: $q_i = q_j = 6$

Logit: The Probability of Individual to Collusive Behavior ($q_i = 6$) The results in Figure 8 are in line with those of Logit models used to investigate the treatment effects on the probability of individual to choose collusion (see Table 8). In this table, we analyse how group identity influences individual collusion and how this impact evolves over supergames. The dependent variable is the dummy variable for collusion, an indicator on a scale from 0 to 1. 1 indicates that individual i chooses the collusive quantity, and zero indicates otherwise. In this model, the first column consists of the independent discrete variables, including the ingroup and the outgroup treatment dummies. The nogroup treatment was dismissed. The indicator variable Ingroup equaling to 1 indicates that the individual is paired with another individual in the same group (ingroup) and 0 implies that the collusive player comes from another group (outgroup). The indicator variable (10^{th}period) equals to 1 for the 10^{th} periods of supergames, and 0 otherwise. In some specifications, control variable Supergame is added as an index of a Supergame trend to increase the precision of the estimation. Moreover, the interactive variable between supergames and group assignment dummies (Supergame∗Ingroup, Supergame∗Outgroup) are contained. Further analysis on 10^{th}period (end game effect) dummy variable, interactive variable and group assignment dummies (10^{th}period∗Ingroup, 10^{th}period∗Outgroup) are added in the additional models. The coefficients are probability derivatives. Column (1) indicates that the participants show a slight tendency to choose the collusion strategy in the ingroup matchings. An ingroup matching increases participants' likelihood of collusion by 10.4%. In column (2) and (4), the coefficients of Supergame are always positive, suggesting that the participants are leaning to collude over repeated supergames. For example, in column (2), a supergame increases the participants' likelihood of collusion by 14.7% (p<0.010). As shown in Column (3), the coefficient of Supergame∗Ingroup is 0.113, which is slightly higher than the coefficient of Supergame is 0.109. Therefore, ingroup matching significantly accelerates the collusion over supergame compared with that of the nogroup treatment.[35]

[35] We confirmed in logit models of the following form:

$$\begin{aligned} collusion_i = \beta + \beta_0 Ingroup + \beta_1 Outgroup + \beta_2 Supergame + \\ \beta_3 Supergame * Ingroup + \beta_4 Supergame * Outgroup + \\ \beta_5 (Period = 10) + \beta_6 (Period = 10) * Ingroup + \beta_7 (Period = 10) * Outgroup \end{aligned} \tag{21}$$

where the collusion is an indicator variable equal to 1 if it is the individual i collusion, and 0 otherwise.

Table 8: Logit finitely repeated interactions: The probability individual to Collude ($q_i = 6$) (Percentage change in the log odds)

	(1)	(2)	(3)	(4)	(5)
Constants	-0.779***	-1.384***	-1.223***	-1.130***	-1.124
	(0.04)	(0.06)	(0.09)	(0.10)	(0.10)
Ingroup	0.104*	0.106*	-0.372***	-0.380***	-0.380***
	(0.06)	(0.06)	(0.14)	(0.14)	(0.14)
Outgroup	0.003	0.003	-0.005	-0.005	-0.005
	(0.06)	(0.06)	(0.13)	(0.14)	
Supergame		0.147***	0.109***	0.111***	0.112***
		(0.01)	(0.02)	(0.02)	(0.02)
Supergame$*$Ingroup			0.113***	0.116***	0.116***
			(0.03)	(0.03)	(0.03)
Supergame$*$Outgroup			0.002	0.002	0.001
			(0.03)	(0.03)	(0.03)
10^{th}period				-1.385***	-1.539***
				(0.11)	(0.20)
10^{th}period$*$Ingroup					0.116
					(0.28)
10^{th}period$*$Outgroup					0.329
					(0.27)
Observations	8400	8400	8400	8400	8400
log_likelihood function	-5279.26	-5201.17	-5191.34	-5085.93	-5085.16
Pseudo R^2	0.00	0.02	0.02	0.04	0.04
Efron's R^2:	0.00	0.02	0.02	0.05	0.05
Cragg-Uhler(Nagelkerke) R^2:	0.00	0.03	0.03	0.06	0.06
AIC	1.258	1.239	1.237	1.213	1.213
BIC	-65316.670	-65463.815	-65465.385	-65667.187	-65650.637

Standard errors in parentheses * $p<0.1$, ** $p<0.05$,*** $p<0.01$
Likelihood-ratio test (Prob > chi2): (1) versus (2), 0.00; (2) versus (3), 0.00; (3) versus (4), 0.00; (4) versus (5), 0.47; (4) is the best est estimate.
BIC: Bayesian information criterion.

Logit: The Probability of JPM ($q_{i,t} = q_{j,t} = 6$) The definition of JPM is that all firms in the same markets choose collusion ($q_{i,t} = q_{j,t} = 6$) simultaneously. Logit model was used to investigate the treatment effects on the probability of JPM. Table 9 presents the results of Logit specifications that determine markets' likelihood to JPM. These columns present the results of logit specifications of the treatment and the supergame trends. In the column (3) and (4), we further interact with each of the covariates with the group assignment dummies to examine group-contingent effects. As shown in column (1) and (2), in the average markets, the odds of ingroup matchings are significantly higher to reach JPM. Ingroup matching increases the likelihood of the JPM by 11.7% (p<0.065) [12% (p<0.062)], as illustrated in column in the column (1) [(2)]. As suggested in column (3) and (4), the explanatory variables exhibit the group-contingent effects. Supergame interacted with ingroup dummy enters a marginal effect of 12.2% (p< 0.008), indicating a marginally stronger response to the supergame of JPM in the ingroup treatment than that of the nogroup treatment. However, no group contingent effect was found during the last period.

Table 9: Logit finitely repeated interactions: The probability of JPM ($q_{i,t} = q_{j,t} = 6$) (Percentage change in the log odds)

	(1)	(2)	(3)	(4)	(5)
Constants	-1.270***	-2.147***	-1.977***	-1.873***	-1.871***
	(0.05)	(0.08)	(0.11)	(0.11)	(0.11)
Ingroup	0.117*	0.121*	-0.404**	-0.417**	-0.420**
	(0.06)	(0.06)	(0.16)	(0.17)	(0.17)
Outgroup	0.037	0.038	0.049	0.049	0.047
	(0.06)	(0.07)	(0.16)	(0.16)	(0.16)
Supergame		0.207***	0.169***	0.173***	0.173***
		(0.01)	(0.02)	(0.02)	(0.02)
Supergame$*$Ingroup			0.117***	0.122***	0.121***
			(0.03)	(0.03)	(0.05)
Supergame$*$Outgroup			-0.003	-0.002	-0.003
			(0.03)	(0.03)	(0.00)
10^{th}period				-2.475***	-2.702***
				(0.21)	(0.00)
10^{th}period$*$Ingroup					0.363
					(0.69)
10^{th}period$*$Outgroup					0.262***
					(0.00)
Observations	8400	8400	8400	8400	8400
log_likelihood function	-4512.939	-4512.939	-4512.939	-4512.939	-4512.939
Pseudo R^2	0.00	0.027	0.029	0.063	0.063
Efron'sR^2:	0.00	0.028	0.030	0.059	0.059
Cragg-Uhler (Nagelkerke) R^2:	0.001	0.044	0.047	0.099	0.099
AIC	1.075	1.046	1.044	1.008	1.009
BIC	-66852.865	-67088.056	-67086.940	-67381.735	-67364.157

Standard errors in parentheses * p<0.1, ** p<0.05,*** p<0.01
Likelihood-ratio test (Prob > chi2): (1) versus (2), 0.00; (2) versus (3), 0.00; (3) versus (4), 0.00; (4) versus (5), 0.78; (4) is the best estimate.
BIC: Bayesian information criterion.

8.4 Collusion Duration

Based on many experiments, collusion goes against the prediction of rational play, which is still observed in finitely repeated interactions. The group identity facilitates the collusion under the dynamic quantity interaction if players consider collusive quantity choices to be kind and punishment quantity choices to be unkind. The deviation happens because the future losses deviating from the collusion of the ingroup (nogroup) matching players are higher than that of outgroup matching ones while the short-run deviation gain of an outgroup matching player is less than that of an ingroup (nogroup) one.

Result 5. *The collusive outcomes are more persistent in the outgroup than those in the ingroup and nogroup treatments.*

According to the statistic supports of Table 10, it shows treatments on the basis of a comparison with the specified duration periods of JPM. Dur1 refers to the supergames beginning with the JPM's aggregate output (Markets reached JPM in the first period). Dur2 implies that the pairs continue the JPM after the first period of the current supergame. Dur3 shows the pairs keep the JPM for all first three periods of the current supergame. Dur9 stands for the continuous JPM quantity choice selected in the previous nine periods of the current supergame. By that analogy, the JPM choice always continues to the penultimate period. The rows present the observations of the JPM duration over 140 ten-periods finitely repeated markets in each treatment. From a pure observation perspective, it is evident that the outgroup matching is beneficial to ensure the sustainability of the JMP choice.[36]

[36]The first deviation of the mean periods is an index of the collusion sustainability. The first deviation of the mean periods on the joint duopoly market for the nogroup treatment, ingroup treatment and outgroup treatment are respectively 0.14, 0.15 and 0.21.

Table 10: Finitely repeated interactions: The observations of JPM duration

Duration	Nogroup	Ingroup	Outgroup
Dur1	6	9	17
Dur2	6	7	17
Dur3	6	7	16
Dur4	6	7	16
Dur5	6	7	16
Dur6	6	7	15
Dur7	6	7	15
Dur8	5	7	15
Dur9	5	6	15
Dur10	0	2	2

Regarding the sustainability of the market collusion, the outgroup matching pairs are always good at retaining collusive strategies. Our explanation on this counter-intuitive result is that the combinations with theories of the topsy turvy game. Therefore, for the group identity influence whether firms are able to collude, the ingroup favouritism has a positive effect on the possibility of reaching an agreement. (see Figure 8) However, it has an adverse impact on the sustainability of the existing collusion. (see Table 10)

9 Study III: Indefinitely Repeated Interactions

This section unveils the critical influence of group identity on the indefinitely repeated Cournot interactions with a continuous rule in the lab, which is a challenging domain in game theory where collusion is found very difficult to maintain in the long term. The contribution in this paper mainly helps understand the fundamental question of whether and how group identity affects individual quantity choices and strategies in a long-term strategic environment.

9.1 The Impact of Group Identity on Quantity Choices

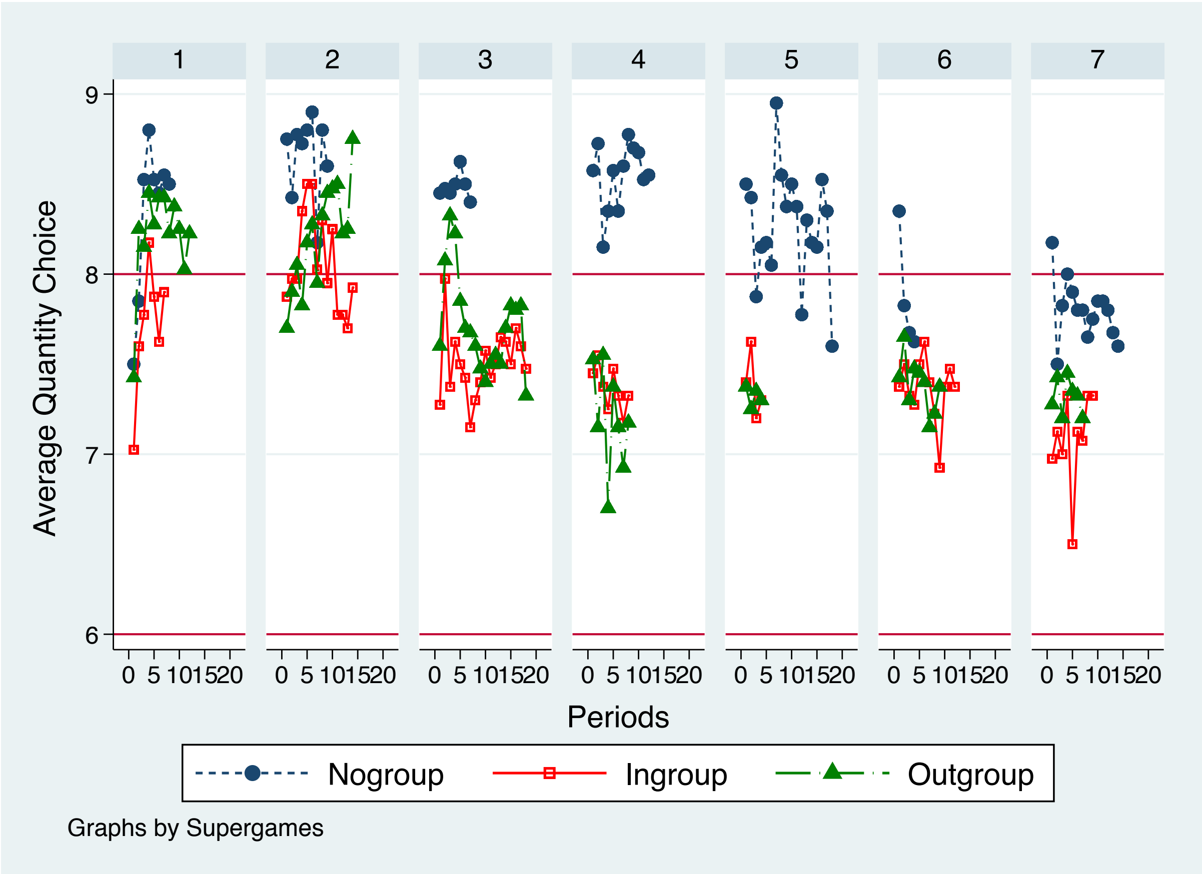
Result 6. *In the indefinitely repeated interactions: the average quantity choices are significantly lower in the group assignment treatments compared to the nogroup treatment. That is, ingroup matching leads to a significant decrease in quantity choices, and outgroup matching also leads to a substantial reduction in quantity choices.*

Figure 9 and Table 11, respectively provide graphical and econometric support. Among them, Figure 9 depicts the evolution of average individual quantity choices per period and per treatment in seven different supergames, showing a downward trend of average quantity choices over the seven supergames. Table 11 shows the average quantity choices of individuals by treatments. The third, fourth and fifth columns respectively show the average quantity choices and standard deviations in three treatments. For a more accurate display, the average quantity choice results of the whole period and supergames, the 1/4 of supergames and the 5/7 of supergames are respectively presented. The two-sided p-values of t-test and Mann-Whitney U test are reported in the last six columns. Based on Table 11, individual quantity choice in the ingroup treatment is generally lower than that in the nogroup matchings, while the outgroup individuals do well as ingroup individuals. The average of quantity choices in the ingroup treatment is 0.84 lower than in the nogroup treatment (7.54 in ingroup vs 8.38 in nogroup, p<0.001) in all periods and the all supergames.[37][38]

[37] The figure of the 'Average quantity choices over each periods' shows the negative impact of group identity on quantity choices is heterogeneous in supergames.

[38] The mean outcome quantity was $7.6 \pm 2.04(SD)$ in the Cournot games of Huck et al. (2001). The properties of the aggregate market outcomes are mainly divided into three regions: cooperation region, Nash region, and competition region. If the aggregate market outcomes are lower than 16, the market will be at the cooperation region. And, if the aggregate market outcomes are at 16, the market will be marked as the Nash region. Otherwise (the aggregate market outcomes are higher than 16), the market will be located in competition region. The equation is $\rho = (Q^{actual} - Q^{Nash})/(Q^{JPM} - Q^{Nash})$. If the aggregate market quantities are the Cournot-Nash equilibrium, $\rho = 0$, while $\rho = 1$ at the JPM benchback. If the positive values of ρ indicate cooperative behaviour, $0 < \rho < 1$. However, if the $\rho < 0$, the quantity choices are more competitive than the Cournot-Nash equilibrium. The cooperation index of nogroup treatment is -0.19, clearly lower than Huck et al. (2001); Potters and Suetens (2009).

Figure 9: Indefinitely repeated interactions: Average quantity choices over supergames and periods



The Cournot Nash Equilibrium level of quantity choice is at 8. The Collusion level of quantity choice is at 6.

Table 11: Indefinitely repeated interactions: Individual average quantity choices by treatment and supergames

	Obs.	No Mean (SD)	In Mean (SD)	Out Mean (SD)	*p*-values (*t*-test) No vs In	No vs Out	In vs Out	*p*-values (ranksum) No vs In	No vs Out	In vs Out
Supergames (1/7)	8640	8.38 (1.86)	7.54 (1.82)	7.73 (1.67)	0.00	0.00	0.00	0.00	0.00	0.00
Supergames (1/4)	4280	8.52 (1.90)	7.68 (1.74)	7.88 (1.65)	0.00	0.00	0.00	0.00	0.00	0.06
Supergames (5/7)	4240	8.04 (1.81)	7.27 (1.92)	7.35 (1.66)	0.00	0.00	0.86	0.00	0.00	0.04

The number of the observations in each situation is noted in the second columns.
Two-sided (Mann-Whitney U test) *p*-values of *t*-test are reported in the last six columns.

9.2 Regression Analysis of Quantity Choices

The regression analysis is used to examine further quantity choices, which allows for the control of visible differences between individuals. Table 12 shows a simple OLS regression to analyse how group identity influences individuals' quantity choices and how this impact evolves over supergames. In all models, we regress quantity choices on constant and dummy variables, indicating whether an individual is in the ingroup treatment, and outgroup treatment (thus, individuals in the nogroup treatment constitute the reference group). The dependent variable is the individual quantity choices in the current period. Moreover, columns are based on all periods of the repeated games. In the models (2) and (3), we control the supergame effects through the variable "Supergame". Standard errors are clustered at the session level. The results are very absolute, and there are significant differences between the outgroup and the nogroup treatments, and between the ingroup treatment and the nogroup treatment in any specification. Column (1) of Table 12 shows that average quantity choices are significantly lower in the in/outgroup than the nogroup treatment (-0.743/-0.545; p=0.000/p=0.002). The coefficients of the variables "Supergame" in model (2) and (3) are negative, suggesting an opposite relationship between quantity choices and supergames of play. This reveals that individual's quantity choices decrease over supergames. In the model (3) that includes the supergame trend, the coefficient of Supergame$*$Outgroup is -0.053 ($p<0.01$) compared to the coefficient of Supergame -0.124 ($p<0.01$).

Table 12: Indefinitely repeated interactions OLS regression: Treatment effect on individual quantity choices

	(1)	(2)	(3)
Constant	8.278***	8.889***	8.806***
	(0.00)	(0.07)	(0.00)
Ingroup	-0.743***	-0.805***	-0.774***
	(0.04)	(0.04)	(0.12)
Outgroup	-0.545***	-0.661***	-0.461***
	(0.00)	(0.01)	(0.00)
Supergame		-0.143***	-0.124***
		(0.02)	(0.00)
Supergame$*$Ingroup			-0.006
			(0.02)
Supergame$*$Outgroup			-0.053***
			(0.00)
Observations	8640	8640	8640
r^2	0.030	0.053	0.054
r^2 Adjusted	0.030	0.053	0.053

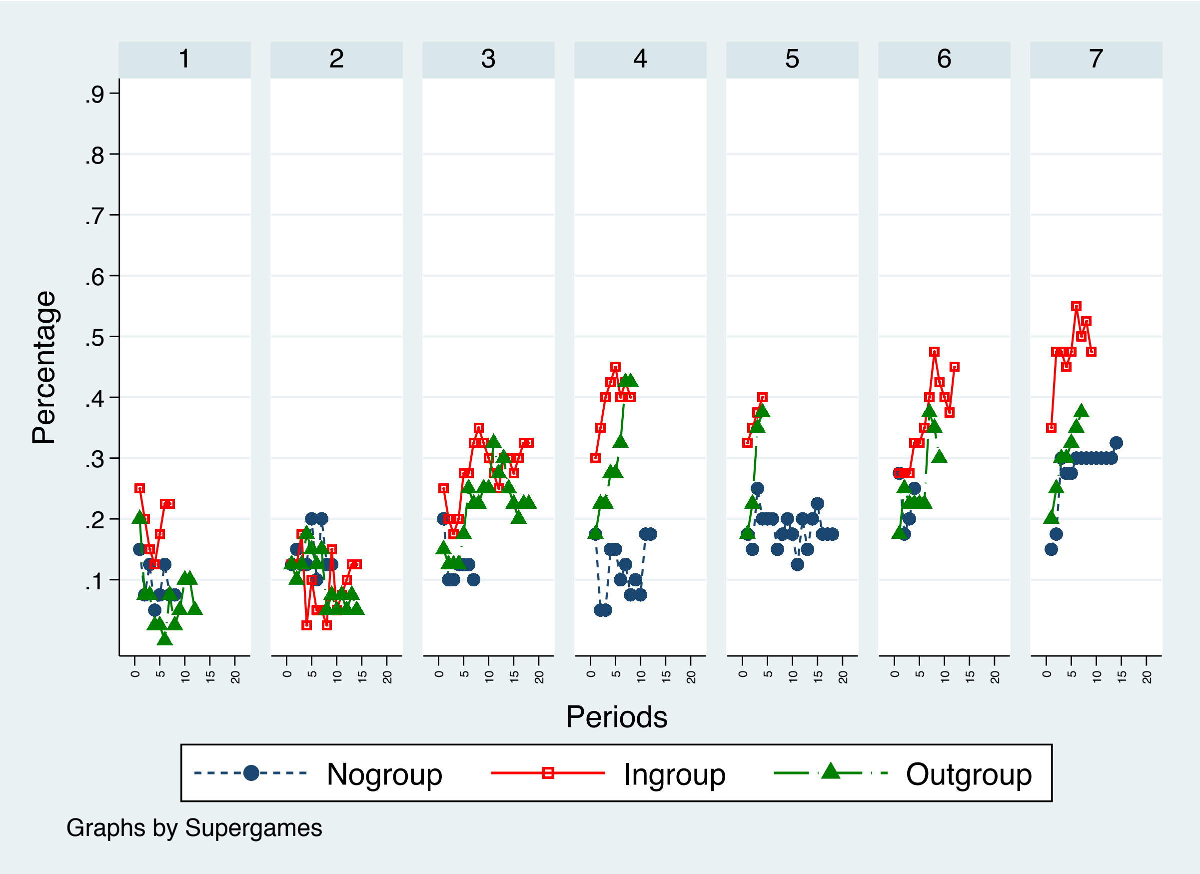
Standard errors in parentheses * p<0.1, ** p<0.05,*** p<0.01

