Literature Review

Control effects on cooperation in embedded interactions

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Contents

1 Introduction

Social dilemmas are at the core of everyday life. Students may anticipate a good grade for their group work with minimal effort by free-riding on the work of their peers, researchers could obtain another publication by letting their collaborators do the lion's share of the required work (Corten, Buskens, & Rosenkranz, 2020) and a car dealer may hide several vehicle defects when selling a second-hand car to a relatively uninformed customer (Buskens & Weesie, 2000). In these situations, for all individuals involved it would be rational to behave opportunistically. However, the rational decision to behave opportunistically would yield lower collective returns than what could have been achieved under mutual cooperation, and hence the term "social dilemma" (Kollock, 1998; Ostrom, 1998). Under the assumption of "social isolation", that is, the interacting actors can be considered perfect strangers that do not anticipate any future interactions, actors can maximize their individual returns by exploiting their transaction partners.

Theoretically, it is well established that in isolated social dilemmas, it is generally hard to establish a cooperative relationship (e.g., see Luce & Raiffa, 1989 for the Prisoner's Dilemma; and Buskens & Raub, 2002 for the Trust Game). Consider for example the standard one-shot Prisoner's dilemma. Regardless of the choice of one's partner, an individual actor obtains the highest pay-off by acting opportunistically. Defecting when the other player cooperates leads to a higher pay-off relative to cooperating, similarly to defecting when the other player defects as well. Hence, the Nash equilibrium is mutual defection, even though both players would be better off with mutual cooperation. Contrary to these ominous theoretical findings, in practice researchers generally find non-negligible rates of cooperation in one-shot games (e.g., see Hayashi, Ostrom, Walker, & Yamagishi, 1999; Cooper, DeJong, Forsythe, & Ross, 1996), although these cooperation rates tend to decline as participants gain experience with these games (Dal Bó, 2005).

Multiple scholars, however, noted that most real-life interactions do not take place in social isolation, but are actually embedded (Axelrod, 1984; Granovetter, 1985). Embeddedness refers to the fact that the actors involved often share a common environment that could foster cooperation (e.g., Buskens & Raub, 2002; Yamagishi & Yamagishi, 1994). These actors may have interacted in the past, and/or speculate on interacting again in the future, which is referred to as *dyadic embeddedness*. Additionally, the actors may be connected indirectly, through third parties that have interacted with any of the two in the past, or speculate on doing so in the future, which is referred to as *network embeddedness*. Obviously, actors can be embedded both dyadically as well as in a network at the same time.

In the game-theoretic literature, there are two mechanisms through which embeddedness is considered to affect cooperation between actors: *control* and *learning* (e.g., Buskens & Raub, 2013; Yamagishi & Yamagishi, 1994). Control, which will be the focus of this review, denotes the opportunity to sanction opportunistic behaviour by exerting some control over one's partner's long-term returns. Under dyadic embeddedness, one can punish the defection of one's interaction partner in the previous interactions by refraining from cooperation in the current round and the future. Additionally, it might be possible to inform future transaction partners of a defecting actor, who can in turn refuse to cooperate with this actor. Hence, the short-term benefits of acting opportunistically come with the prospect of future retaliation, hanging over the head of opportunistic actors as the sword of Damocles. Notably, what Buskens & Raub (2013) termed "control" differs from what is called "the illusion of control" in the social psychological literature (e.g., Morris, Sim, & Girotto, 1998; Hayashi et al., 1999). Where "control" in the sense of Buskens & Raub (2013) refers to actual sanctioning opportunities, "the illusion of control" concerns the finding that people act as if they can control their partner's behaviour in one-shot games, if this person's decision is made prior to the decision of the partner, even though no information is transferred between the players (Morris et al., 1998).

Learning refers to the situation where the actors involved have interacted in the past, when they are embedded dyadically, and hereby gained information about each others' past behaviour (Buskens & Raub, 2013). If this behaviour is cooperative, the actors may infer that they deal with a partner that will behave cooperatively again in the future. When the actors are embedded in a common network, this network may allow the actors to learn about each other's past behaviour during interactions with third parties. Again, if one's current partner behaved cooperatively during past interactions with oneself or with third parties, one might infer that the transaction partner that will behave cooperatively in the current transaction as well. Obviously, when an actor's partner has abused cooperative behaviour of this actor, or of a third party, the actor may not be willing to take the risk of getting exploited, and defect in the current interaction as well.