9.3 The Impact of Group Identity on Collusion and JPM

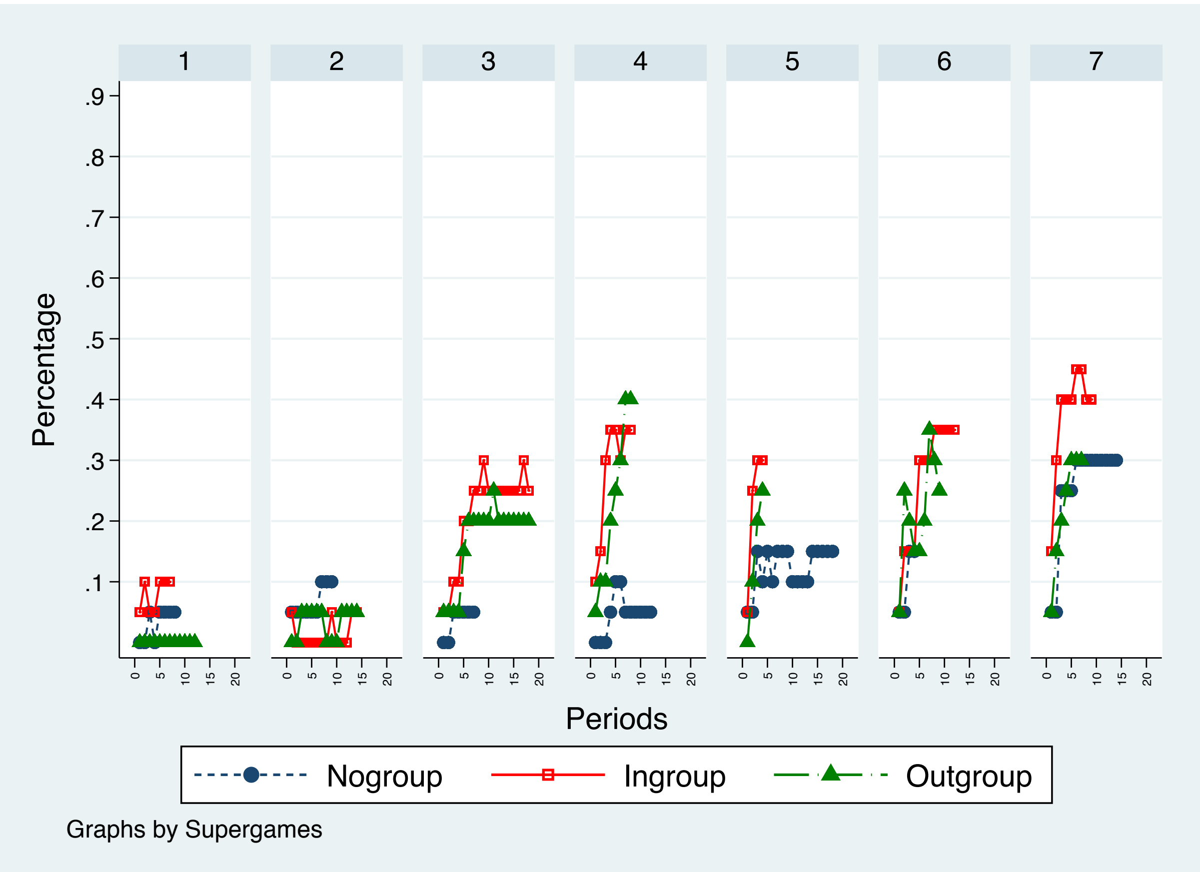
Result 7. *The collusion of players is significantly higher in the ingroup compared with the other two treatments. And, ingroup matching promotes collusive learning procedures.*

Figure 10a and Figure 10b provide graphical and econometric supports for Table 13 and Table 14 regressions. The percentage of collusion strategy for 40 individual players and 20 markets in different supergames and different treatments is shown in Figure 10. Participants in the ingroup treatment are more likely to choose collusion strategy during all periods, and the markets in the outgroup treatment and ingroup treatment are more likely to reach an agreement at the JPM. The paired market collusion in this figure is consistent with the individual collusion, which shows a remarkably consistent collusion result, that is, whether for individual or market is more likely to arrive collusion in the ingroup treatment than in the nogroup treatment.

Figure 10: Indefinitely repeated interactions: Rate of choice of collusion over supergames and periods by treatment



(a) Indefinitely repeated interactions: $q_i = 6$



(b) Indefinitely repeated interactions: $q_i = q_j = 6$

Logit: The Probability of Individual to Collusive Behavior ($q_i = 6$) The dependent variable is the likelihood of individual collusion behaviour. The independent variables for all regressions include dummy variables that describe whether the individual participates in an ingroup or an outgroup session, with the nogroup treatment as the omitted treatment. Other independent variables included the experimental supergame time tend, and the interaction terms between the matching scheme and dummy variables for the Supergames. The coefficients of Ingroup are respectively 0.676, 0.811 and 0.555 for three different Logit regressions, which are significantly positive compared with the nogroup treatment. Therefore, the players in the ingroup treatment are more likely to adopt the collusion behaviour. As for the players in outgroup treatment (Outgroup=0.151 in the column (1) and p=0.000, 0.357 in the column (2) and p=0.000), there is also a propensity for collusion behaviours, but the coefficients are relatively small. Ingroup matching significantly accelerates the collusion learning over supergames (p=0.000 in the column (2) and p=0.000 in the column (3)). The strength of the group identity effect mainly depends on interaction. The interaction between Supergames and groups indicates that the collusion differential in outgroup interaction is about 3% larger when compared with nogroup treatment interactions.

Table 13: Logit indefinitely repeated interactions: The probability individual to Collude (q_i = 6) (Percentage change in the log odds)

	(1)	(2)	(3)
Constant	-1.570*** (0.05)	-2.705*** (0.08)	-2.539*** (0.14)
Ingroup	0.676*** (0.06)	0.811*** (0.07)	0.555*** (0.17)
Outgroup	0.151** (0.07)	0.357*** (0.07)	0.188 (0.18)
Supergame		0.249*** (0.01)	0.214*** (0.03)
Supergame∗Ingroup			0.056 (0.03)
Supergame∗Outgroup			0.035 (0.04)
Observations	8640	8640	8640
log_likelihood function	-4542.59	-4542.592	-4542.592
Pseudo R^2	0.014	0.050	0.051
Efron's R^2:	0.015	0.054	0.054
Cragg-Uhler(Nagelkerke) R^2:	0.023	0.079	0.080
AIC	1.037	1.000	1.000
BIC	-69330.968	-69649.979	-69634.410

Standard errors in parentheses * p<0.1, ** p<0.05,*** p<0.01
Likelihood-ratio test, (Prob > chi2): (1) versus (2), 0.00; (2) versus (3), 0.278; (2) is the best estimate.
BIC: Bayesian information criterion.

Logit: The Probability of JPM ($q_{i,t} = q_{j,t} = 6$) Table 14 presents the results of Logit specifications for factors that determine markets' likelihood to reach JPM. If both players choose $q = 6$, JPM is an indicator variable equal to 1, otherwise 0. The indicator variable Ingroup is 1 if the individual is paired with another individual from the same group, while 0 if the other individual is from another group. The coefficients are probability derivatives. The table shows the results of logit specifications for the treatments and supergames. In column (3), I further interact with each covariate with the group dummy variables to examine group-contingent effects. Based on the results from column (1), on average, the market is significantly more likely to reach JPM in the ingroup treatment and the outgroup treatment. The ingroup matching increases the markets' likelihood to reach JPM by 70% (p<0.001), while the outgroup matching also increases the markets' likelihood to reach JPM by 19% (p<0.018). The column (2) implies that the next supergame increases the markets' likelihood to reach JPM by 34.7% (p<0.001). In column (3), supergame interactes with the ingroup [outgroup] dummy enters with the marginal effect of -0.088 (p<0.05) [-0.087 (p<0.07)], which suggests that the negative effect of supergame on JPM is stronger in the group assignment treatments.

Table 14: Logit indefinitely repeated interactions: The probability of JPM ($q_{i,t} = q_{j,t} = 6$) (Percentage change in the log odds)

	(1)	(2)	(3)
Constant	-2.108*** (0.06)	-3.753*** (0.11)	-4.114*** (0.21)
Ingroup	0.704*** (0.08)	0.888*** (0.08)	1.337*** (0.24)
Outgroup	0.193*** (0.08)	0.474*** (0.08)	0.914*** (0.25)
Supergame		0.347*** (0.02)	0.415*** (0.04)
Supergame$*$Ingroup			-0.088* (0.05)
Supergame$*$Outgroup			-0.087* (0.05)
Observations	8640	8640	8640
log_likelihood function	-3571.445	-3571.445	-3571.445
Pseudo R^2	0.014	0.077	0.078
Efron's R^2:	0.012	0.061	0.062
Cragg-Uhler(Nagelkerke) R^2:	0.020	0.110	0.111
AIC	0.816	0.764	0.764
BIC	-71242.559	-71685.898	-71672.196

Standard errors in parentheses * p<0.1, ** p<0.05,*** p<0.01
Likelihood-ratio test, (Prob > chi2): (1)versus(2), 0.00; (2)versus(3), 0.11; (2) is the best estimate.
BIC: Bayesian information criterion.

9.4 Collusion Duration

Result 8. *There is no significant treatment effect on the sustainability of the JPM.*

Specifically, the sustainability of the JPM will be measured by the number of the market that continues collusion after the cartel is explicitly formed.[39] Table 15 shows the differences in JPM sustainability in three different group treatments in each supergame, which is the messiness of the JPM. There are 7 supergames in each treatment session with different periods (the number of periods in each supergame and treatment is different; e.g., there are eight (seven) [twelve] periods in the first supergame in the nogroup treatment (ingroup treatment) [outgroup treatment]). The third row presents the number of supergames in three different treatments. The numbers of the first column represent the periods of each supergame. The block 'N' marks the end of a supergame at current period. Table 15 contains the number of JPM markets out of 20 markets, which have sustained collusion since the beginning of supergame in each different treatment. For example, for the nogroup treatment, in the first supergame, there is no market start with collusion, and there is no chance to continue the collusion. For the ingroup treatment, in the seventh supergame with the nine periods, there are three markets out of 20 markets agree at JPM at the beginning to the second, third, ...periods, until to the end of the supergame. For the outgroup treatment, in the sixth supergame with nine periods, there is only one market out of 20 markets reach the JPM at the first period of the supergame, and the JPM does not break until the seventh period. No more than 15% of the pairs begin with JPM, which does not meet expectations in all treatments and all supergames. In fact, many of the markets in all treatments show deviations from the perfect JPM, meaning that they are not able to form a stable JPM. Despite the pairs in ingroup treatments do better in collusion than other treatments, this result has adopted an unconvincing argument to prove our Hypothesis.

[39] The more markets keep the JPM agreement, the cartels are more stable.

Table 15: Indefinitely repeated interactions: The observations of JPM duration

	Nogroup(NG)							Ingroup(IG)							Outgroup(OG)						
	Supergame No.							Supergame No.							Supergame No.						
Periods	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
1	0	1	0	0	1	1	1	1	1	1	2	1	1	3	0	0	1	1	0	1	1
2	0	1	0	0	0	0	1	1	0	0	2	1	1	3	0	0	0	1	0	1	1
3	0	1	0	0	0	0	1	1	0	0	2	1	1	3	0	0	0	1	0	1	1
4	0	1	0	0	0	0	1	1	0	0	2	1	1	3	0	0	0	1	0	1	1
5	0	1	0	0	0	N	1	1	0	0	2	N	1	3	0	0	0	1	N	1	1
6	0	1	0	0	0	N	1	1	0	0	2	N	1	3	0	0	0	1	N	1	1
7	0	1	0	0	0	N	1	1	0	0	2	N	1	3	0	0	0	1	N	0	1
8	0	1	N	0	0	N	1	N	0	0	2	N	1	3	0	0	0	1	N	0	1
9	N	1	N	0	0	N	1	N	0	0	N	N	1	3	0	0	0	1	N	0	N
10	N	N	N	0	0	N	1	N	0	0	N	N	1	N	0	0	0	N	N	N	N
11	N	N	N	0	0	N	1	N	0	0	N	N	1	N	0	0	0	N	N	N	N
12	N	N	N	0	0	N	1	N	0	0	N	N	1	N	0	0	0	N	N	N	N
13	N	N	N	N	0	N	1	N	0	0	N	N	N	N	N	0	0	N	N	N	N
14	N	N	N	N	0	N	1	N	0	0	N	N	N	N	N	0	0	N	N	N	N
15	N	N	N	N	0	N	N	N	N	0	N	N	N	N	N	N	0	N	N	N	N
16	N	N	N	N	0	N	N	N	N	0	N	N	N	N	N	N	0	N	N	N	N
17	N	N	N	N	0	N	N	N	N	0	N	N	N	N	N	N	0	N	N	N	N
18	N	N	N	N	0	N	N	N	N	0	N	N	N	N	N	N	0	N	N	N	N

There are 20 markets in each treatment and each supergame.
'Supergame' No. is the order of seven supergames.

In this experiment, the ingroup favouritism and outgroup favouritism can be observed, while the ingroup favouritism is more significant than outgroup favouritism. It can be found that the social group identity may be dormant in one individual, and this group identity may be triggered by the repeated devices of Cournot interactions. In all repeated games, the ingroup matching individual's "enlightened self-interest" is to cooperate in the hope of eliciting other-regarding preferences.

10 Norms Associated with Group Identity in Repeated (Finitely and Indefinitely) Cournot Duopoly Interactions

Social norms and social identity are two essential aspects of many fields of human activities. At the basis of the utility incorporating identity (Akerlof & Kranton, 2000), we use different group matching frames describe the social norms, and then introduce the Cournot competition sample scenario. Does the group identity affect the enforcement of the collusions in the Cournot repeated interactions? We use the simulation methodology to answer this question by estimating individuals' quantity choice adjustment norms based on group treatments from our experimental data. Simulation results show that the implementation of norms relies heavily upon the group matching and repeated devices.

Mounting experiments provide evidence that group identity could determine the group contingent other-regarding in many one-shot and short-term games. Our experimental evidence from one-shot illustrates that collusive quantity decisions are not related to group identity. But, from our repeated experimental results suggest that collusive decisions are related to group identity. We think that group identity plays a more role in repeated games than in one-shot games, and collusive behaviour in repeated games may not result from group contingent other-regarding motives. Based on our Cournot experimental design, the reaction functions are downward-sloping Huck et al. (2001). This implies that if the quantity choice decisions are larger than the JPM choices, then cutting own quantity choices increase collusion and increasing quantity choices decreases collusion. Participants are not only interested in the best response strategies, they also keep an eye on appropriate quantity choice adjustment process. Most of the participants adjust their quantity choices, which determined by rival and their own profits and quantity choices. If the opponent has chosen quantity choice over than collusive choice, the player would increase own quantity choice. This can directly cause downward payoffs of both players, and this was related to an increase in the group assignment. This section discusses that the size of the adjustment in the quantity choices would be affected by group identity during decision making.

To study the relevance of group identity in motivation, we were especially interested in group identity correlated with the adjustment decisions that the players made in their quantity choice adjustments when observed the relative payoff changes comparisons. The collusion in repeated games arises from the combinations between group assignment and players experience when observing each others' quantity adjustments and relative profit changes comparisons. We did further simulation study on the processes behind the decisions, instead of the only separately behaviour.

The norm of condition cooperation is a proximate behind the famous tit for tat strategy.[40] Given the opponent's quantity choices in the Cournot interactions, the increase of the own quantity choices will lead to the costly informal sanctions. Social norms refer to the universality of behaviours in a relevant group, such as the number of individuals who already have been assigned to the same group. The enforcement patterns of norms are qualitatively different among treatments. Within the specific group, members have the perception of the specific norms that define the expected behaviour of identity groups while the gain utility depends on the consistency of the norms that apply to their own group. The membership in groups may affect the willingness of members to engage in the enforcement of the pro-social behaviour norms. Higher rates of cooperation and more negative punishment between ingroup members. In both finitely repeated and indefinitely repeated duopoly devices, we model firms' quantity choice to explain the role of group identity on the firms' decisions in the adjustment process. Though the simulation analysis we find: (1) how group members learn to estimate the optimal quantity choices over periods as a function of group identity and (2) which aggregate market quantity choices are optimal for the complexity group matching.

The norms will be defined at first, and a simple framework of material profit changes will be presented to understand their potential influence on quantity changes. We then demonstrate how one can identify the norms that make up one source of quantity choice adjustments. The framework of material profit changes shows how the norms are elicited from one set of individuals by means of the experimental data yield as well as predictions on simulation behaviours. It is also noted that this study is the first to introduce the Cournot-based elicitation method to identify norms.

[40]Norms are the joint-recognized agreements regarding appropriate or inappropriate behaviour within a specific social group (Bettenhausen & Murnighan, 1991; Elster, 1989; Fehr & Schmidt, 1999; Lindbeck, Nyberg, & Weibull, 1999). Studies illustrate that what other players are going to do as well as their historical actions could build the norm-compliance.

10.1 The Algorithm: Quantity Choices Adjustment Norms

In the Cournot interaction experiments, people collude much more than that predicted by the standard economic theory assuming rational and selfish individuals. The appropriateness norms guide players adjusting their quantity choice ask themselves, "What does the player like me do in a certain situation?" There are three determinant factors to solve this problem: classification of the kind of relative profit change comparison situation, the group matching of the player, ad the application of norms in guiding quantity adjustments. Our examination on the importance of conditional collusion is based on a novel experimental design described in detail in the following paragraphs.

10.1.1 Quantity Choice Adjustments to Relative Profit Changed Comparisons and Group Matchings

Table 16: Relative profits changed comparisons categories

Categories	Comparisons of material profits' changes
Both gain:	$\Delta\pi_{i,t-1} > 0$ & $\Delta\pi_{j,t-1} > 0$
Own gain, other not gain:	$\Delta\pi_{i,t-1} > 0$ & $\Delta\pi_{j,t-1} \leq 0$ $\Delta\pi_{i,t-1}=0$ & $\Delta\pi_{j,t-1} <0$
Other's gain, self not gain:	$\Delta\pi_{i,t-1} \leq 0$ & $\Delta\pi_{j,t-1} > 0$ $\Delta\pi_{i,t-1} < 0$ & $\Delta\pi_{j,t-1}=0$
No change:	$\Delta\pi_{i,t-1}=0$ & $\Delta\pi_{j,t-1}=0$
Both lose:	$\Delta\pi_{i,t-1} < 0$ & $\Delta\pi_{j,t-1} < 0$

Two discrete determining factors control the players' quantity changes. One is the group assignement (Nogroup, Ingroup, Outgroup) and the other is the material profits changes (Both gain, Both lose, Own gain, Other's gain, Both no changes); forming a 3*5 categories matrix. The Table 16 summarises the five different comparisons of profits changed in the previous two periods. Figure 11 and Figure 12 show quantity adjustments of nogroup, ingroup and outgroup for each category about material profits changes, in fact, most of player adjust their quantity choice in the same norm as their rivals.

The popular strategy about the norm is tit for tat, that is the name of the quantity choice adjustment rule that moves its opponent has done previously. By studying how the material profits change in a period, the production quantity is adjusted upwards on Period t if the opponent has gained profits between Periods t-2 and t-1, but the player himself has not. The production quantity is adjusted downwards on the Period t in the other cases when only the player himself gains and when both of them lose. It is the key to understanding in which situations the punishment may be a pro-social act to foster collusion and when it may turn into efficiency to reduce antisocial punishment. The players will be encouraged to coordinate under specific norms (the norms were accepted by those belonging to a specific identity group).

Figure 11: Finitely repeated interactions: Average and 95% confidence intervals of quantity choice adjustment over five material profits' changes and by treatment

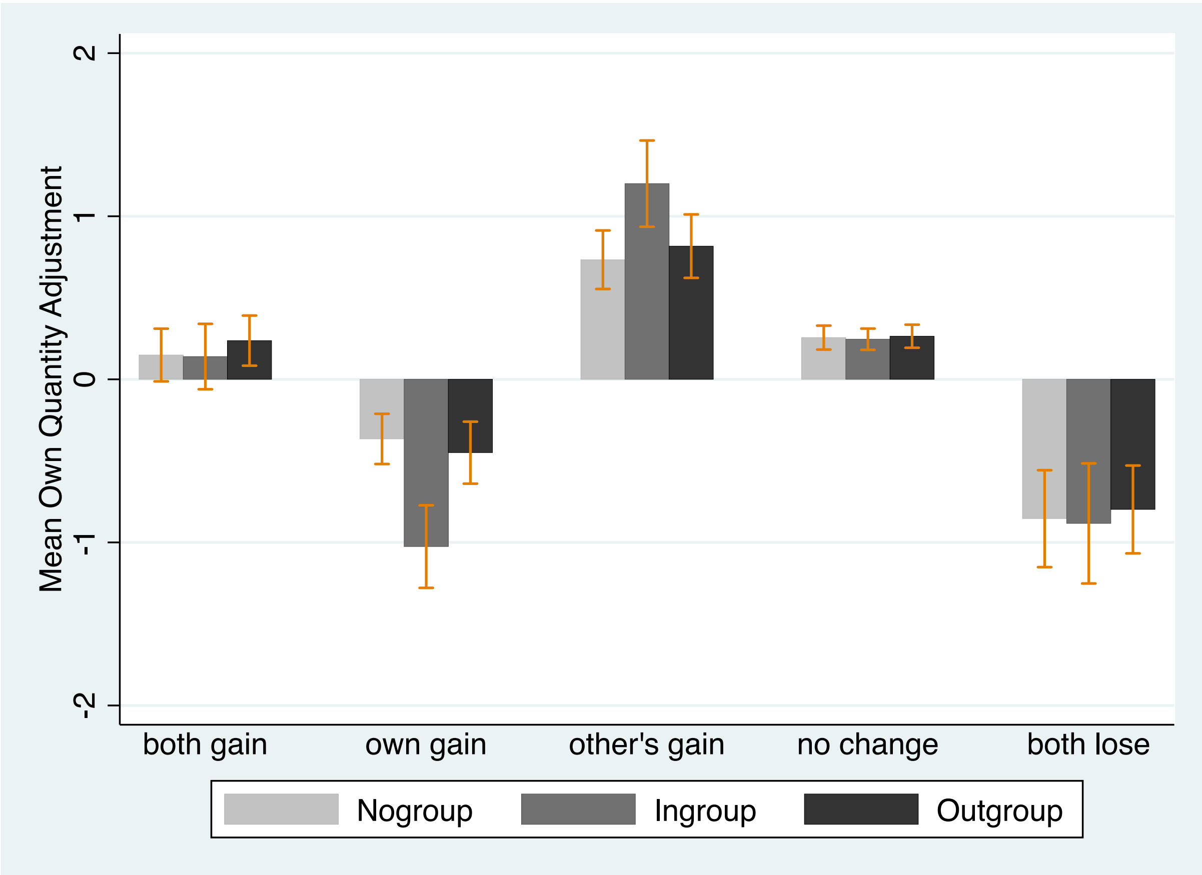
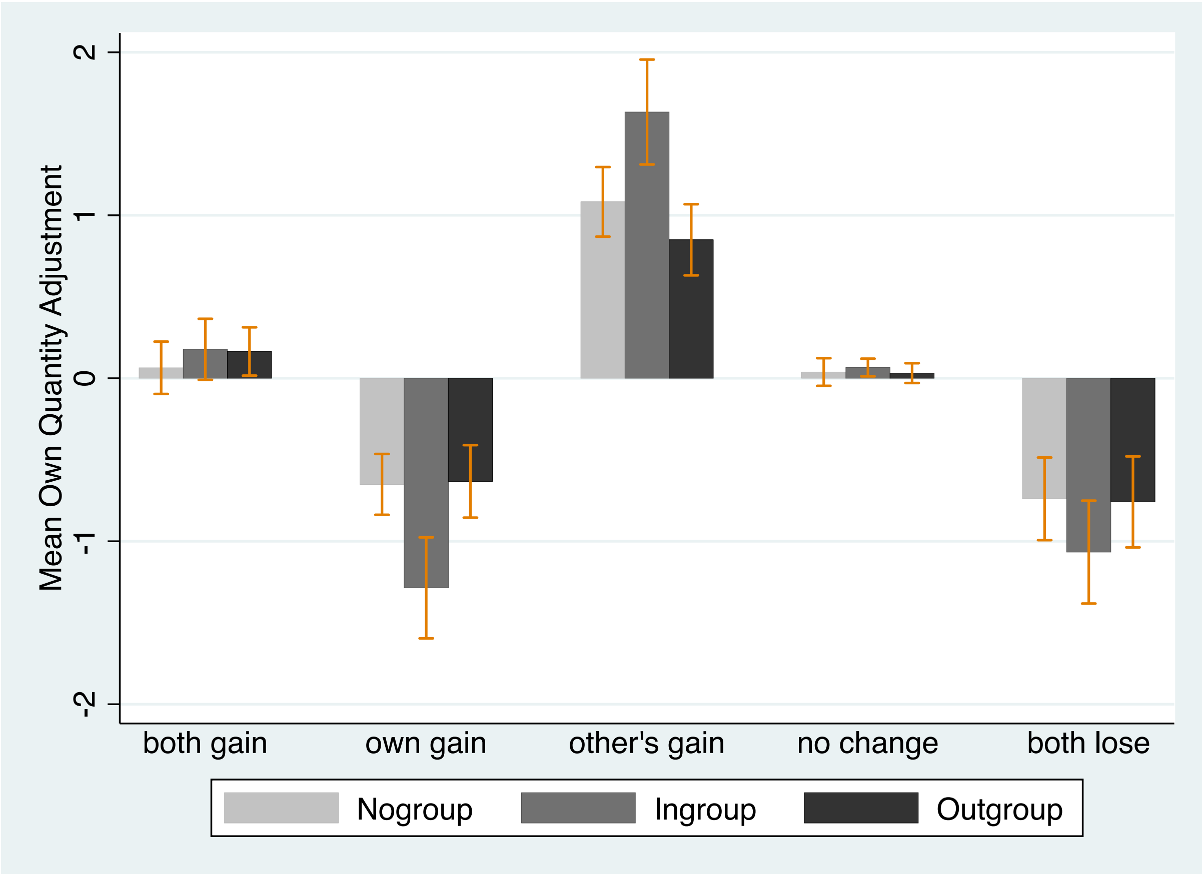


Figure 12: Indefinitely repeated interactions: Average and 95% confidence intervals of quantity choice adjustment over five material profits' changes and by treatment



Quantity change by different treatments in the indefinitely repeated games over five different categories of material profits changes. Error bars indicate 95% confidence intervals: Average and 95% confidence interval.

The observations of the bars from left to right are (250, 200, 272); (405, 430, 338); (205, 430, 338); (926, 1008, 1010) and (254, 172, 282) in the finitely repeated games.

The observations of the bars from left to right are (468, 250, 292); (364, 423, 452); (364, 423, 452); (732, 984, 888) and (392, 249 236) in the indefinitely repeated games.

Table 17: Change in individual quantity $\Delta q_{i,t}$ with respect to the lagged change in joint profits ($\Delta\pi_{i,t-1}$, $\Delta\pi_{j,t-1}$)

	(1) Finitely	(2) Indefinitely
Constant	0.124**	0.038
	(0.059)	(0.074)
Ingroup	0.007	0.028
	(0.080)	(0.098)
Outgroup	0.029	-0.007
	(0.080)	(0.100)
Both Gain	0.229*	0.156
	(0.125)	(0.119)
Ingroup∗Both Gain	-0.232	-0.162
	(0.185)	(0.185)
Outgroup∗Both Gain	0.028	-0.054
	(0.173)	(0.180)
Both Lose	-1.086***	-0.778***
	(0.124)	(0.126)
Ingroup∗Both Lose	-0.060	-0.355*
	(0.191)	(0.191)
Outgroup∗Both Lose	0.004	-0.012
	(0.171)	(0.193)
Other's Gain	0.542***	1.044***
	(0.105)	(0.129)
Ingroup∗Other's Gain	0.452***	0.523***
	(0.145)	(0.174)
Outgroup∗Other's Gain	0.048	-0.226
	(0.152)	(0.173)
Own Gain	-0.557***	-0.689***
	(0.105)	(0.129)
Ingroup∗Own Gain	-0.675***	-0.663***
	(0.145)	(0.174)
Outgroup∗Own Gain	-0.120	0.025
	(0.152)	(0.173)
10^{th} *Period*	0.806***	
	(0.065)	
Observations	6720	6960

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 17 presents how the group treatments and material profits changes categories influence the quantity changes in the finitely repeated games and indefinitely repeated games. The reference category is nogroup treatment, and the profit of both players has no change. There is no significant treatment effect on $\Delta q_{i,t}$. However, there are significant interaction effects between the group assignment and material profits change category. Especially for the ingroup treatment players, the production quantity is adjusted upwards on Period t if the opponent has gained between Periods t-1 and Period t-2 but the player himself/herself had not; the adjustment is more significant in the ingroup matching. The production quantity is adjusted downward on Period t if only the player himself/herself gained and the adjustment decrease is more significant in the ingroup matching. Column (1) is the regression for the finitely repeated games, and column (2) model is the OLS of the indefinitely repeated games. In Column (1), the sample mean in the data is set as $\Delta q_{i,t}$, in nogroup treatment, all players whose profits have no change equal to 0.124 (p>0.05). The coefficient of Ingroup is 0.007 (p= 0.904), which means that if both of their profits do not change between Period t-1 and Period t-2, the two ingroup matching players will slightly increase by $\Delta q^{I}_{i,t}$. Moreover, the ingroup matching and outgroup matching players are not different compared with nogroup treatment players if they all have no change in the first two periods. Compared with the case of no change in material profits, there is no significant change of quantity in the profit growth of both players', and the group treatments effects can also be ignored. However, in the nogroup treatment, if both players experience a loss of profits between Period t-1 and Period t-2, the $\Delta q^{N}_{i,t}$ will decrease by 1.086 (p<0.001) from 0.124 to -0.946. In the case of Both Lose, the group treatment effects are not statistically significant. In the nogroup treatment, compared with the case of both players' profits having no change, if the rival's profit increased while the playing self does not, the players' quantity will increase by 0.542 (p<0.001). The coefficient of Ingroup∗Other's Gain is 0.452 (p<0.001), which implies that for ingroup matching players, if the opponent has gained between Period t-1 and Period t-2, while the player self has not gained, the estimated mean $\Delta q^{I}_{i,t}$ is 1.125 (calculation: 0.124+0.007+0.542+0.452). In the case of the Other's gain, there is no significant difference between nogroup matchings and outgroup matchings. The coefficient of "Own gain" implies that the player will decrease his/her quantity by 0.433 (0.675-0.124; p<0.001) at the following period if his/herself profit increases while the rival's profit does not increase in the nogroup treatment in the finitely repeated games. Nevertheless, for the ingroup assignment players, the difference of quantity changes increases by 0.675 (p<0.001). In the face of such a case, the difference between nogroup treatment and outgroup matching is negligible. In the Column (2), in the indefinitely repeated games, the signs of the coefficients are completely consistent with those of Column (1), and there is only a small difference between the settings of changes. The analysis of decisions illustrates that the one-sided gains in the material profits between two periods motive the players upward quantity adjustments, while downward adjustments if Both Lose. In other words, the group membership increases willingness to enforce a norm of collusion. The players are more likely to reward an ingroup member's decreased quantity and more likely to punish an ingroup member's increased quantity.

Table 18 summarises the norms in the three different treatments and two repeated Cournot interactions. The player will adjust herself/himself to the change of her/his quantity to cope with changes in the material profits in the previous periods (the corresponding numbers in the brackets are the probability).[41] For example, if both players' profit have no change at the previous two periods, the two players have a 10% chance of increasing quantity by one unit and keeping the quantity level at the following period at 90%. In the three different treatments, the most apparent differences are cases of one player's profit increases, while the others do not. In the case of the "Own gain, other not gain", the ingroup matchings will decrease quantity by two at 25% or decrease by one at 75%. However, for the nogroup matchings and outgroup matchings, they will decrease quantity by one at 60%, or stay the quantity settings at 40%.

Table 18: Simulation norms: Δq_i^g for finitely and indefinitely interactions by treatment

Categories	Finitely			Indefinitely		
	Ingroup	Nogroup	Outgroup	Ingroup	Nogroup	Outgroup
Both gain:	0 (100%)	0 (100%)	0 (100%)	0 (100%)	0 (100%)	0 (100%)
Own gain, other not gain:	-1 (75%) -2 (25%)	-1 (60%) 0 (40%)	-1 (60%) 0 (40%)	-1 (65%) -2 (35%)	-1 (67%) 0 (33%)	-1 (67%) 0 (33%)
Other's gain, self not gain:	1 (100%)	1 (50%) 0 (50%)	1 (50%) 0 (50%)	1 (40%) 2 (60%)	1 (100%)	1 (100%)
No change:	0 (90%) 1 (10%)	0 (90%) 1 (10%)	0 (90%) 1 (10%)	0 (100%)	0 (100%)	0 (100%)
Both lose:	-1 (90%) -2 (10%)	-1 (90%) -2 (10%)	-1 (90%) -2 (10%)	-1 (90%) -2 (10%)	-1 (78%) 0 (22%)	-1 (78%) 0 (22%)

[41] We use a 5% statistical significance level as a threshold (unless stated otherwise) to establish the significance of an effect.

10.1.2 Simulations

We conduct simulations using individual-level quantity choice adjustment norm estimates to determine if the norm with group identity interprets the characteristics of the experiments. Next, we use the simulations with more observations to present how collusion would evolve in group identity.

Group identity presents a proximate motivation for observed behaviour. However, is this the ultimate evolutionary explanation for differences of norms produced by group identity? Experimental data are processed through Stata software to simulate the entire choice decision process. We perform simulations to assess the extent to which the norm model fits the data obtained in the experimental sessions. These simulations consist of 10,000 sessions by treatment (30,000 in the finitely repeated games and 30,000 in the indefinitely repeated games) through the norm model previously estimated, and add the subjects who assigned to groups or did not assign to groups. The composition of each session is obtained by randomly taking a pair of subjects from the subjects that participated in the corresponding treatment at the first two periods in each seven supergames.

The specification of desirable behaviour and the sanction rules in a community can be regarded as norms, and we analyse how such norms work to support efficient outcomes in frequent transactions. The players are following the adaptive quantity choice adjustments rely on own quantity choice in past period to infer about future quantity choices. Table 17 shows an extracting rules algorithm based on class feature matrix. The varies magnitude of quantity choice adjustment depends on the probability distributions of Δq_i^g, group matchings, and relative profit change comparisons. As a summary, here we review the forecast and adjustment steps for a given entropy values:

- The input variables are the quantity choices in the first two periods: $q_{i,1}^g, q_{j,1}^g, q_{i,2}^g, q_{j,2}^g$.
- Based on the observation of $q_{i,1}^g, q_{j,1}^g, q_{i,2}^g, q_{j,2}^g$ and $\Delta\pi_{i,2}, \Delta\pi_{j,2}$; and the norms. It estimates how much to produce: $\widehat{q_{it}^g} = q_{i,t-1}^g + \Delta q_i^g$

The choices at the following periods will obey the simplified algorithm.

Figure 13: Finitely repeated interactions' simulation: Quantity choice changes over individual and by treatment

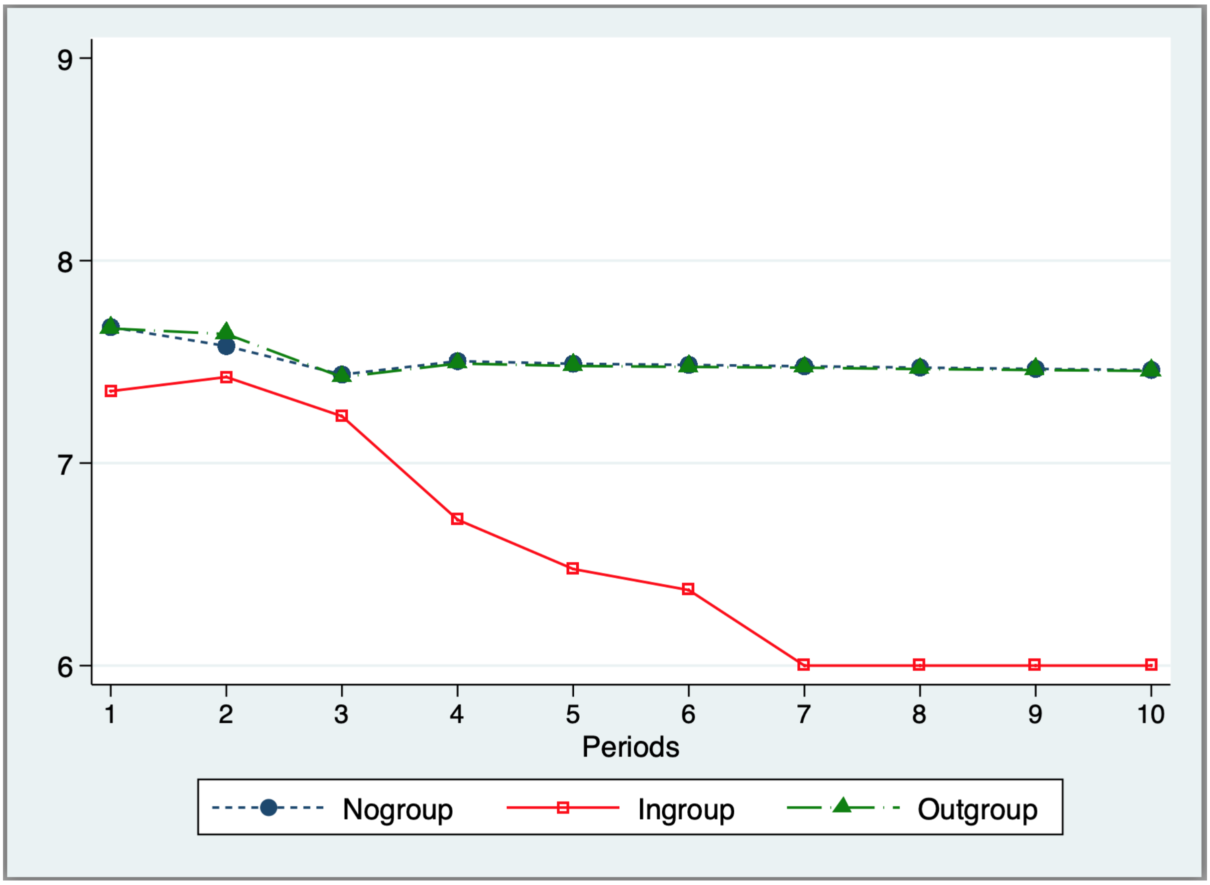


Figure 14: Indefinitely repeated interactions' simulation: Quantity choice changes over individual and by treatment:

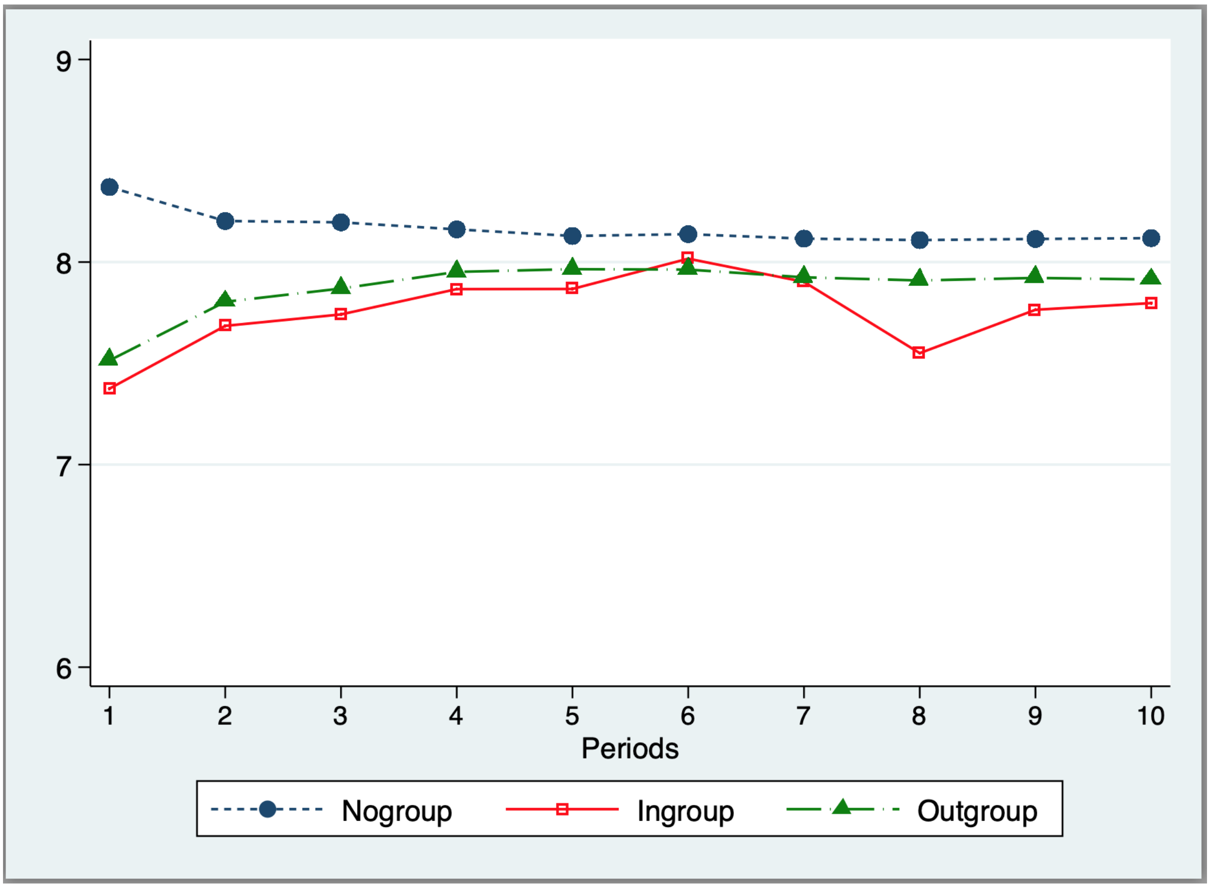


Figure 13 and Figure 14 show the way average quantity choices in 10,000 simulations with different group identities in the finitely repeated games, and in the indefinitely repeated games. The three connected lines are displayed in quantity choice to facilitate the comparisons of group matching quantitative effects among the evolution of behaviour in the nogroup matching, ingroup matching and outgroup matching. According to the results of this experiment with 240 Chinese participants, it can be confirmed that players of the Cournot interaction games would collude more with ingroup members than outgroup members and nogroup members in the simultaneous game. Here, computer simulations are used to show that collusion can arise when players who are sufficiently similar to themselves in the ingroup matching decrease their own quantity in the finitely interactions. Their behavioural responses may be determined by the default norm associated with particular group assignments. Somewhat surprisingly, it turns out that norms yield a collusive outcome, and they are able to sustain "collusion" outcomes under enhanced norms (ingroup matchings in the finitely repeated interactions). When we look back Table 17, we do not find the effect of group identity in two cases: Both Gain and Both Lose, but effects are reflected in the Other's Gain and Own Gain cases. For different group matching categories (nogroup matchings, ingroup matchings and outgroup matchings), if the coefficients of Own Gain are larger than those of Other's Gain, the matchings are able to sustain "collusion" outcomes. In contrast, if the coefficients of Own Gain are lower than those of Other's Gain, the outcomes are more inclined to the Cournot Nash equilibrium. These could explain why the quantity choices processes are very similar among three different treatment in the indefinitely repeated interactions. In sum, different kinds of group matchings determine the size of quantity choice adjustments facing five different comparisons of profit changes in the previous two periods. The quantity choice process norm established has important reference value to developing the complex models that consider group matchings, the coefficients of difference comparison categories comprehensively.