A second distinction that can be made relates to the nature of the embeddedness of a transaction. Namely, rather often, researchers decide who will interact with whom in an experiment, a situation that is commonly referred to as *exogenous embeddedness*. However, in real life, people often choose with whom they wish to interact, at least to a certain extent (Chaudhuri, 2009; Yamagishi et al., 1994). Some researchers tried to incorporate this characteristic of real-life encounters in their research, which is referred to as *endogenous embeddedness*. This distinction is considered because overall, it appeared that endogenously formed relations tend to have a larger effect on cooperation rates than exogenously formed relationships (e.g., Chaudhuri, 2011; Frey, Buskens, & Corten, 2019; Gürerk, Irlenbusch, & Rockenbach, 2014; Scheider & Weber, 2013; Wang, Suri, & Watts, 2012).

Substantively, the remainder of this paper will be concentrated around the question to what extent control affects cooperation. Hence, the effect of learning, as well as possible explanations for cooperation outside the game-theoretic paradigm such as inequity aversion or altruism(e.g., Fehr & Schmidt, 1999; Carpenter, Connolly, & Myers, 2008; Dreber, Fudenberg, & Rand, 2014) fall beyond the scope of this review. A distinction will be made between control in dyadically embedded interactions and in network embedded interactions, as well as between exogenously and endogenously formed relationships. This question will be answered via a literature review, with a focus on experimental research that employed 2-person Prisoner's Dilemma games or Trust games. That is, in general, experiments will be considered in which the behaviour of an actor only affects oneself, as well as the single actor towards whom this behaviour is directed. When occasionally another type of game or an N-person game (i.e., when the behaviour of an actor is directed towards more than one others) is discussed, this will be explicitly mentioned.

Notably, game-theoretic assumptions yield that actors maximize their utilities. Yet, in research settings, it is often complicated to infer the utilities of the participants at hand, as it is unclear how they value potential payoffs as specified in the study at hand. To partially overcome this problem, all participants of the experiments incorporated in this review faced economic incentives in the form of points that they can earn. The amount of points an actor will earn is dependent both on the behaviour of this actor, as well as on the behaviour of this actor's partner. Although these monetary payoffs do not diminish the possibility that subjects may strive for non-materialistic goals, it is assumed throughout that incentivizing the payoffs allows to interpret the payoffs as the actors' utilities.

Also note that a great deal of the work published in this area has not distinguished between learning and control explicitly, but merely addresses the question how different forms of embeddedness in general affect cooperation. Nevertheless, it is often possible to assess the effect of control, either explicitly or implicitly. In general, there are two ways to disentangle learning and control. The first possibility is to study solely behaviour of participants in the first round of a given game, because then no learning could have taken place. The second way, that is often used to analyse behaviour in finitely repeated games, is to assess the effect of the number of rounds left after controlling for any learning that could have taken place. Specifically, previous actions by an actor's transaction partner are taken into account when analysing the behaviour of an actor in any given round and assessing the effect of the number of rounds to play.

2 Control effects in dyadic relations

Control effects in dyadic relations can be studied in both finitely and infinitely repeated interactions. In finitely repeated interactions, however, it follows from backward induction that, under the assumption of game-theoretic rationality, no cooperation is possible (e.g., Luce & Raiffa, 1989; Selten, 1978). Namely, in the last round of the game, non-cooperative behaviour cannot be punished in any subsequent round, and hence, defecting always yields a higher payoff than cooperation. As actors decided to defect in the final round, actions in the penultimate round do not affect behaviour in the last round, and again defection is the payoff maximizing strategy. This pattern repeats itself to the first round of the game, and hence, under the assumption of rationality, no cooperation is possible in any round of the game. A wide variety of experiments however showed that subjects act cooperatively in initial rounds, leading Rapoport (1997, p. 122) to conclude that in practice, subjects do not rely on, or are not capable of backward induction.