Part IV

CONCLUSION and DISCUSSION

Contributions The aim of this research is to examine whether group identity could effect change in individuals' quantity choices through other-regarding preferences, and its underlying repetition devices. To that end, lab experiments were conducted to bridge the gap between this study and literature based on individual-level and market-level analysis of group contingent other-regarding preferences. My findings are in line with recent Cournot interactions and show essential organization implications.[42] Solid evidence was obtained to substantiate the hypothesis that group identity shapes individual quantity setting decisions. It is observed in the new experiments as the main contribution that these primary effects of group identity are at work based on the Cournot interactions. The fact that group norms, group identity can lead to a more collusive equilibrium has been demonstrated in the context of the Cournot games. This research demonstrates the effect of social identity cues from several perspectives. Firstly, to the best of our knowledge, it is the first study which documents Cournot interactions based

[42] In the quantity setting oligopolies, the successful collusion is difficult, and the Nash Cournot equilibrium dominant the main position under random matching Holt (1985); Huck et al. (2001, 2004). However, the collusion could be more likely under fixed matching.

on group identity primed. In this sense, group identity can be seen as a sort of lubricant for competitive economic transactions, especially in the event of imperfect markets and incomplete contracts. Secondly, we conclude that group identity discrimination can be caused by statistical discrimination, the participants have relatively accurate expectations about the opponent's identity and their quantity choices in pairs who are from the same identity group are reduced. Thirdly, our findings shed light on the controversial issues of outgroup favouritism.

Our experiments are distinctive from other studies in three essential ways. First, numerous earlier studies focused on a few potential choices in the prisoner's dilemma games, yet our experiments extend the potential choices (Goodwin & Fiske, 2001; Wit & Wilke, 1992; Yamagishi & Kiyonari, 2000; Yamagishi et al., 2013). Second, group identity is induced in the industrial organization theory to test its effects on non-cooperative environments. Third, the players can play the part of the punisher, and the varying levels of punishment were prescribed based on the different group matchings (nogroup matching, ingroup matching, and outgroup matching), including the no punishment, the non-cost (gentle) punishment, and cost (severer) punishment.[43] Some contributions are made to facilitate further study of this model.

Conclusion The experiment is designed to provide a clarified comparison of quantity settings in three different Cournot interaction devices and group identity, including ingroup matchings, nogroup matchings and other with outgroup matchings. Collusive play in Cournot interactions is investigated to evaluate the validity of leading theories of observed collusion: group contingent other-regarding preferences. Collusion can be viewed from two aspects: the likelihood and the sustainability of collusion.

As mentioned in the introduction part, this paper takes the initiative towards a better understanding of group identity and its influence on non-selfish preferences. The intergroup bias is motivated by utility based on members of different group differential (Abbink & Harris, 2012; Y. Chen & Li, 2009). Our observations about the ingroup favouritism out of the group identity are consistent with the previous discussion to some extent. In the dynamic interactions the ingroup favouritism leads to more cooperative outcomes. Regarding the effect of group identity, it is found that the effect of group identity on collusion is greater in repeated game than one-shot games when all the other conditions are of the same. The high probability of collusion in

[43]The previous works concentrated on the two-stage experiments with punishments, and the punisher is the third party.

the ingroup treatment is caused by the factor of group identity among the ingroup members. In contrast, research shows that if the fixed pairs finitely repeatedly interact, the outgroup fixed matchings prove better in sustaining the market collusion than ingroup matchings.

Given the existence of intergroup discrimination behaviours in Cournot interactions, the other-regarding preferences are inconsistent with play in one-shot Cournot interactions. It is concluded that other-regarding preferences alone are not sufficient to justify our observation. In other words, the group contingent other-regarding preferences models are consistent with the repeated Cournot interactions in part. Firms in duopolies with group identity primed more times manage to collude, than in duopolies without group assignment. As Akerlof and Kranton (2000, 2005) suggested: the individuals put themselves in the specific group identity groups, and then they assign their social identity. That is to say, social norms systematically shape such discrimination. Quantity choices would be a good indicator of group identity which determines quantities with ingroup matchings to secure the group identity of the members. Players adopt similar decisions under finitely repeated games and indefinitely repeated games devices. Nevertheless, the players are influenced by the ingroup matchings to a great extent than other matchings (nogroup and outgroup). It is found that in all group matchings output adjustment can be explained to some extent by inspecting the individual quantity choice decisions pertaining to norms. The players were more likely to punish norm violations from ingroup as opposed to outgroup members in spite of the ingroup bias. This situation could be explained by the fact that the enforcement of cooperative norm violations is an evolved mechanism which requires within-group cooperation. The simulation results show that adaptive quantity choice adjustment norms, which are enhanced by group identity, may accelerate to collusion in the repeated Cournot interactions. According to the proposed hypothesis, people prefer to cooperate with ingroup members because they expect reciprocal responses from ingroup members, but not from outgroup members.

Moreover, it is determined that people tend to collude less with outsiders as the result of interactions, and conflict can appear due to punishment behaviour. Thus, the good collusive performances in the outgroup treatments should be explained by the determinant punishment factor of group identity. The harsher punishment is helpful to sustain the collusion. In regard to outgroup favouritism, we inspected individual behaviour in all treatments with a group assignment, and found that the impact of collusion becomes larger and surpasses the effects of the myopic best response. We also find that experience places an critical role in quantity setting Cournot interactions, and the role of experience varies depending upon the group assignments and repeated interaction devices. The level of collusion increases with experience and converges to higher levels in the group assignment treatments in the repeated interaction devices. Take together, our results suggest that while an equilibrium action may be a necessary condition for the arising of collusion among those with the same group identity, it is not sufficient. It is also suggested that no single social preference norm is sufficient to elucidate these behaviours. According to our simulation results, the norms (subsection 10.1) may well explain in part the effect of group identity on collusion.

The relationship between intergroup bias and collusion relationship can be summarized as (1) ingroup matchings tend to set lower quantity choices; (2) differentially enforced norms are dependent on the group membership of their interaction opponents. In terms of the effect of Cournot interaction devices, higher aggregate quantities and notably lower incidence of collusion were confirmed in the one-shot interactions than in repeated interaction devices. Finally, it is proved that nogroup matching markets are always at Cournot Nash quantity, and that when group membership is assigned, the performance of the market is more collusive than Cournot Nash Equilibrium.

Even in the ingroup matching duopoly with one-shot interactions, the players generally were not inclined to keep such collusion. This result implies that although ingroup matching result in insignificantly lower aggregate quantities during the first half of interactions, it is not enough to sustain such collusion. The capability to coordinate mutual trust and the credibility of the promise are the two conditions to sustain the collusion (Balliet, 2010). Group membership assignment is more effective than nogroup membership assignment concerning the fostering of collectivism, which positively impacts collusion. In addition, group membership assignment allows the players to stick to social norms and to form expectations, thereby making the mutual promise credible. The results have been summarized in regard to the tacit collusive behaviour that has implications for applied questions, such as the optimal design of the industrial organization. We find that group identification can facilitate collusion in the market where competition happens between fixed matchings, given that the successful tempted establishment of norms can be executed in similar strategies such as tit for tat.

Existing Work and Limitations This study is not without limitations. Following Y. Chen and Li (2009),[44] the group identity was induced by two steps: (1) the players were randomly allocated into different groups, and (2) they were asked to finish the "group identity enhancement" task by discussing the painting questions within their group members. Such group assignment may create more cooperation than in the Cournot interactions if they have cooperated in the painting tasks. In light of this, two additional treatments can be added if the randomly allocated players in the group could not have effective communication with other group members when they were trying to solve the painting questions.

Another limitation of this research is that there is no guarantee for the behaviour impacted by group identity and preference in Cournot interactions to be answered accurately. In the repeated interactions, the players may form their beliefs about the opponent's quantity choices. For example, Nyarko and Schotter (2002) stated that the beliefs of players differ dramatically in Cournot interactions. Therefore, the influence of group identity on behaviour is revealed by changes in beliefs of what the opponent will do. I may obtain evidence to show the impact of group identity on behaviour in Cournot interactions.[45] Meanwhile, by using this improved experimental design, the changes and the asymmetric response of players, and the changes of the averaged weight of players playing on their opponent's material profits can be observed in a direct manner.

A large body of experimental researches focuses on analysing the relationship between market structure and performances. Some of these works are applicable to merger policy in a broad sense. First, while experimental research can lead to an insightful opinion about human behaviour, it is still unclear how these results can be applied outside of the laboratory. Conversely, in the real industrial organization, the cost of ways to measure market share differs considerably. The number of established firms and potential entrants is limited in this study. F. Dolbear et al. (1969) showed that subjects using small matrix tend to reach the joint maximum, although such cooperation is unstable.

Further Studies All the further studies should be conducted on the basis of the above drawbacks. One cannot help wondering is the effect of minimal groups, just a quantitatively dif-

[44] They found the primed group identities have little impacts on behaviour, however, the group identities increase the self-reported attachment.

[45] Y. Chen and Li (2009) found that the "group identity enhancement" increased the players' self-report attachment to their own group members, yet the effects on behaviour are marginal. This suggests that such beliefs could not fully reflect the actual group identity.

ferent weaker version of what is observed in the real groups or the minimal groups behave quantitatively different from real groups? Will the randomised assignment of individuals, regardless of ethnic or national discrimination, provides stronger group manipulation than artificial groups in laboratory experiments which are devoid of social content?[46]

Our results show that the group identity of organization plays is of great help to the forming of collusion behaviour. Therefore, the optimal size of an organization and the demographic differences which could prim efficient group identity should be analysed. It should also be determined whether the group identity characteristic differences give rise to strong group ties. It is a complicated issue to determine whether the various behaviours caused by group identity can be explained by the preference-based models or belief-based models (Y. Chen & Li, 2009; Guala et al., 2013; McLeish & Oxoby, 2011). In further experiments, the dictator game might be employed to measure the behaviour produced by preference-based model. In addition, a possible direction which measures group identity experimental games may also be used to evaluate players' beliefs about other players' actions through the trust game senders' behaviour. Finally, the group identity effects should be examined in the event of a player interacts with two or more players from different groups (mixing the intragroup and intergroup interactions). Intergroup discrimination might intensify the external competition, leading to a higher degree of collusion Tajfel and Turner (1979). Since the paper focuses on the general aspects of game theory and industrial organization, some specific industries are not discussed. It should be emphasised that the applicability of game theory to industry organization is another matter of evaluation.

Implications Firms are often divided into sections or groups. Group bias is easy to spot in real life at work because it has more space for development. The social identity theory of group identification is new in the literature of organizational behaviour. Most of the previous researches on the effects of group identity rely on the ultimate measurement of firm performance, yet we pay more attention to efficiency among oligopolies in this paper. Herein, we introduced the definition of group identity and group bias based on its concept and theory, and we can perceive the causes for group bias, the various manifestations of group bias, and motivations of group bias. All those notions help to understand the internal mechanism of intergroup bias and to use group bias in a flexible fashion. Our results shed light on the associ-

[46]Comparing bias between social/geographical groups and artificial groups (Goette, Huffman, & Meier, 2012; Li et al., 2011), while Abbink and Harris (2012) compared artificial groups with political groups.

ation between identity and cooperation. Coordinated behaviour within a specific group could arise even if they have no intention to collude. For the organizations in a single industry, group identity could stimulate cooperation among its members, subsequently promoting the benefits of the organization. Nevertheless, the extent of group bias should be under proper control so as to avoid negative derivatives from intergroup derogations. All these could turn positive interactions into a negative one, undermining the effectiveness and coordinative development of members. Social identity or competition alone does not improve the market performance of a firm.

Part V

APPENDIX

A Group Identity Effects on Different Games

Prisoner's Dilemma Experimenters found that, without interaction between groups, individuals are more prone to cooperate altruistically in a prisoner's dilemma game with ingroup as opposed to outgroup members (Goette et al., 2010). Similar results occurred highly in five PD games. The players are more likely to choose cooperation. Laboratory tests showed in PD games that participants were 50% more likely to choose cooperation; these results are not consistent with the standard theoretical hypotheses. Bernhard, Fehr, and Fischbacher (2006); Charness et al. (2007); Goette, Huffman, Meier, and Sutter (2012) from the group identity point of view further explained the relations between social preference and cooperative behaviours. In generally, dictators give 15% - 25% endowment to the receivers. Bernhard, Fehr, and Fischbacher (2006); Camerer and Fehr (2004) explained the observed behaviours by the concept of the group identity. Although the dictators have the chance to occupy the whole interests, they also would like to give partial interests to others (Forsythe, Horowitz, Savin, & Sefton, 1994). Ingroup favouritism is a strong push in altruistic norm enforcement and sharing decisions (Zizzo, 2012). The response in the ultimatum games always rejects the allocation schemes. Güth, Schmittberger, and Schwarze (1982); Morita and Servátka (2013) discovered that the rejection probability of receivers increasing with the larger allocation difference, even if the allocations are bigger than zero. There are trust behaviours and return behaviours in the trust games. The real naturally-existing group identity also causes the ingroup favouritism in the trust experiments (Falk & Zehnder, 2007), i.e, people trust strangers from their own district significantly more than strangers from other districts. Previous studies have repeatedly made clear that the strong group identity impacts on the social preference in the Trust Games (Berg, Dickhaut, & McCabe, 1995; Ploner, Soraperra, et al., 2004). The investors tend to give trust and investment to agents, and the agents always will reward investors with partial benefits (Berg et al., 1995). In the trust games, the outgroup derogation effects are more significant than ingroup favouritism (Fang & Loury, 2005). Landa (1994), the first study to examine the effects of group identity in gift exchange games. Fehr et al. (1997), who discovered that in return for higher salaries provided by employers, the employees are more likely to work hard. In the Prisoner's Dilemma, the aggressive stance of the hosts produces a shift toward the unique Nash Equilibrium outcome where both players defect, and the result is a reduction of average payoff.

Public Goods Game Cooperative behaviour in a repeated public goods game, which is sufficient to overcome self-interest, cooperation in public goods games caused by the ingroup favouritism, evidenced by Charness, Cobo-Reyes, and Jiménez (2014); Y. Chen and Li (2009); Eckel and Grossman (2005). The salience of group membership induces the players to coordinate on the outcome with positive payoffs depending on the location, and the result is an increase of average payoff compared to the no audience environment. There are investments behaviours in public game (Marwell & Ames, 1979) (the public game with punishment mechanisms (Fehr & Gächter, 2002b)). But a new study expert shows just the opposite, "free-ride" phenomenon could not overcome just through pure group identity. The consequence of this increased aggressive behaviour on social outcomes depends on the games. In the Battle of the Sexes, although Charness et al. (2007) found that the groups being formed by the pure random assignment are not sufficient to affect participants' behaviour.

Table A1: The pro-social behaviours and social preferences in the individual game theory games (Camerer & Fehr, 2004)

Experiments Types	Experimental Description & (Decision Path)	Reality Examples	Economists Equilibrium	Experimental Results	Social Preference	Outcome Interdependence
Prisoner Dilemma[a]	The two players have two decisions, cooperation or no-cooperation. (A⟷B)	Environmental pollution, Noise generation	The players always choose non-cooperation	Over 50% players chosen co-operation, and communication can promote more co-operation.	Reciprocity preference	Yes
Ultimatum Games	The initial welfare is S, the sponsors decide part of welfare X to the responders, if the responders accept the X, the payoff of sponsors is S-X, and the payoff of responder is X. If the responders reject the allocations, the players get zero payoff. (A⇆B)	The perishable goods' Monopoly pricing.	The sponsors give $X = \epsilon$, and ϵ is positive, and the responders accept the allocations.	$X \in \{0.3S, 0.55S\}$ If the $X < 0.2S$, more than half responders will reject the allocations.	Reciprocity preference, Altruism preference, and difference aversion preference	Yes
Dictator games[b]	Based on the ultimatum games, the responders do not have the right to reject the sponsors. The payoff for sponsors and responder are S-X and X; respectively. (A→B)	Charitable donations	X=0	On the average, the dictator will give responders, X=0.2S	Altruism preference	No
Third party punishment	Based on the dictator games, the third-party will punish the sponsors by costly punishment behaviour. (A⟶B, then C$\overset{Punishment}{\longrightarrow}$A)	The social censure to the unfair allocations.	The dictators allocate X=0 to responders, and the third-party will not give punishment to the dictator.	If the X is lower than a certain level, the third-party will give the same punishment to the sponsors, and the punishment will increase with the lower X.	Altruism preference	Yes
Public goods games	The each player has y endowment, and invest some to the public good, and the investment $g_i(0 \leq g_i \geq y)$. The profits of each player is $\pi_i = y - g_i + mG$, $G = \sum_i g_i$, m is the ratio of the investment. (A⟷B)	The group cooperation, the excessive use of the public resource, the output of whole tiny society	$g_i = 0$	In the one shot games, $g_i \geq y$. For the repeated games, the investment will decrease with the times of repetitions. The punishment policy and communications will improve the level of co-operation.	Reciprocity preference, altruism preference, difference aversion preference	Yes
Trust games[c]	The two players, one is the trustee, the other is the truster. The two players have the endowment S, and invest y ($0 \leq y \leq S$) to the trustee, the trustee will get 3y, and decide x ($0 \leq x \leq 3y$)to return to the truster. Thus, the profit truster is $S - y + x$, the profit trustee is $S + 3y - x$. (A⇆B)	The business behaviour without contracts	y=0, and x=0	On the average, $y = 0.5S$, and $x < 0.5S$, x is proportional to y	Reciprocity preference, Altruism preference	Yes
Gift exchange games	The employer will give w to the employee, the employee could choose the effort level e ($1 \leq e \leq 10$), and the cost is c (e), the profit out of the effort is 10e, thus the profit of the employer is 10e-w, the profit of employee is w-c(e). (A⇆B)	The relationships between employ and employee	e=0, and the employer give minimum wages to employees.	The wage is proportional to effort of employees'.	Reciprocity preference, Altruism preference	Yes

Note: A and B refer to the two players interacting in the decision-making task, with A being the focal player, C is the third-party.

This table reference the Table 1 of Camerer and Fehr (2004) and the Table 1 of Levitt and List (2007).

[a] Ando (1999); Goette, Huffman, and Meier (2012) find that cooperate more with ingroup than outgroup members , Simpson (2006) do not find ingroup advantegaous over cooperations.

[b] Ben-Ner, McCall, Stephane, and Wang (2009); Liebe and Tutic (2010); Whitt and Wilson (2007) observe strong ingroup favouritism, but Lei and Vesely (2010); Stürmer, Snyder, and Omoto (2005). The third-party dictators always exhibit the larger difference between ingroup and outgroup members, the coefficients is 1.077 in the meta-regression (Lane, 2017).

[c] Fershtman and Gneezy (2001); Harris, Herrmann, and Kontoleon (2009) find significant ingroup favouritism in trust games, but Güth, Levati, and Ploner (2008); Johansson-Stenman, Mahmud, and Martinsson (2009) do not find enough evidence to support ingroup favouritism.

B Experiment Instructions and Interface

B.1 Instructions

We present the experimental instructions for the nogroup treatments. Instructions for the ingroup and outgroup treatments also included the words/sentences in italics and square brackets below.

B.1.1 Instructions (One-shot Games)

Welcome Welcome to today's experiment. Please read the following instructions carefully as they are directly relevant to how much money you will earn today. Please do not communicate with other people during the experiment. Please kindly switch your mobile phone off or put it on silent mode. Students causing a disturbance will be asked to leave the room. You will enter all of your decisions in today's experiment using only the computer mouse and keyboard. If you have any questions at any point during today's session, please raise your hand, and one of the monitors will come to help.

Task You are about to participate in a decision-making process in which you will play games with other players in this room. What you earn depends on your decisions, partly on the decisions of others, and partly on chance. As you came in you drew an index card [*a white envelope*] with a number on it [*with a number on it and a card in it*]. This number, randomly assigned, is your ID number used in this experiment to ensure the anonymity of your decisions [*your group name printed on the card*]. Please do not show your ID number [card] to anyone else. Please turn off cellular phones now. We ask that you do not talk to each other during the experiment. If you have a question, please raise your hand, and an experimenter will assist you. This experiment consists of two parts and 40 players. Your earnings in each part are given in points. At the end of the experiment, you will be paid in private and in cash based on the following exchange rate 1.5 Yuan = 100 points Your total earnings will be the sum of your earnings in each part plus a 15 Yuan participation fee. We will now start at Part 1. The instructions for Part 2 will be given after Part 1 ends.

Part 1

We will now start at Part 1. [*Please open the white envelope and discreetly pull out the contents. It contains either a Luojiashan card or a Donghu card. The character represents the group that you are assigned to. The 40 players in this experiment are randomly assigned to one of two groups of 20 people. If you drew a Luojiashan card, you would be in the Luojiashan group. If you drew a Donghu card, you would be in the Donghu group. The group assignment will remain the same throughout the experiment. Please return the index card to the envelope now. Do not show them to others. Please raise your hand if you have any questions about this step.*] In Part 1 everyone will be shown three pairs of paintings by two artists, Kandinsky and Klee. You will have three minutes to study these paintings. And then, at the end of the three minutes, two additional paintings printed on the A4 paper. Then every player judges each of the two new paintings made by the artists in eight minutes [*You may communicate with others in your group through a chat program while answering the questions. But in the course of chatting, please do not deliver the personally identifiable information (e.g. gender, race, and major), major. Please avoid obscene or offensive language. Apart from these, you could discuss any topics you want, and your contexts are public to all group members.*] You will be given up to 8 minutes to answer both questions. Submit your answers below when you are ready. [*Note you are not required to give the same answers as your group members.*] Each correct answer is worth 100 experiment points. You will find out about your earnings in Part 1 at the end of the experiment. [*Please tell us how you belonged feel to your group and the other group at this moment. Enter a number from 1 ("not belonged at all") to 10 ("very closely belonged") that most accurately reflects your* *feelings. (These answers will not affect your earnings.) The sense of belongingness to your group The sense of belongingness to the other group*

Part 2 (One-shot)
In part 2, you will make quantity decisions in periods. You will be randomly paired with another player in this room [*in your group/in the other group*] (called your opponent) for sequences of periods. In interactions, you will choose quantity 70 times, your history choices, history opponents' choice, market prices and experimental players' points will be shown on the decision screen. Subjects are either assigned to a random pairing at the beginning of a new period. A player does not know at which periods he has previously played against (or will in the future play against). Before each new period, each player was anonymously matched with one of the 30 [*19*] players with whom s/he had not previously played a period not know who your opponent is and vice-versa. Once a period ends, you will be randomly paired with another player [*in your group/in the other group*] (i.e., another opponent) for a new period. [*A player in the Luojiashan group will only be paired with another player in the Luojiashan/Donghu group. A player from the Donghu group will only be paired with another player in the Donghu/Luojiashan group.*]

***Quizzes before the experiment**

1 During the part two of experiments, how many matches to execute to make quantity choices?

2 According to the payoff table, if you sell six boxes, and the other player sells 12 boxes, what's your profit? And what is the other's profit?

***Quantity choices and Payoffs**
The choices and payoffs in each period are shown below:

Figure B1: Payoff matrix

	0	6	7	8	9	12
0	(0,0)	(0,108)	(0,119)	(0,128)	(0,135)	(0,144)
6	(108,0)	(72,72)	(66,77)	(60,80)	(54,81)	(36,72)
7	(119,0)	(77,66)	(70,70)	(63,72)	(56,72)	(35,60)
8	(128,0)	(80,60)	(72,63)	(64,64)	(56,63)	(32,48)
9	(135,0)	(81,54)	(72,56)	(63,56)	(54,54)	(27,36)
12	(144,0)	(72,36)	(60,35)	(48,32)	(36,27)	(0,0)

You and your opponent each can choose among six quantity choices, 0, 6, 7, 8, 9, and 12. The first entry in each cell represents your payoff and the second entry your opponent's payoff. Your payoffs are bolded for your convenience. In each period, before knowing each other's decision, you and your opponent will simultaneously choose quantity choice by clicking on the radio button of choice. If you and your opponent both choose 0, each of you get 0 points in this period. If you choose 0 and your opponent chooses 6, you get 0 points, and your opponent gets 108 points in this period. If you choose 6 and your opponent chooses 0, you get 108 points, and your opponent gets 0 points in this period. If you and your opponent both choose 6, each of you get 72 points in this period. Therefore, your earnings depend on your decision and your opponent's decision in each period.

***Earnings in Part 2**
Your earnings in each period are the sum of your earnings in the decision-making task. Your total earnings in Part 2 are your cumulative earnings in all periods. Recall that 100 points equal to 1.5 yuan. In each period before you provide your quantity choose an action, your decisions, your opponent's decisions and your earnings in each of the previous periods will appear in a history window. Before we start, let's review some important points. 1. You will be randomly paired with an opponent [*in your group/in the other group*]. The number of periods in a supergame is randomly determined. 2. A new period will start in which case you will be randomly paired with a different opponent [*in your group/in the other group*]. 3. In each period, you and your opponent each choose an action simultaneously before knowing each other's choice. If you have a question, please raise your hand.

Post-Experimental Survey
(1)[*Which group do you belong to?*] (2) What is your age? (3)What is your gender? (4) Before today, how many times have you participated in any economics or psychology experimental studies? (5) On a scale from 1 to 10, please rate how familiar you with those paintings. 1 is not at all. (6) [*Please choose a number between 1-10 to indicate the level of attachment/belonging you feel towards Team East Lake. 1 means not at all, 10 means very much.*] (7) [*On a scale from 1 to 10, please rate how much you think communicating with your group members helped solve questions, with 1 meaning "not much at all".*] (8) [*Please choose a number between 1-10 to indicate the level of attachment/belonging you feel towards Team Loujiashan Mountain. 1 means not at all, 10 means very much.*] (9) What is your major (10) In the box selling decision task, how would you describe your strategy? (11) Please share with us any other aspects of your decisions in the experiment that were not captured in the questions above.

B.1.2 Instructions (Finitely Repeated Games)

Welcome Welcome to today's experiment. Please read the following instructions carefully as they are directly relevant to how much money you will earn today. Please do not communicate with other people during the experiment. Please kindly switch your mobile phone off or put it on silent mode. Students causing a disturbance will be asked to leave the room. You will enter all of your decisions in today's experiment using only the computer mouse and keyboard. If you have any questions at any point during today's session, please raise your hand and one of the monitors will come to help.

Task You are about to participate in a decision-making process in which you will play games with other players in this room. What you earn depends on your decisions, partly on the decisions of others, and partly on chance. As you came in you drew an index card [*a white envelope*] with a number on it [*with a number on it and a card in it*]. This number, randomly assigned, is your ID number used in this experiment to ensure the anonymity of your decisions [*your group name printed on the card*]. Please do not show your ID number [card] to anyone else. Please turn off cellular phones now. We ask that you do not talk to each other during the experiment. If you have a question, please raise your hand, and an experimenter will assist you. This experiment consists of two parts and 40 players. Your earnings in each part are given in points. At the end of the experiment, you will be paid in private and in cash based on the following exchange rate 1.5 Yuan = 100 points Your total earnings will be the sum of your earnings in each part plus a 15 Yuan participation fee. We will now start at Part 1. The instructions for Part 2 will be given after Part 1 ends.

Part 1

We will now start at Part 1. [*Please open the white envelope and discreetly pull out the contents. It contains either a Luojiashan card or a Donghu card. The character represents the group that you are assigned to. The 40 players in this experiment are randomly assigned to one of two groups of 20 people. If you drew a Luojiashan card, you would be in the Luojiashan group. If you drew a Donghu card, you would be in the Donghu group. The group assignment will remain the same throughout the experiment. Please return the index card to the envelope now. Do not show them to others. Please raise your hand if you have any questions about this step.*] In Part 1 everyone will be shown three pairs of paintings by two artists, Kandinsky and Klee. You will have three minutes to study these paintings. And then, at the end of the three minutes, two additional paintings printed on the A4 paper. Then every player judges each of the two new paintings made by the artists in eight minutes [*You may communicate with others in your group through a chat program while answering the questions. But in the course of chatting, please do not deliver the personally identifiable information (e.g. gender, race, and major), major. Please avoid obscene or offensive language. Apart from these, you could discuss any topics you want, and your contexts are public to all group members.*] You will be given up to 8 minutes to answer both questions. Submit your answers below when you are ready. [*Note you are not required to give the same answers as your group members.*] Each correct answer is worth 100 experiment points. You will find out about your earnings in Part 1 at the end of the experiment. [*Please tell us how belonged you feel to your group and the other group at this moment. Enter a number from 1 ("not belonged at all") to 10 ("very closely belonged") that most accurately reflects your feelings. (These answers will not affect your earnings.) The sense of belongingness to your group The sense of belongingness to the other group*]

Part 2 (Finitely repeated)

In part 2, you will make decisions in periods and supergames. In interactions, you will choose the quantity in 7 supergames, each sequence of 10 periods is referred to as a supergame. Your history choices, the current supergame opponent's history choices, market prices and experimental players' points will be showed on the decision screen. You will be randomly paired with another player in this room [*in your group/in the other group*] (called your opponent) for sequences of periods in supergames. You and your opponent do not know each other. Subjects are either assigned to a fixed pairing at the beginning of a supergame. Once a supergame ends, you will be randomly paired with another player [*in your group/in the other group*]. In sessions in which a fixed pairing protocol is used, the fixed pairings changed from one supergame to the next; before the first period of each new supergame, each player was anonymously matched with one of the 39 [*19*] players with whom s/he had not previously played a supergame. In addition, every time the computer rematched the subject, the words 'New Partner' flashed on the computer screen. (i.e., another opponent) for a new supergame. [*A player in the Luojiashan group will only be paired with another player in the Luojiashan/Donghu group. A player from the Donghu group will only be paired with another player in the Donghu/Luojiashan group.*]

***Quizzes before the experiment.**

1 During the part two of experiments, how many players will be paired with you to make quantity choices?

2 According to the payoff table, if you sell six boxes, and the other player sells 12 boxes, what's your profit? And what is the other's profit?

***Quantity choices and Payoffs**
The choices and payoffs in each period are shown below:

Figure B2: Payoff matrix

	0	6	7	8	9	12
0	(0,0)	(0,108)	(0,119)	(0,128)	(0,135)	(0,144)
6	(108,0)	(72,72)	(66,77)	(60,80)	(54,81)	(36,72)
7	(119,0)	(77,66)	(70,70)	(63,72)	(56,72)	(35,60)
8	(128,0)	(80,60)	(72,63)	(64,64)	(56,63)	(32,48)
9	(135,0)	(81,54)	(72,56)	(63,56)	(54,54)	(27,36)
12	(144,0)	(72,36)	(60,35)	(48,32)	(36,27)	(0,0)

You and your opponent each can choose among six quantity choices, 0,6,7,8,9, and 12. The first entry in each cell represents your payoff and the second entry your opponent's payoff. Your payoffs are bolded for your convenience. In each period, before knowing each other's decision, you and your opponent will simultaneously choose quantity choice by clicking on the radio button of choice. If you and your opponent both choose 0, each of you get 0 points in this period. If you choose 0 and your opponent chooses 6, you get 0 points, and your opponent gets 108 points in this period. If you choose 6 and your opponent chooses 0, you get 108 points, and your opponent gets 0 points in this period. If you and your opponent both choose 6, each of you get 72 points in this period. Therefore, your earnings depend on your decision and your opponent's decision in each period.

***Earnings in Part 2**
Your earnings in each period are the sum of your earnings in the decision-making task. Your total earnings in Part 2 are your cumulative earnings in all periods. Recall that 100 points equal to 1.5 yuan. In each period before you provide your quantity choose an action, your decisions, your opponent's decisions and your earnings in each of the previous periods will appear in a history window. Before we start, let's review some important points. 1. You will be randomly paired with an opponent [*in your group/in the other group*]. The number of periods in a supergame is randomly determined. 2. A new period will start in which case you will be randomly paired with a different opponent [*in your group/in the other group*]. 3. In each period,

you and your opponent each choose an action simultaneously before knowing each other's choice. If you have a question, please raise your hand.

Post-Experimental Survey
(1)[*Which group do you belong to?*] (2) What is your age? (3)What is your gender? (4) Before today, how many times have you participated in any economics or psychology experimental studies? (5) On a scale from 1 to 10, please rate how familiar you with those paintings. 1 is not at all. (6) [*Please choose a number between 1-10 to indicate the level of attachment/belonging you feel towards Team East Lake. 1 means not at all, 10 means very much.*] (7) [*On a scale from 1 to 10, please rate how much you think communicating with your group members helped solve questions, with 1 meaning "not much at all".*] (8) [*Please choose a number between 1-10 to indicate the level of attachment/belonging you feel towards Team Loujiashan Mountain. 1 means not at all, 10 means very much.*] (9) What is your major (10) In the box selling decision task, how would you describe your strategy? (11) Please share with us any other aspects of your decisions in the experiment that were not captured in the questions above.

B.1.3 Instructions (Indefinitely Repeated Games)

Welcome Welcome to today's experiment. Please read the following instructions carefully as they are directly relevant to how much money you will earn today. Please do not communicate with other people during the experiment. Please kindly switch your mobile phone off or put it on silent mode. Students causing a disturbance will be asked to leave the room. You will enter all of your decisions in today's experiment using only the computer mouse and keyboard. If you have any questions at any point during today's session, please raise your hand and one of the monitors will come to help.

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Part 1

We will now start at Part 1. [*Please open the white envelope and discreetly pull out the contents. It contains either a Luojiashan card or a Donghu card. The character represents the group that you are assigned to. The 40 players in this experiment are randomly assigned to one of two groups of 20 people. If you drew a Luojiashan card, you would be in the Luojiashan group. If you drew a Donghu card, you would be in the Donghu group. The group assignment will remain the same throughout the experiment. Please return the index card to the envelope now. Do not show them to others. Please raise your hand if you have any questions about this step.*] In Part 1 everyone will be shown three pairs of paintings by two artists, Kandinsky and Klee. You will have three minutes to study these paintings. And then, at the end of the three minutes, two additional paintings printed on the A4 paper. Then every player judges each of the two new paintings made by the artists in eight minutes [*You may communicate with others in your group through a chat program while answering the questions.*

But in the course of chatting, please do not deliver the personally identifiable information (e.g. gender, race, and major), major. Please avoid obscene or offensive language. Apart from these, you could discuss any topics you want, and your contexts are public to all group members.] You will be given up to 8 minutes to answer both questions. Submit your answers below when you are ready. [*Note you are not required to give the same answers as your group members.*] Each correct answer is worth 100 experiment points. You will find out about your earnings in Part 1 at the end of the experiment. [*Please tell us how you belonged feel to your group and the other group at this moment. Enter a number from 1 ("not belonged at all") to 10 ("very closely belonged") that most accurately reflects your feelings. (These answers will not affect your earnings.) The sense of belongingness to your group The sense of belongingness to the other group*]

Part 2 (Indefinitely repeated)
In part 2, you will make decisions in periods and supergames. In interactions, you will choose the quantity in 7 supergames, each sequence of randomly determined periods is referred to as a supergame. Your history choices, the current supergame opponent's history choices, market prices and experimental players' points will be showed on the decision screen. You will be randomly paired with another player in this room [*in your group/in the other group*] (called your opponent) for sequences of periods. Subjects are either assigned to a fixed pairing at the beginning of a supergame. In sessions in which a fixed pairing protocol is used, the fixed pairings changed from one supergame to the next; before the first period of each new supergame, each player was anonymously matched with one of the 39 [*19*] players with whom s/he had not previously played a supergame. At the end of every stage period, the play would continue for another period with a probability of 90% and a 10% chance that the supergame will end. If the supergame continues, the opponent will not change. If the supergame end, a new supergame will start and a new opponent will be paired. In addition, every time the computer rematched the subject, the words 'New Partner' flashed on the computer screen. Furthermore, every time the beginning of the next period, the words 'the player would continue for another period with a probability of 90%' flashed on the computer screen. You will not know who your opponent is and vice-versa. Each sequence of periods is referred to as a super-game. Once a supergame ends, you will be randomly paired with another player [*in your group/in the other group]* (i.e., another opponent) for a new supergame. [*A player in the Luojiashan group will only be paired with another player in the Luojiashan/Donghu group. A player from the Donghu group will only be paired with another player in the Donghu/Luojiashan group.*]

***Quizzes before the experiment**

1 During the part two of experiments, how many players will be paired with you to make quantity choices? Are the periods in each supergame fixed? What is the probability of game continuity?

2 According to the payoff table, if you sell six boxes, and the other player sells 12 boxes, what's your profit? And what is the other's profit?

***Quantity choices and Payoffs**
The choices and payoffs in each period are shown below:

Figure B3: Payoff matrix

	0	6	7	8	9	12
0	(0,0)	(0,108)	(0,119)	(0,128)	(0,135)	(0,144)
6	(108,0)	(72,72)	(66,77)	(60,80)	(54,81)	(36,72)
7	(119,0)	(77,66)	(70,70)	(63,72)	(56,72)	(35,60)
8	(128,0)	(80,60)	(72,63)	(64,64)	(56,63)	(32,48)
9	(135,0)	(81,54)	(72,56)	(63,56)	(54,54)	(27,36)
12	(144,0)	(72,36)	(60,35)	(48,32)	(36,27)	(0,0)

You and your opponent each can choose among six quantity choices, 0,6,7,8,9, and 12. The first entry in each cell represents your payoff and the second entry your opponent's payoff. Your payoffs are bolded for your convenience. In each period, before knowing each other's decision, you and your opponent will simultaneously choose quantity choice by clicking on the radio button of choice. If you and your opponent both choose 0, each of you get 0 points in this period. If you choose 0 and your opponent chooses 6, you get 0 points, and your opponent gets 108 points in this period. If you choose 6 and your opponent chooses 0, you get 108 points, and your opponent gets 0 points in this period. If you and your opponent both choose 6, each of you get 72 points in this period. Therefore, your earnings depend on your decision and your opponent's decision in each period.

***Earnings in Part 2**
Your earnings in each period are the sum of your earnings in the decision-making task. Your total earnings in Part 2 are your cumulative earnings in all periods. Recall that 100 points equal to 1.5 yuan. In each period before you provide your quantity choose an action, your decisions, your opponent's decisions and your earnings in each of the previous periods will appear in a history window. Before we start, let's review some important points. 1. You will be randomly paired with an opponent [*in your group/in the other group*]. The number of periods in a supergame is randomly determined. 2. A new period will start in which case you will be randomly paired with a different opponent [*in your group/in the other group*]. 3. In each period, you and your opponent each choose an action simultaneously before knowing each other's choice. If you have a question, please raise your hand.

Post-Experimental Survey
(1)[*Which group do you belong to?*] (2) What is your age? (3)What is your gender? (4) Before today, how many times have you participated in any economics or psychology experimental

studies? (5) On a scale from 1 to 10, please rate how familiar you with those paintings. 1 is not at all. (6) [*Please choose a number between 1-10 to indicate the level of attachment/belonging you feel towards Team East Lake. 1 means not at all, 10 means very much.*] (7) [*On a scale from 1 to 10, please rate how much you think communicating with your group members helped solve questions, with 1 meaning "not much at all".*] (8) [*Please choose a number between 1-10 to indicate the level of attachment/belonging you feel towards Team Loujiashan Mountain. 1 means not at all, 10 means very much.*] (9) What is your major (10) In the box selling decision task, how would you describe your strategy? (11) Please share with us any other aspects of your decisions in the experiment that were not captured in the questions above.