Kreps, Milgrom, Roberts, & Wilson (1982) proved that even populations of rational actors could maintain high levels of cooperation, under the assumption that these rational actors belief with high enough probability that their transaction partners have no incentive to defect, until their partners are defected on themselves. If the rational actors believe that the probability to meet such a conditional cooperator is high enough, the benefits of mutual cooperation outweigh the gains of exploiting a conditional cooperator once and being punished with defection thereafter. The prospect of mutual cooperation directly allows for the introduction of control (Buskens & Raub, 2013). Namely, after an actor defects, it is immediately known to the other player that the defecting actor is not a conditional cooperator, and the finitely repeated game would be one of mutual defection hereafter if the players are rational. Yet, as long as both players cooperate, it is not known whether any of the two players is a conditional cooperator. The actors can thus control one another, because future payoffs depend on one's behaviour in the current round. In the final rounds of the finitely repeated game however, the long term benefits of mutual cooperation do no longer outweigh the short-term costs of maintaining one's reputation (i.e., the opportunities to control future behaviour of one another diminish), and hence rational actors will try to exploit their partners in these rounds.

In infinitely, or indefinitely, repeated games, there is no end-game effect, as there is no predetermined final round. Namely, a game will be played for another round with a certain continuation probability δ, which Axelrod (1984) aptly termed the “shadow of the future”, and end with probability $(1 - \delta)$. However, comparing cooperation rates in the first round of an infinitely repeated game to cooperation rates in a one-shot game allows to assess the effect of control. Namely, in a one-shot game, there is no possibility to sanction opportunistic behaviour, and thus there is no control. Although the analysis of first round behaviour is merely a practical issue, that is, due to the continuation probability δ there is no guarantee that a second round will be played, it is beneficial to disentangle learning and control. Namely, in the first round of a finitely repeated game, no learning can have occurred yet.

2.1 Control in exogenously dyadically embedded interactions (repeated games)

In exogenously formed finitely repeated games, one can generally observe a pattern of high cooperation in the initial rounds of a finitely repeated game, with a sharp decrease in cooperation towards the end of the game (e.g., Buskens, Raub, & Van der Veer, 2010; Embrey, Fréchette, & Yuksel, 2018; Mao, Dworkin, Suri, & Watts, 2017; Van Miltenburg, Buskens, & Raub, 2012). However, this decline in cooperation cannot entirely be ascribed to the lack of control opportunities in the final rounds of the game. Participants may namely refrain from cooperation for three different reasons. First, defection could be a response to defection of one’s partner in an earlier rounds. Second, an actor may have learned in previous games that in the final rounds of the repeated game, hardly any cooperation is possible, and hence defecting serves as a protection against being exploited. Third, an actor may realize that the short-term benefits of defecting outweigh the possibly returns of another round of mutual cooperation. [**ADD EMBREY, FRECHETTE & YUKSEL (2018) ON FINITELY REPEATED GAMES** Increasing the number of rounds within a finitely repeated game increases the sanctioning opportunities, as more rounds yield higher payoffs for mutual cooperation.]

Buskens et al. (2010) explicitly study the presence of control effects in a Trust Game, which slightly changes the nature of the game relative to a Prisoner’s Dilemma. Rather than mutually risking possible exploitation, in the Trust Game only the trustor, who decides whether or not to trust the trustee, risks being exploited. The trustee on the other hand, has to decide whether whether to honor or abuse trust, if trust is placed, but cannot choose between these options if no trust is placed. Hence, the possible actions of the trustee depend on the initial choice of the trustor. Under dyadic embeddedness, Buskens et al. (2010) find that after controlling for learning effects in terms of past moves of one's transaction partner, there is a positive effect of the number of rounds still to be played (i.e., control opportunities) on cooperation, for both the trustor and the trustee. Additionally, these authors study the effect of dyadic embeddedness when the dyadic relation is embedded in a small network, where two trustors are in a relationship with a single trustee (i.e., a triad). In this network, information can be exchanged between the first trustor and the second trustor, and hence, the trustors can learn about the trustee not only from their own game with the trustee, but also from the game of the other trustor in the triad with the same trustee. Also in this condition, it is found that the number of rounds that has to be played between a trustor and a trustee is positively related to cooperation for both trustor, and trustee, after controlling for learning effects in terms of past moves of the trustee in the game with the trustor at hand, as well as in terms of past moves of the trustee in the game with the other trustor. [**STILL CHECK WHETHER, AND IF SO, HOW, TO INCORPORATE THE SECOND TRUST IN TRIADS STUDY BY MILTENBURG ET AL, BECAUSE THE ANALYSES ARE SOMEWHAT DIFFERENT AND I DONT HAVE THEM READILY AT THE TOP OF MY MIND**].