B.2 Interface

B.2.1 Interface: Part One

Figure B4: Part one: Paintings study

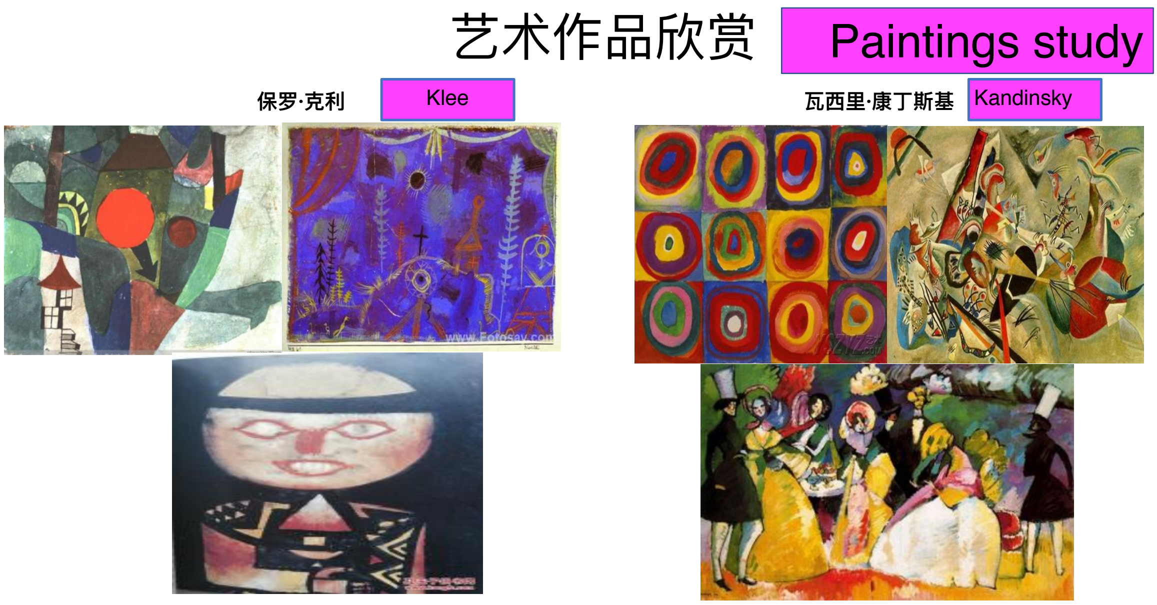


Figure B5: Part one: Paintings self-study (Beginning page)

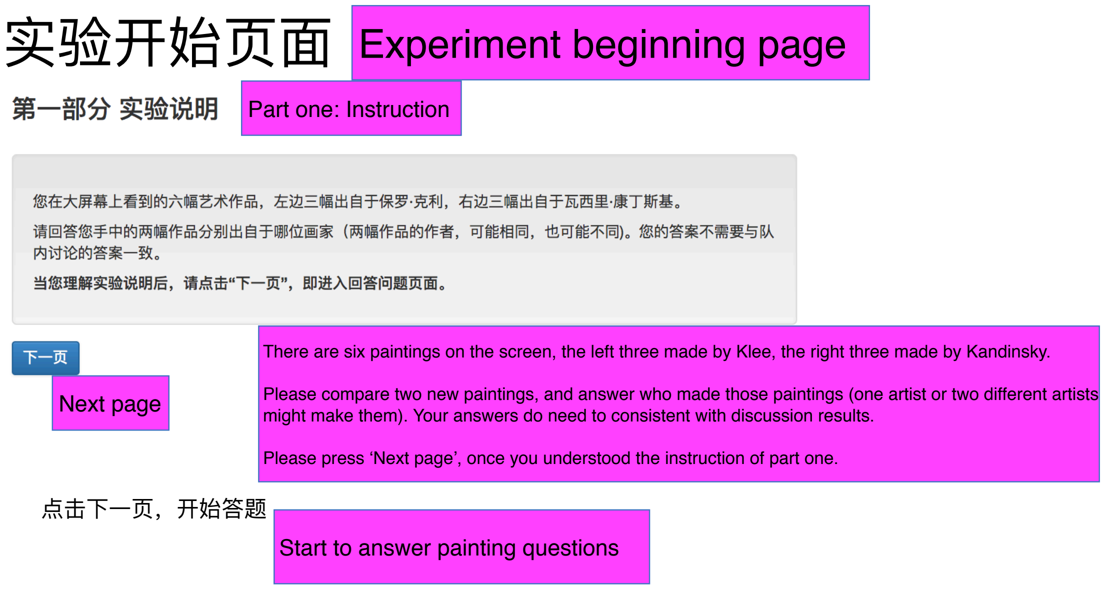


Figure B6: Part one: Two additional paintings comparisons

Figure B7: Part one: Within group discussion

Figure B8: Part one: Problem-solving

Figure B9: Part one: Individual payoff

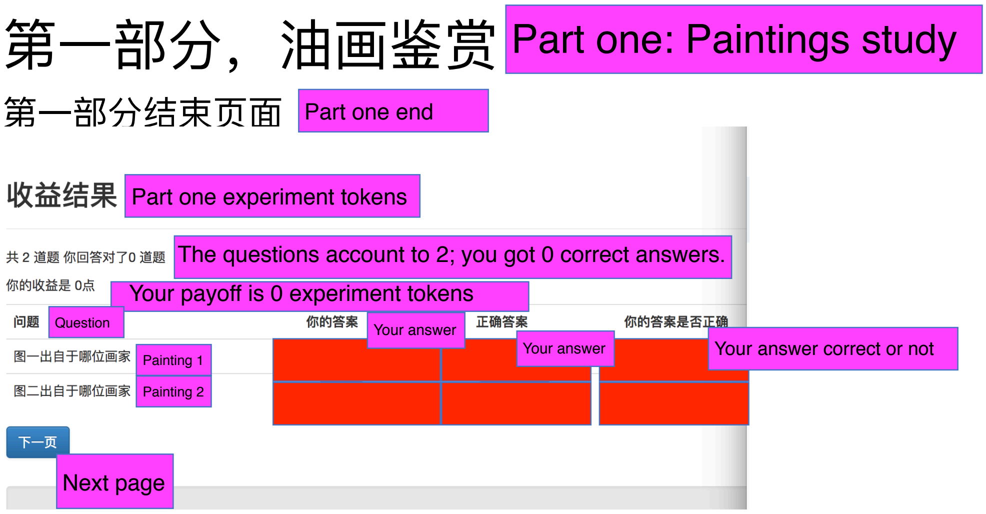
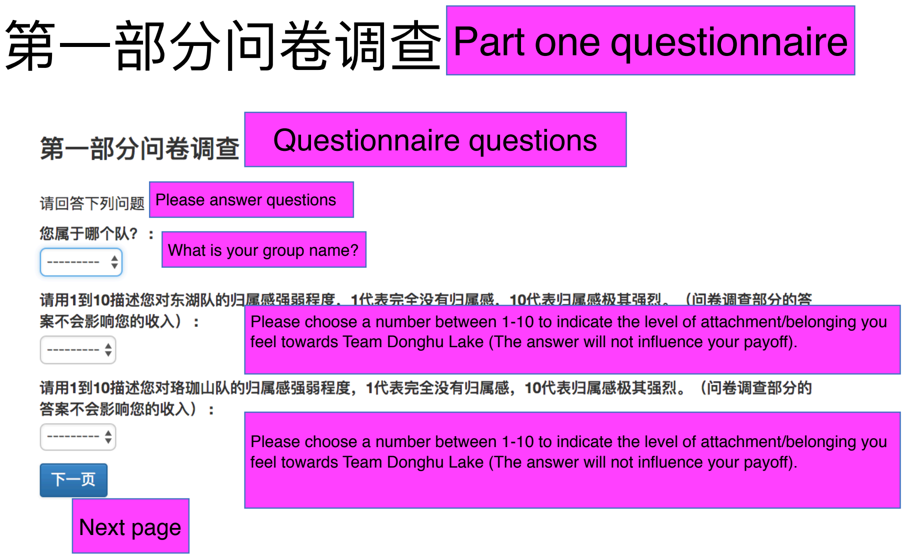


Figure B10: Part one: Questionnaire (Group assigned treatments)



Notes: The part one questionnaire just answered by the group assignment players.

B.2.2 Interface: Part Two

Figure B11: Part two: The beginning of the part two

Figure B12: Part two: Instruction of part two

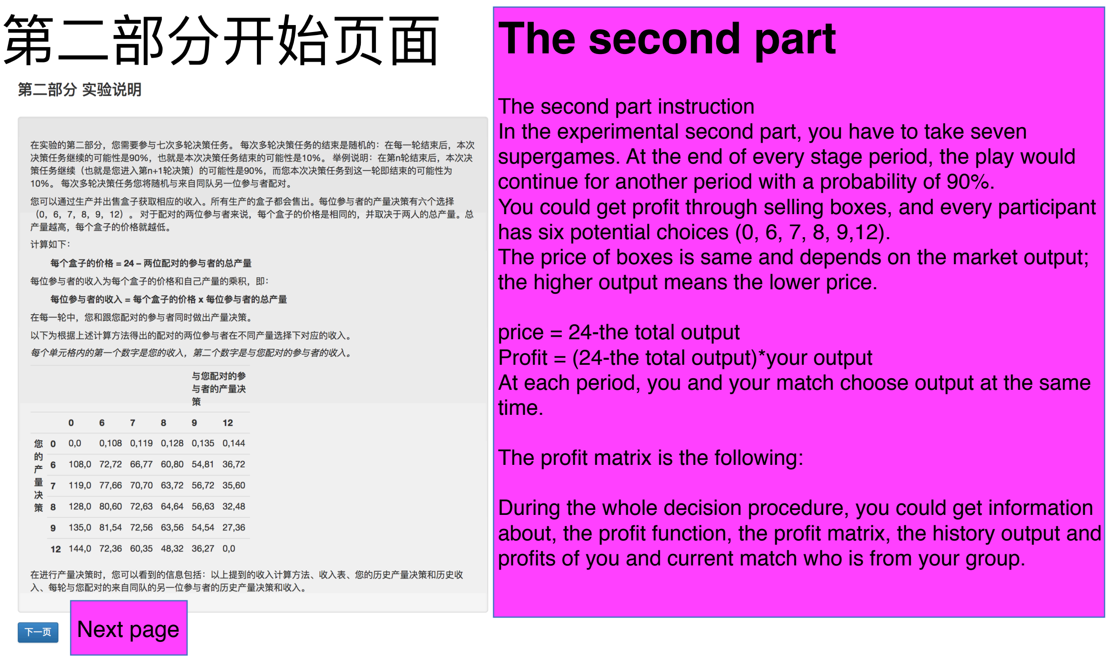


Figure B13: Part two: Decision task

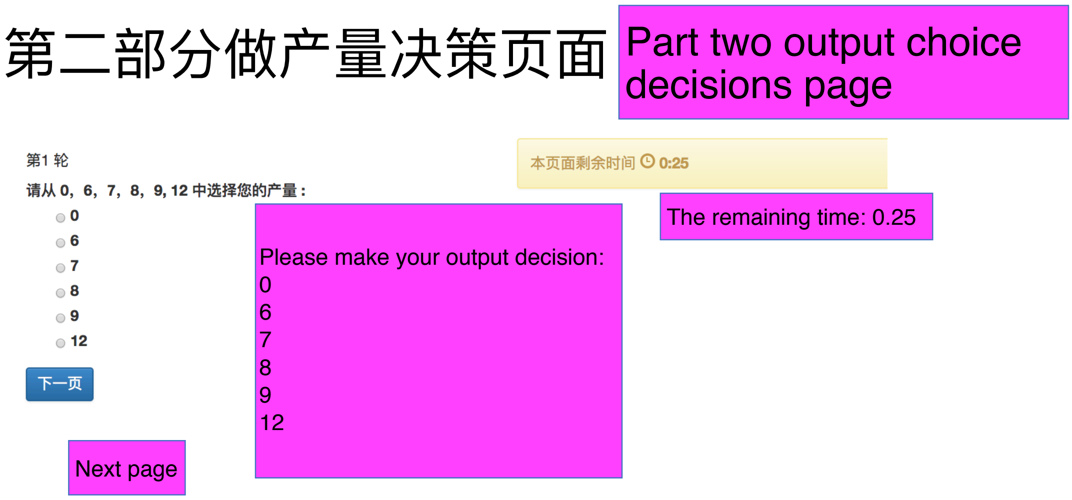


Figure B14: Part two: Decision task

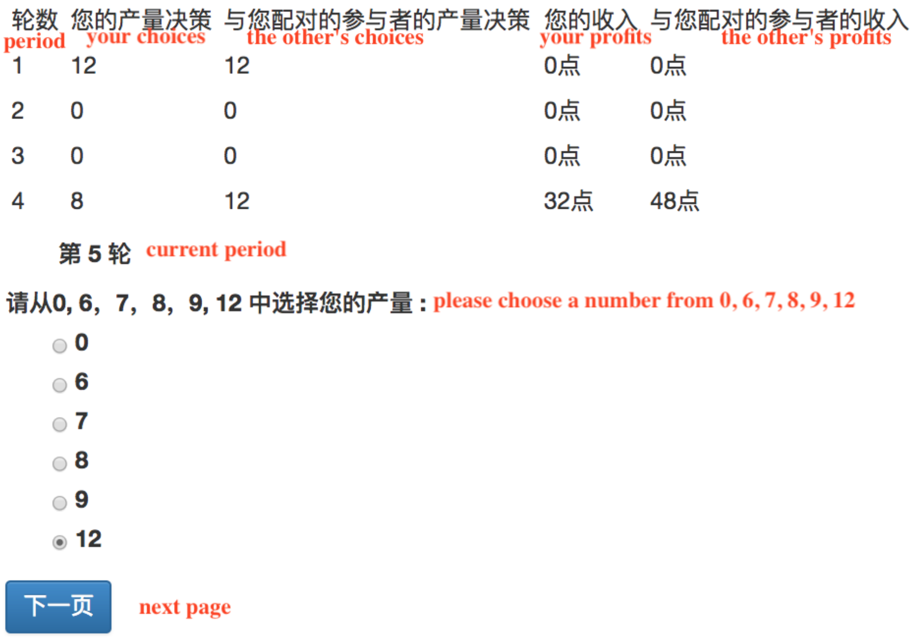


Figure B15: Part two: The beginning of the next period

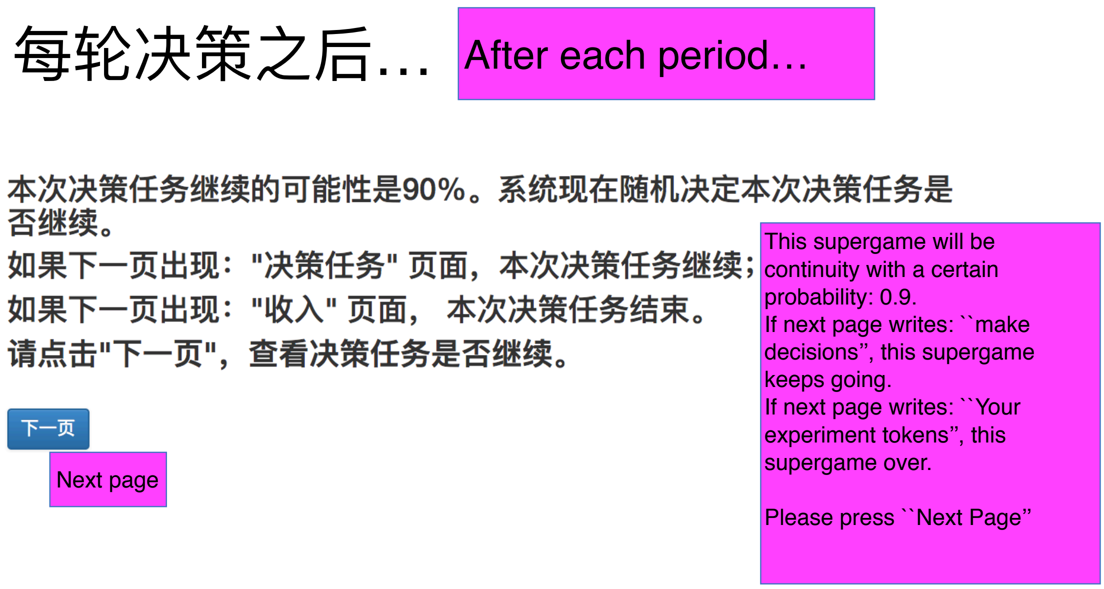


Figure B16: Part two: The waiting page

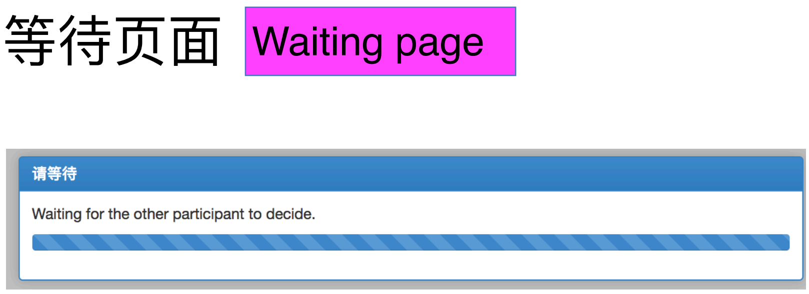


Figure B17: Part two: Questionnaire

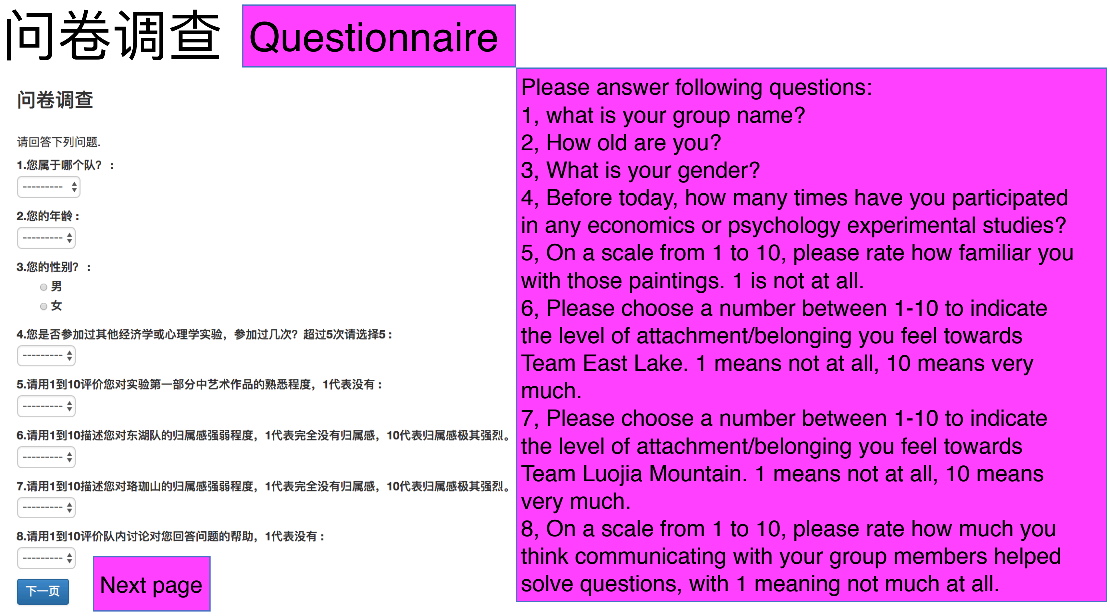
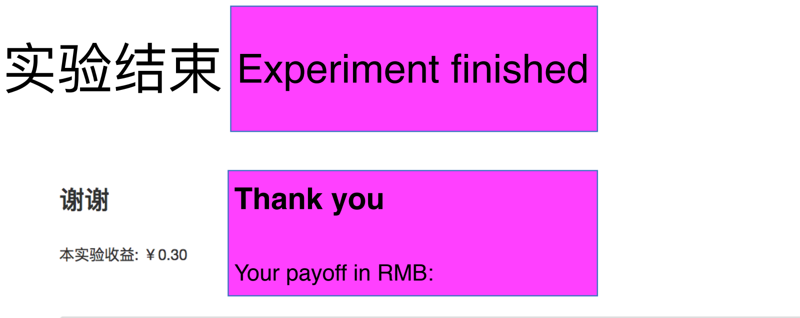


Figure B18: The total material payoff



C Theoretic Models

Since all firms in the experiments are identical, the interaction between a pair of them can be regarded as a symmetric game. In addition, the paired firms have the same group contingent other-regarding preference. That is to say, $firm_i$'s utility in each period is separable in its monetary profits and the profits of its rivals. Therefore, we have:

$$\begin{aligned} u_i(\pi_i^g, \pi_j^g) = \pi_i^g + \omega^g(\pi_j^g - \pi_i^g), where\ \pi_i = (Z - q_i - q_j)q_i \\ thus, \\ u_i = \omega^g \pi_j^g + (1-\omega^g)\,\pi_i = \omega^g \left[\left(Z - q_i^g - q_j^g\right) q_j\right] + (1-\omega^g)\left[\left(Z - q_i^g - q_j^g\right) q_i^g\right] \end{aligned} \tag{A.1}$$

where term ω represents the preference for group contingent other-regarding and the weight that $firm_i$ places on its rivals' monetary profits. It is dependent on the group of $firm_j$:

$$\omega^g(\pi_i, \pi_j)\begin{cases} > 0.5 & \text{Pure altruism} \\ > 0 & \text{Impure altruism} \\ = 0 & \text{Self-interest} \\ < 0 & \text{Spiteful (envious)} \end{cases} \tag{A.2}$$

$$\omega^g(\pi_i, \pi_j)\begin{cases} > 0 & \text{if } g = I; \omega^I > \omega^N > \omega^O \\ = 0 & \text{if } g = N; \omega^I > \omega^N > \omega^O \\ < 0 & \text{if } g = O; \omega^I > \omega^N > \omega^O \end{cases} \tag{A.3}$$

To be more specific, $firm_i$ places a positive weight on $firm_j$'s monetary profit when i and j are in the same group. The weight under this circumstance is higher than that of the other two combinations. $firm_i$ places no weight on j's monetary profits when i and j do not share the same group identity. However, $firm_i$ places a negative weight on firm j's monetary profit when j belongs to a different group. In the partial derivative equation of firm i's a single period utility, we have

$$\begin{aligned} \frac{\partial u_i}{\partial q_i^g} &= (1-\omega^g)(Z-Q) - [(1-\omega^g)q_i^g + \omega^g q_j^g] \\ &= 2(1-\omega^g)(12 - \frac{1}{2(1-\omega^g)}q_j^g - q_i^g) \end{aligned} \tag{A.4}$$

where ω^g is a function that measures how differences in monetary profit between $firm_j$ and $firm_i$ impacts the weight that $firm_i$ puts on $firm_j$'s monetary profit. Based on the first order conditions for preference maximization, we can derive the firms' best response functions:

$\frac{\partial u_i^g}{\partial q_i^g} = 0$ for q_i^g. This equation recognizes the implicit non-negatively constraint on output, which can be obtained from $firm_i$'s reaction function. R_i^g specifies each output chosen by $firm_j$, and the output represents $firm_i$'s best response as follows:

$$R_i(q_j)^g = \begin{cases} 0 & \text{if } 24(1-\omega^g) \le q_j \\ \frac{24(1-\omega^g) - q_i^g}{2(1-\omega^g)} & \text{if } 0 \le q_j \le 24(1-\omega^g) \end{cases} \tag{A.5}$$

In the relevant range, we have $\frac{\partial \pi_i}{\partial q_i} > (<)0$ for $q_i < (>)Ri(q_j)$. Therefore, $R_i(q_j)$ can identify $firm_i$'s (unique) best response to $firm_i$'s output choice. For $\omega^g \in [-1, 1]$ the Cournot equilibrium is unique. The symmetric firms can choose the same output $q_i^{*(g)}$, and this the solution is

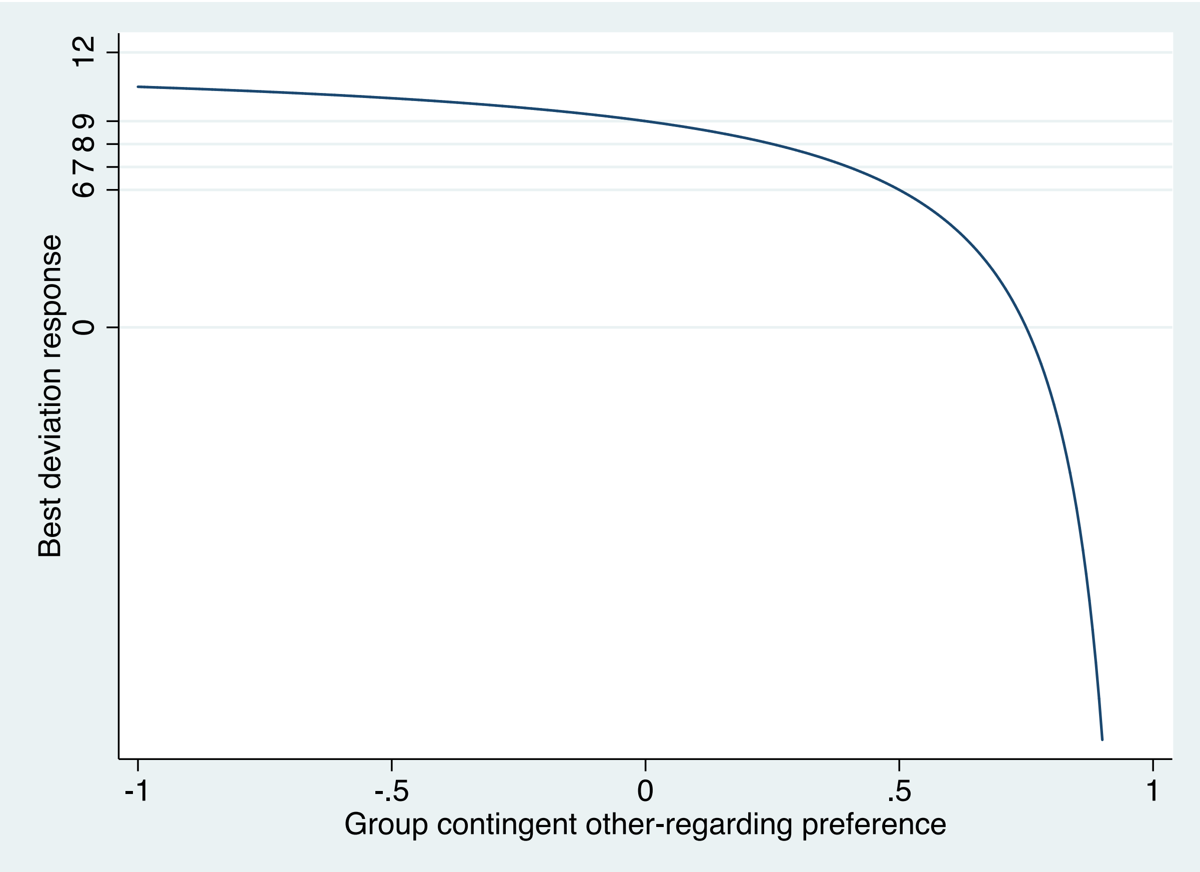
$q_i^{*(g)} = R_i(q_j^{*(g)})$. Therefore, the output of Cournot equilibrium outputs with partial ownership ω can be expressed as $q^{*(g)} = \frac{1-\omega^g}{3-2\omega^g}Z$. The utility of each firms is

$$u^{*(g)} = (Z - \frac{1-\omega^g}{3-2\omega^g}Z - \frac{1-\omega^g}{3-2\omega^g}Z) * \frac{1-\omega^g}{3-2\omega^g}Z \\ \frac{Z * Z(1-\omega^g)}{(3-2\omega^g)^2} \tag{A.6}$$

The aggregate monopoly output can be calculated by setting q_j as 0. This setting yields a total monopoly output of $\frac{24}{2}$; therefore each firm's equal share of the monopoly output is $\widehat{q}_i = 6$. A firm which deviates optimally from the monopoly outcome would choose output q^D (see Figure C19), which can be expressed as

$$q^D = R(\widehat{q}) = \frac{24(1-\omega^g) - \widehat{q}_j}{2(1-\omega^g)} = \frac{9-12\omega^g}{1-\omega^g} \tag{A.7}$$

Figure C19: Best response to collusive opponent with group identity parameter



A firm which deviates optimally against a rival selling output $\widehat{q}_i$ will have its output q^D and earn utility u^D. These parameters satisfy the equation:

$$u^D = [(1-\omega^g)q^D(24 - q^D - \widehat{q}) + \omega^g\widehat{q}](24 - q^D - \widehat{q}) == \frac{(9-6\omega^g)^2}{1-\omega^g} \tag{A.8}$$

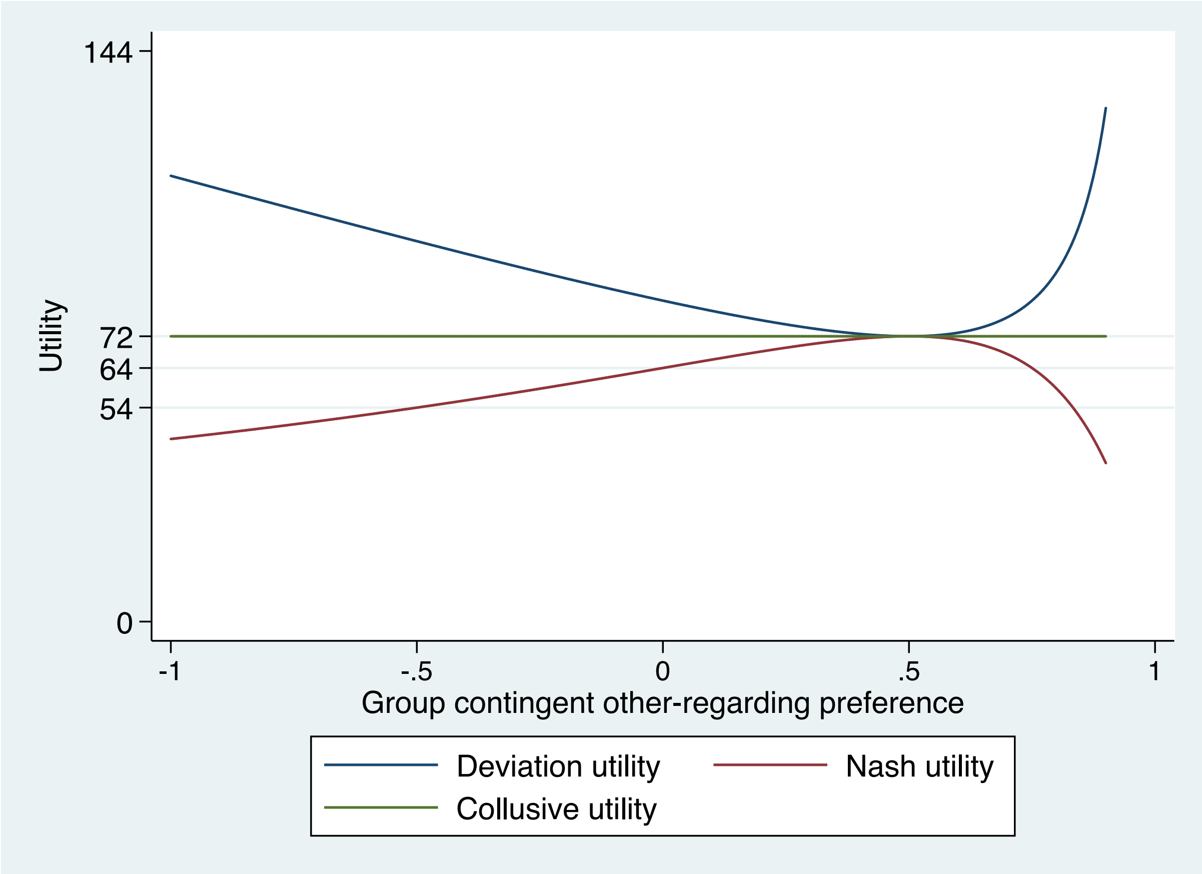


Figure C20: Utility changing with group contingent other-regarding preference parameters

Each $firm_i$ entitled to the group contingent other-regarding to the fraction ω in regard to the profits of its rival. As illustrated in Figure C20, the Cournot Nash utility and the deviation utility change with different group contingent other-regarding parameters $\omega^g \in [-1, 1]$. Figure C21 shows the $firm_i$'s utility gains from collusion to deviation.

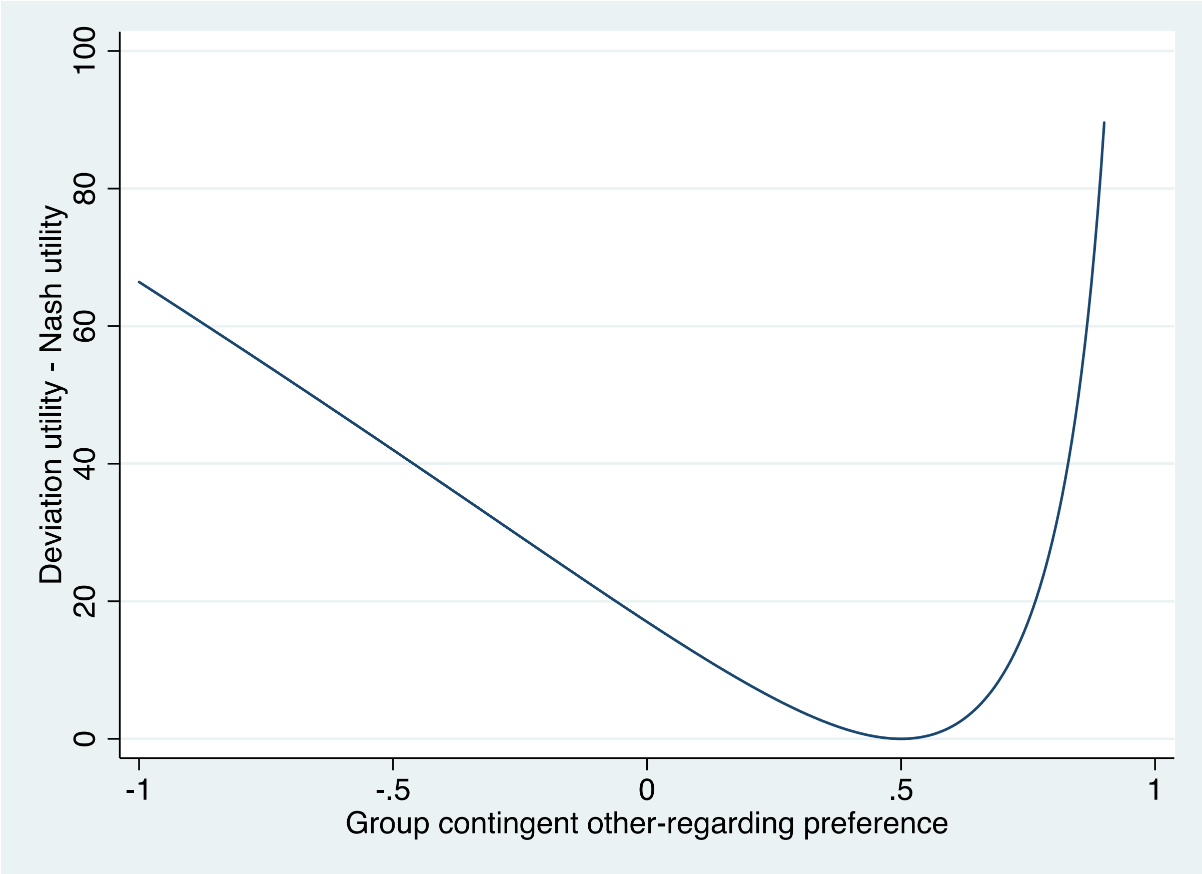
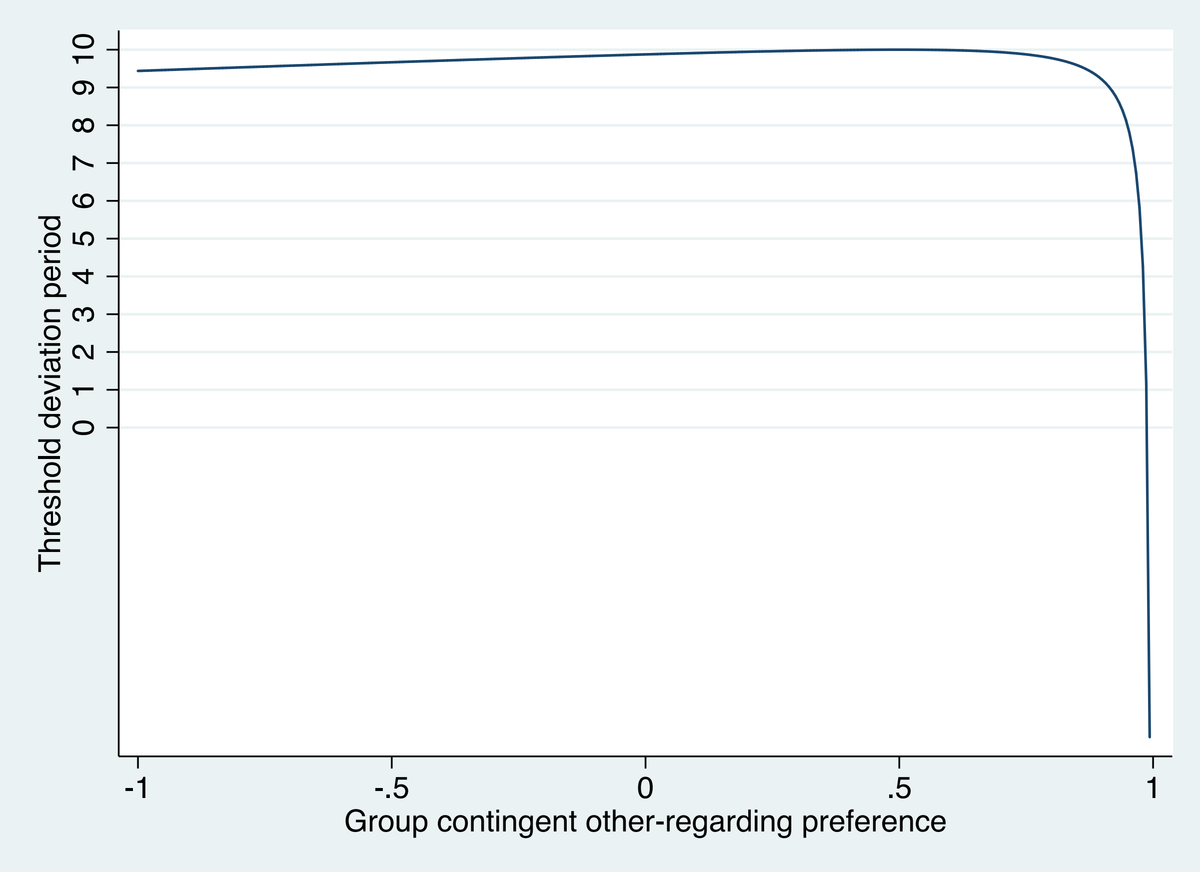


Figure C21: Deviation utility gains

Collusion As the test of group contingent can affect the extent of collusion, whether the firms can support the monopoly outputs in each period by the implicit threat should be considered. In other words, if this “collusion” ever breaks down, both firms will forever set their outputs equal to the static Cournot equilibrium outputs. I ask whether each implementing the following strategy can constitute a Sub-game Perfect Nash Equilibrium in the repeated game. As in other models, this “trigger” strategy will form a Sub-game Perfect Nash Equilibrium if and only if the firm’s discount factors exceed the critical level.

Finitely Repeated Interactions Figure C22 illustrates the influence of group contingent other-regarding on the period of threshold deviation.

Figure C22: Finitely repeated interactions: Threshold deviation period



For $\omega^g \in [-1, 0.5]$, the threshold deviation period is concentrated between 9th and 10th period. For $\omega^g \in [0.5, 1]$, the threshold deviation period decreases with the increased group contingent other-regarding parameter.

Indefinitely Repeated Interactions If the increased group contingent other-regarding improves this critical discount factor, then collusion is less likely to happen. That is because the set of parameters can support collusion before the happening of increased group contingent other-regarding. Firms discount is set at the rate of $\delta \in (0,1)$. The repeated game utility is given by $U_i = \sum_{\infty}^{t=0} u_i(q_i, q_j)\delta^t$. The incentive compatibility condition for a group contingent other-regarding $firm_i$ sustains the selfish collusive outcome by using a grim trigger strategy. This situation can be expressed as: $u_i^D(R_i(\widehat{q}_j, \widehat{q}_j)) + \frac{\delta}{1-\delta} u_i^{*(g)}(q_i^*(g), q_j^{*(g)}) \leq \frac{1}{1-\delta} \widehat{u}_i(\widehat{q}_i, \widehat{q}_j)$. Therefore, we can obtain

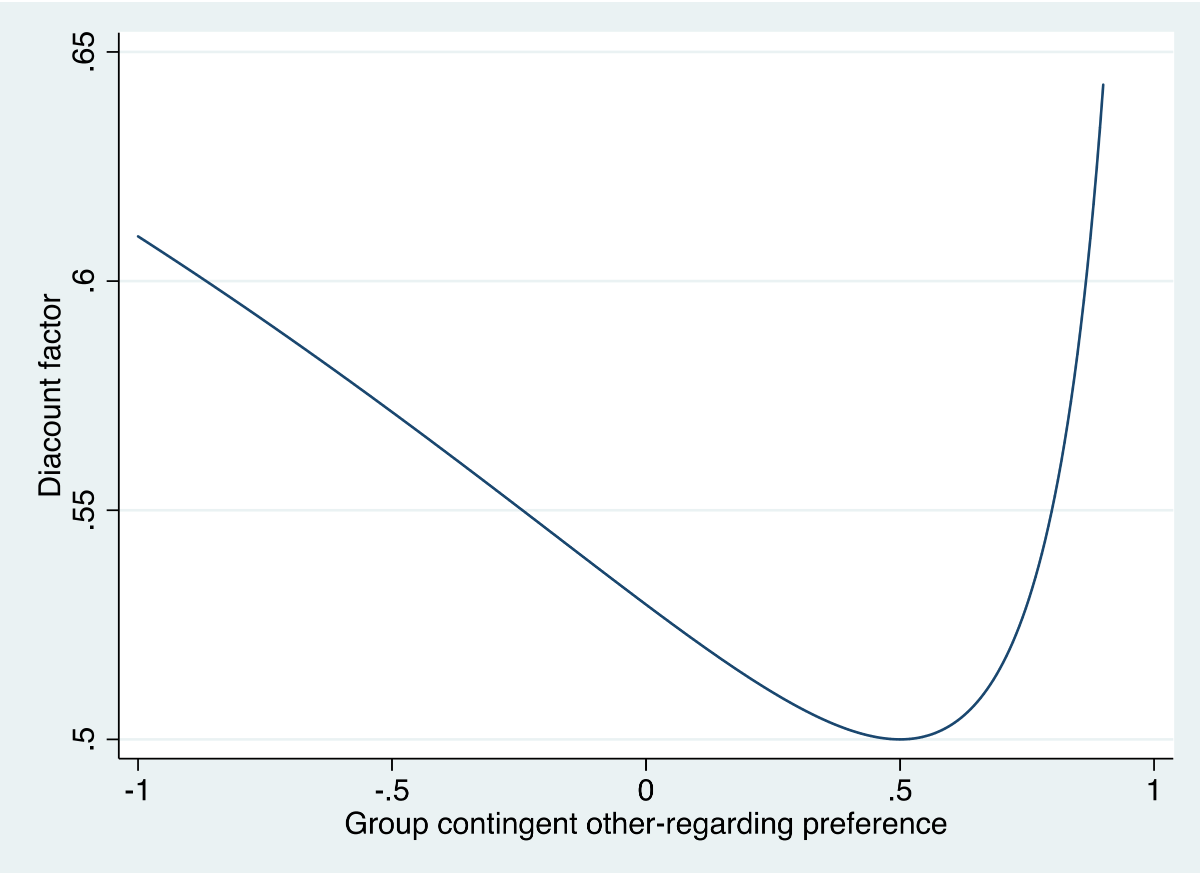
$$\delta^{c(g)} = \frac{u_i^D - \widehat{u}_i}{u_i^D - u_i^*} \leq \delta \tag{A.9}$$

When firms have group contingent other-regarding preferences, they tend to follow the selfish collusive outcome, which can be sustained if the firms are patient enough. $\delta^{C*(g)}$ is the critical discount factor above which the selfish collusive outcome can be sustained by group contingent other regarding firms. In order to determine whether these triggered strategies can constitute an equilibrium, the utility in the repeated model should be calculated. In general, the formula for δ^C is unwieldy; however, we have

$$\delta^{c(g)} \equiv \frac{\frac{(9-6\omega^g)^2}{1-\omega^g} - 72}{72 - \frac{24*24(1-\omega^g)}{(3-2\omega^g)^2}} \tag{A.10}$$

In this function, $\delta^{c(g)}$ would decrease until ω^g approaches to 0.5. After that turning point, $\delta^{c(g)}$ increases. This shows that, for a higher level of group contingent other-regarding, increased cross ownership may actually decrease the likelihood of sustained collusion. This result is shown more dramatically in Figure C23. Hence, in this case, increased group contingent other-regarding no doubt facilitates collusion. As noted earlier, increased group contingent other-regarding softens the punishment phase of the trigger strategy, and reduces the gain from cheating. For $\omega^g \in [-1, 0.5]$, the collusive outcome of single period Cournot interaction can be sustained at a lower discount factor in the indefinitely repeated Cournot duopoly for group contingent other-regarding firms, and vice versa. As the group contingent other-regarding increases in the event of $\omega^g < 0.5$, u^D approaches to $\widehat{u}_i$. This implies that the gains from single-period deviation decrease, which is shown in Figure C21. Alternatively, $u_i^{*(g)}$ increases in the group-contingent other-regarding firms, implying that the punishment for 'cheating' becomes less severe. If $\omega \in [-1, 0.5]$, then $\delta^{c(I)} < \delta^{c(N)} < \delta^{c(O)}$. If $\omega \in [0.5, 1]$, then $\delta^{c(I)} > \delta^{c(N)} > \delta^{c(O)}$.