(**THIS PARAGRAPH IS JUST A NOTE FOR MYSELF**: Add the article by Mao et al., 2017 about resilient cooperators and conditional cooperators. Namely, this article show that repeating a finitely repeated games many times (20) with the same pool of participants, does not result in cooperation unravelling towards the first round of the game. On the contrary, it shows that the presence of conditional cooperators in the population allow other players to abuse trust in the final rounds of the game. In fact, they show that 60% of their samples plays with a strategy in which they abuse cooperation of their partner by defecting in the final rounds of the game, when there is relatively little to win by mutual cooperation.)

[**THIS ALSO IS JUST A NOTE TO MYSELF:** Research into infinitely repeated games started with the work of Roth & Murnighan (1978), who found that playing a Prisoner's Dilemma game indefinitely often resulted in higher cooperation rates than the amount of cooperation that can be observed in one-shot games. However, this increase was generally small, leading the authors to conclude that the introduction of infinitely repeated interactions does foster cooperation, but only to a limited extent. The same findings were found by [ADD REFERENCES]. However, Dal Bó (2005) remarks that these studies did not translate the amount of points participants earned during the experiment linearly to a monetary reward. Additionally, these studies do not allow subjects to gain familiarity with the game, which might be important given the rather artificial circumstances participants are in (Dal Bó, 2005).

Dal Bó (2005) builds upon this initial work in infinitely repeated games, and compares cooperation rates in infinitely repeated games with cooperation rates in finitely repeated games of the same expected length and in one-shot games under a wide variety of circumstances. It is found that first round cooperation rates are significantly higher in infinitely repeated games (with continuation probability $\delta = 1/2$ and $\delta = 3/4$) than in one-shot games. In fact, first-round cooperation increases with δ, implying that the prospect of future benefits through mutual cooperation, and the fear of missing out on these benefits after defection, results in a higher willingness to cooperate. Additionally, cooperation rates in first rounds of infinitely repeated games are systematically higher than cooperation rates in the first rounds of finitely repeated games of the same expected length, especially after the subjects have gained experience with the game they play. Namely, in the finitely repeated games, in earlier games the subjects experienced that cooperation will be abused in the final round of the game, and protect themselves against this behaviour by defecting in an earlier stage already. No such behaviour is present in infinitely repeated games; in fact, the cooperation rates tend to increase with the experience of the participants.

[**I HAVE TO WORK THIS OUT STILL**:These findings have been corroborated by (Dal Bó & Fréchette, 2011, 2018). These subsequent studies additionally remark that subjects learn to play]

- Dal Bo & Frechette
- Buskens, Raub & Van der Veer - the condition without reputation shows a clear end-game effect, indicate for the presence of control effects.

2.2 Control in endogenously dyadically embedded interactions (repeated games)

- Sokolova, Buskens & Raub - show higher cooperation rates in dyadically embedded interactions than in one-shot games.

3 Control effects of network embeddedness

Research on repeated interactions in dyadic relations involve two actors forced into an iterated relation. However, in reality, interaction partners may deliberately choose to engage in a relationship and have the freedom to terminate the relationship (Yamagishi et al., 1994).

Sánchez (2018) remarks in a review that lattices or networks do not support cooperation at all. Even though cooperation in networks generally starts at a high level, with the majority of the actors choosing to cooperate, cooperation rates generally decrease to a fraction of only 20%.

CHECK REFERENCES IN ARTICLE FREY, BUSKENS & CORTEN

3.1 Control in exogenously embedded interactions in networks

3.2 Control in endogenously embedded interactions in networks

4 Conclusion

5 Literature

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