Figure C23: Indefinitely repeated interactions: Critical discount factor δ^c over group identity



In sum, increasing group contingent other-regarding softens the punishment phases of the trigger strategy. At the same time, it also declines the gains from deviations. There are two reasons to explain the decrease in the gains from deviations. On the one hand, the size of gains from deviations must be heavily discounted. On the other hand, with higher other-regarding preference, a more significant share of one's utility comes from the profits of rivals; which could lead a more significant (negative) effect on the utility, thereby also reducing the gains from deviations. Whether increase other-regarding preference makes collusion more or less likely, which depends on the net results of these two effects.

To illustrate how a subject's group identity may affect his or her incentives toward collusion in this duopoly game, we examine the Frieman Index, an indicator of the potential for collusion used in previous research. The Friedman Index is calculated as the ratio of the gains from colluding to the gains from cheating, therefore a greater Friedman Index indicates a higher likelihood of collusion. The Friedman Index can be defined in terms of the agent's utility which allows for the possibility of the same group identity. Function $u(\pi, \varpi^g)$ characterizes the firm's utility from income π and the group identity parameter ϖ^g. ϖ^g is determined by the extent the belongingness of the firms to their group. Then the Friedman Index can be modified as $\frac{u(\pi^C;\varpi^g)-u(\pi^{NE};\varpi^g)}{u(\pi^D;\varpi^g)-u(\pi^C;\varpi^g)}$; where π^C is the profit from the joint profit from maximized (collusive) outcome, π^{NE} is the one-shot Nash equilibrium profit, and π^D is the profit form a unilateral defection from joint profit maximization.

Figure C24: Friedman index

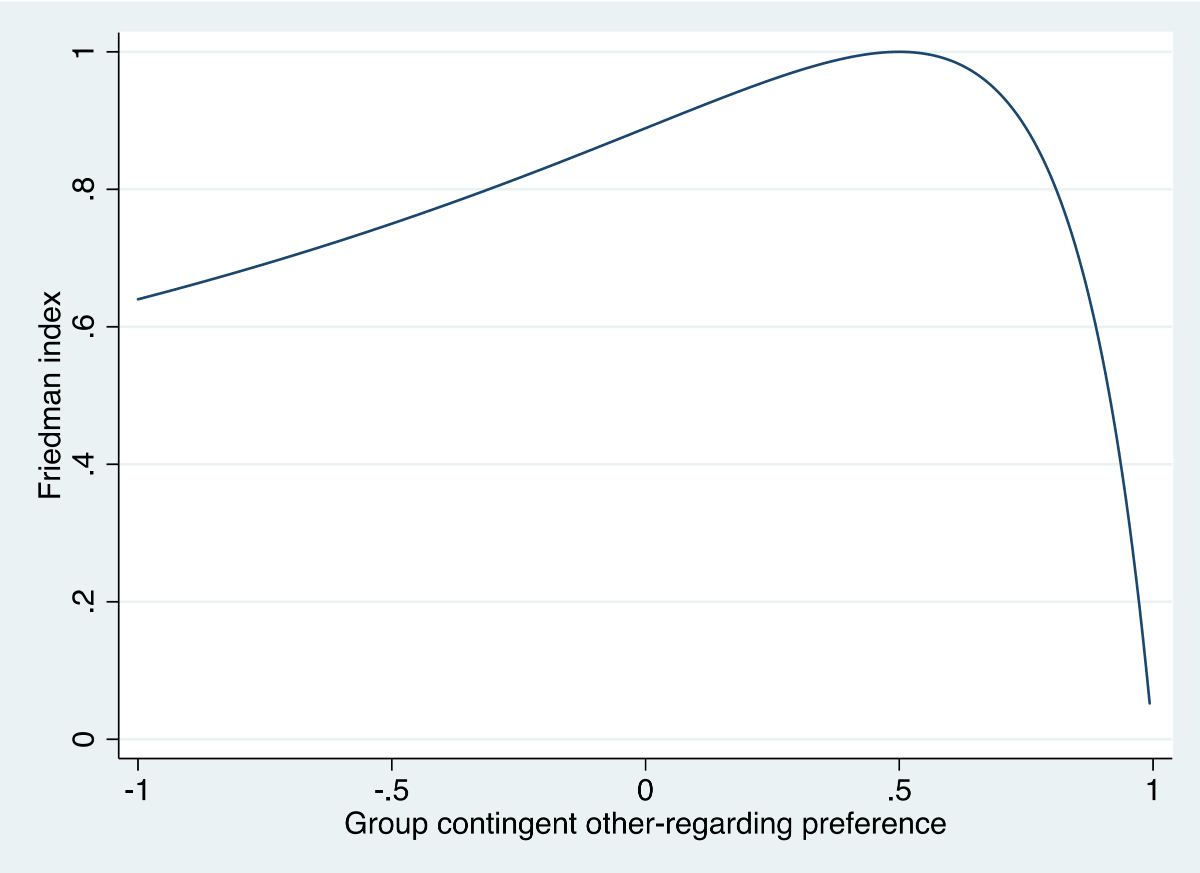


Figure C24 indicates an example of the modified Friedman Index as a function of belongingness to x_{group}. To plot the graph, we use the utility function $U_i = \varpi_i^g \pi_j + (1 - \varpi_i^g)\pi_i$, and the different profit levels can be evaluated based on the parameters of our experiments. Parameter ϖ_i^g is the coefficient of the weight on the opponent's material profit, where positive values indicate favouritism preferences and negative values represent derogation preferences. The Friedman Index increases in ϖ_i^g: allowing tolerance for group identity and a greater likelihood of collusion. While the standard Friedman Index utilizes the ratio of absolute differences in payoffs, the modified measure analyzes the changes in utility. The utility function exhibits a decreased marginal utility of income, and a group favouritism may derive more additional utility from increased profits which were obtained from colluding relation to Nash profits than those from defective relation to collusion.[47]

[47]Because $\pi^D > \pi^C > \pi^{NE}$ and the utility function exhibits a decreasing marginal utility of income, group

D Treatments

Table D2: Treatments

	Experimental part one						Experimental part two						
	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10	Step 11	Step 12	Subjects
One shot													
Nogroup	Draw card	Play recording	Show PPT	Instructions	Study paintings	Answer two additional painting questions	Play recording	Show PPT	Instructions	Quiz	One shot	Result display and questionnaire	40
Ingroup	Draw envelope	Play recording	Show PPT	Instructions	Study paintings	Discuss and answer two additional painting questions, and questionnaire	Play recording	Show PPT	Instructions	Quiz	One shot	Result display and questionnaire	40
Outgroup	Draw envelope	Play recording	Show PPT	Instructions	Study paintings	Discuss and answer two additional painting questions, and questionnaire	Play recording	Show PPT	Instructions	Quiz	One shot	Result display and questionnaire	40
Finitely													
Nogroup	Draw card	Play recording	Show PPT	Instructions	Study paintings	Answer two additional painting questions	Play recording	Show PPT	Instructions	Quiz	Finitely	Result display and questionnaire	40
Ingroup	Draw envelope	Play recording	Show PPT	Instructions	Study paintings	Discuss and answer two additional painting questions, and questionnaire	Play recording	Show PPT	Instructions	Quiz	Finitely	Result display and questionnaire	40
Outgroup	Draw envelope	Play recording	Show PPT	Instructions	Study paintings	Discuss and answer two additional painting questions, and questionnaire	Play recording	Show PPT	Instructions	Quiz	Finitely	Result display and questionnaire	40
Indefinitely													
Nogroup	Draw card	Play recording	Show PPT	Instructions	Study paintings	Answer two additional painting questions	Play recording	Show PPT	Instructions	Quiz	Indefinitely	Result display and questionnaire	40
Ingroup	Draw envelope	Play recording	Show PPT	Instructions	Study paintings	Discuss and answer two additional painting questions, and questionnaire	Play recording	Show PPT	Instructions	Quiz	Indefinitely	Result display and questionnaire	40
Outgroup	Draw envelope	Play recording	Show PPT	Instructions	Study paintings	Discuss and answer two additional painting questions, and questionnaire	Play recording	Show PPT	Instructions	Quiz	Indefinitely	Result display and questionnaire	40

E Poster-experimental Survey, Demographics and Summary Statistics of Players

Participants were asked to fill out a simple questionnaire at the end of the experiment for us to collect some demographic information. The Table E3, Table E4 and Table E5 are some summary statistics of the participants in the three different treatments for the one-shot games, finitely repeated games and indefinitely repeated games; respectively. These tables contain information about: the subjects in the particular treatment, the familiarity with the two paintings, the gender percentage, how many times you have token economic experiments, the age percentage, how many subjects answered correct question 1 and question 2, how to assess the help online chat program to answer question 1 and question 2. Group help: the ratings of the with the group discussion on painting problem-solving.

Table E3: One-shot interactions: Demographic observations

Treatments	Paintings		Gender		Experiments		Age		Questions		Chat help	
	Mean	SD	Female	Male	Mean	SD	Mean	SD	Q 1	Q 2	Mean	SD
Nogroup	2.48	2.25	26(21.7%)	14(11.7%)	0.7	0.90	21	2.04	21	28	-	-
Ingroup	1.35	0.97	30(25%)	10(8.3%)	0.5	1.10	22	1.90	13	25	5.23	2.33
Outgroup	3	2.63	31(25.8%)	9(7.5%)	0.75	1.20	21	2.00	7	35	6.95	2.35
Total	2.28	2.17	87(72.5%)	33(27.5%)	0.65	1.08	21	2.06	41	88	6.09	2.51

Table E4: Finitely repeated interactions: Demographic observations

Treatments	Paintings		Gender		Experiments		Age		Questions		Chat help	
	Mean	SD	Female	Male	Mean	SD	Mean	SD	Q 1	Q 2	Mean	SD
Nogroup	1.78	1.70	24(20%)	16(13%)	0.88	1.16	20	1.24	20	28	-	-
Ingroup	2.25	1.96	20(16%)	20(16%)	0.55	0.85	20	1.53	7	35	5.98	2.03
Outgroup	2.13	1.63	17(14%)	23(19%)	0.78	1.10	20	2.42	16	24	6.15	2.30
Total	2.05	1.77	61(51%)	59(49%)	0.73	1.04	20	1.82	43	87	6.06	2.17

Table E5: Indefinitely repeated interactions: Demographic observations

Treatments	Paintings		Gender		Experiments		Age		Questions		Chat help	
	Mean	SD	Female	Male	Mean	SD	Mean	SD	Q 1	Q 2	Mean	SD
Nogroup	2.2	1.75	22(18.3%)	18(15%)	0.775	1.44	21	1.80	14	26	-	
Ingroup	2.28	1.89	16(13%)	24(20%)	0.225	0.62	20	2.1	7	36	6.45	2.48
Outgroup	1.9	1.57	28(23%)	12(10%)	0.9	0.97	21	1.74	5	24	5.98	1.92
Total	2.13	1.74	66(55%)	54(45%)	0.56	0.88	21	2.00	26	86	6.21	2.24

All players are not familiar with the two paintings; the indexes of familiarity degree are around 2 (see Paintings columns). Nevertheless, it is helpful to answer the painting questions for group assignment members, and the indexes of on-line chat helps are around 6 (see Chat help columns). Overall all experiments, the group contingent other-regarding self-reported the sense of belongingness increase if players are placing into a group and then they have a discussion with own group members (R. Chen & Chen, 2011).[48]

Onc can observe that at least 22 out of 40 players in each treatment are from Economic Business majors, among which they may be very familiar to the Cournot interactions.

favouritism subject may derive more additional $\pi^C > \pi^{NE}$.

[48]Group discussion often has the effect of inducing shift in individual decisions (Cason, Sheremeta, & Zhang, 2012).

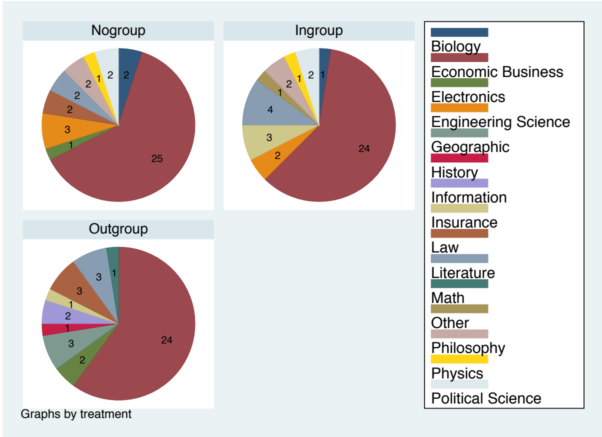


Figure E25: One-shot interactions: Distribution of university programs participants study

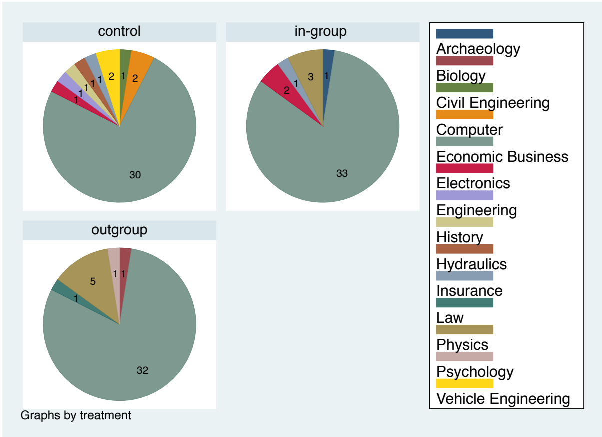


Figure E26: Finitely repeated interactions: Distribution of university programs participants study

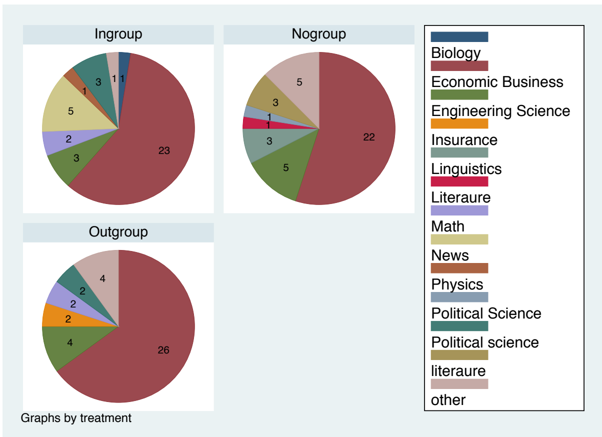


Figure E27: Indefinitely repeated interactions: Distribution of university programs participants study

F Regression with the Sense of Belongingness to Own Group

In this subsection, the sense of belongingness to own group (BOW) as group measures are induced into the LOS regression models. The dependent variable is the individual quantity choice. The independent variables are ingroup matching dummy variable, the group measures, periods, supergames, and the interactions among those variables.

F.0.1 One-Shot Games

Table F6: OLS Regression: Treatment effects on individual quantity choices by treatment with the sense of the belongingness

	(1)	(2)	(3)	(4)
Constants	8.15	8.30***	8.46***	8.48
	(0.00)	(0.07)	(0.09)	(0.06)
Ingroup	-0.08	-0.11	-0.02	- 0.06
	(0.10)	(0.12)	(0.02)	(0.03)
BOW		-0.02	-0.02	-0.00***
		(0.02)	(0.00)	(0.00)
BOW$*$Ingroup		-0.01	-0.02	-0.03
		(0.01)	(0.01)	(0.03)
Periods			-0.01*	-0.01***
			(0.02)	(0.00)
Periods$*$Ingroup				0.004**
				(0.00)
Observations	5581	5581	5581	5581
r^2	0.001	0.004	0.015	0.017
r^2 Adjusted	0.001	0.003	0.014	0.016

Standard errors statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In the column(1), the coefficient of the Ingroup dummy variable is negative, which implies that compared with the outgroup matchings, the participants are more likely to decrease their own quantity choices. We did not find a direct difference effect between ingroup treatment and the outgroup treatment. The interaction between ingroup dummy and the group measure plays a positive role in lowing quantity choice. The coefficient of $Period * Ingroup$ implies that group assignment accelerates the speed of increasing quantity choices over periods. The signs of the coefficient of $BOW * Ingroup$ are negative but do not significant statistical analysis.

F.0.2 Finitely Repeated Games

Table F7: OLS Regression: Treatment effects on individual quantity choices by treatment with the sense of belongingness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constants	7.803	6.985***	7.380***	7.917***	7.968***	7.872***	7.880***
	(0.00)	(0.23)	(0.18)	(0.23)	(0.27)	(0.27)	(0.27)
Ingroup	-0.39**	-0.45**	0.16	0.16	0.26	0.26	0.27
	(0.07)	(0.06)	(0.18)	(0.18)	(0.27)	(0.27)	(0.27)
BOW		0.06	0.09	0.09	0.09	0.09	0.09***
		(0.03)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
BOW∗Ingroup			-0.08**	-0.08**	-0.08**	-0.08**	-0.08**
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Supergame				-0.13**	-0.12	-0.12***	-0.12***
				(0.01)	(0.00)	(0.00)	(0.00)
Supergame ∗Ingroup					-0.03	-0.03	-0.03
					(0.02)	(0.02)	(0.02)
10^{th}period						0.96***	1.03***
						(0.06)	(0.00)
10^{th}period ∗Ingroup							-0.15**
							(0.02)
Observations	5600	5600	5600	5600	5600	5600	5600
r^2	0.012	0.016	0.018	0.039	0.040	0.064	0.064
r^2 Adjusted	0.011	0.015	0.017	0.039	0.039	0.063	0.063

Standard errors statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

F.0.3 Indefinitely Repeated games

Table F8: OLS Regression: Treatment Effects on Individual Quantity Choices by Treatment with the sense of the belongingness

	(1)	(2)	(3)	(4)
Constants	7.73	7.52**	8.12***	8.20**
	(0.00)	(0.04)	(0.07)	(0.00)
Ingroup	-0.20**	-0.20*	-0.24*	-0.412
	(0.05)	(0.05)	(0.07)	(0.15)
BOW		0.03**	0.02**	0.02
		(0.01)	(0.00)	(0.00)
BOW∗Ingroup			0.01**	0.01**
			(0.00)	(0.00)
Supergame			-0.15**	-0.18***
			(0.02)	(0.00)
Supergame∗Ingroup				0.05
				(0.02)
Observations	8640	5760	5760	5760
r^2	0.030	0.004	0.033	0.033
r^2 Adjusted	0.030	0.004	0.032	0.032

Standard errors statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

G Measures of Collusion (Harrington Jr et al., 2016)

There is the regularity in quantity choices one could typically definite a collusive equilibrium ($q_i = q_j = 6$). We would like to analysis the collusion by two additional measures: the same collusive quantity choice (*Same*) and the longest number of consecutive periods when two firms set the collusive quantity choice (*Duration*). The high measures of *Same* and *Duration* imply that two firms are colluding.

Table G9: Collusion measures

	Supergames	Finitely			Indefinitely		
		Nogroup	Ingroup	Outgroup	Nogroup	Ingroup	Outgroup
Number of period with JPM ($q_i = q_j = 6$)							
	1	0.95	1.00	1.35	0.25	1.10	0.00
	2	1.70	1.20	1.65	0.60	0.40	0.45
	3	2.35	1.75	2.00	0.25	7.60	3.00
	4	2.25	2.45	2.25	0.55	4.5	1.8
	5	2.4	3.5	2.8	2.2	1.8	0.55
	6	2.95	3.15	2.7	0.4	6.3	1.9
	7	2.75	3.75	3.05	3.55	6.7	1.55
Duration of JPM ($q_i = q_j = 6$)							
	1	0.91	1.00	1.29	0.20	0.52	0.00
	2	1.70	1.20	1.65	0.60	0.2	0.25
	3	2.62	1.75	2.00	0.25	3.2	2.80
	4	2.00	2.58	2.25	0.55	1.61	1.47
	5	2.40	3.33	2.68	1.9	0.53	0.42
	6	3.20	2.75	2.70	0.26	3.15	1.83
	7	2.62	3.72	3.14	3.55	2.90	1.55

Table G10: Mann-Whitney-Wilcoxon tests

p-values for the test that same and Duration is the same between two treatments

		Finitely	Indefinitely
Number of period with JPM ($q_i = q_j = 6$)			
Nogroup	Ingroup	0.030	0.000
	Outgroup	0.906	0.000
Ingroup	Outgroup	0.034	0.000
Duration of JPM ($q_i = q_j = 6$)			
Nogroup	Ingroup	0.460	0.000
	Outgroup	0.950	0.006
Ingroup	Outgroup	0.430	0.038

No matter in finitely repeated interactions or indefinitely repeated interactions, the number of periods in ingroup treatment firms set identical collusive quantity choices are more than in nogroup treatment and in outgroup treatment (p-values < 0.05). However, the differences between nogroup treatment and outgroup treatment just happened in the indefinitely repeated interactions. In terms of the maximal number of consecutive periods, there were no differences across two treatments in the finitely repeated interactions. But, in the indefinitely repeated interactions, the maximal number of consecutive periods in the ingroup treatment and outgroup treatment are higher than the nogroup treatment (p-values <0.001).

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