Social networks and intergroup conflict

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"…it is social structure that can transform free ridership into zeal."
James S. Coleman: Foundations of Social Theory (1990: 275)

CHAPTER 2

SEGREGATION AND INTERGROUP CONFLICT

Theoretical developments and analysis of single-shot situations[1]

[1] Parts of this chapter are drawn from Takács (2001).

2.1 Introduction

In this chapter we present a theoretical model that provides predictions about the structural conditions under which harmful intergroup conflict is likely to occur and when peaceful coexistence might be expected. We focus on a factor that has been surprisingly neglected in previous research: the effect of structural embeddedness (cf. Granovetter, 1985). Previous models have not taken into account that individual network ties within *and* between the groups transmit social and cognitive rewards that influence participation in intergroup related collective action (see Section 1.5). In particular, while it is widely believed that dense in-group relations help the establishment of collective action (Marwell, Oliver, and Prahl, 1988; Marwell and Oliver, 1993; Gould, 1993a; 1993b), in the intergroup context, we do not know much about why and under what conditions dense in-group and scarce out-group relations (segregation, clustering) support harmful collective action. We will investigate this question in this chapter, considering competition situations between two distinct groups. As a first step, we focus on single-shot situations. Since history effects are quite crucial in empirical examples, Chapter 4 will be devoted for the development of a dynamic model that considers repeated intergroup relations.

In Section 1.4 we discussed that if individual contributions are costly, group beneficial collective action is difficult to achieve. This partly explains why lethal conflicts are more the exceptions than the rule (Fearon and Laitin, 1996; Gould, 1999). On the other hand, experimental findings have revealed that a presence of an out-group, especially in the case of competitive intergroup relations might help to establish collective action within the groups. This duality of intergroup and within group interdependencies and their interrelation is represented in the *Intergroup Public Goods* (IPG) game (Rapoport and Bornstein, 1987; Bornstein, 1992).

The original IPG model disregards the *structural embeddedness* of individual actions. As it was discussed in Section 1.5, everyone's behavior is to a large extent constrained and influenced by neighbors, friends, and the family, regardless of their group membership. In this chapter, we would like to demonstrate the underlying mechanisms of *social control* behind these network constraints. In the close social environment *selective incentives* are distributed (Sandell and Stern, 1998). Selective incentives from fellow group members help the establishment of collective action, but friends from the other group provide *traitor incentives* that suppress contribution. *Behavioral confirmation* that accompanies almost every kind of human interaction (Lindenberg, 1986) is also transmitted by network ties. In large-scale collective action people are not likely to conform to everyone's behavior or to be fair to everyone. Behavioral confirmation is distributed in the social network environment, which appraises expectations about the behavior of friends and neighbors.

These social control mechanisms can be represented as overlapping dyadic interdependencies. Each dyadic relation is subject to playing local coordination games (cf. Ellison, 1993; Morris, 2000), but in a form that is inseparable from participation choice in collective action. Surrounded by extremist fellow group members, people are highly constrained to participate. On the other hand, peaceful friends or many friends from the rival group can provide enough confirmation pressure to avoid contribution to the harmful collective action. Such mobilization process is also referred to as “block recruitment” (Oberschall, 1973) and can provide the micro foundation for collective actions such as demonstrations, urban gang fights or civil war.

In this chapter, we incorporate these different mechanisms in the model of intergroup conflict. Intergroup competition, structural embeddedness, and strong social control in dyadic connections might mobilize group members to participate in intergroup related collective action. A theoretical investigation in this chapter supported by computer simulations aims to show under what structural conditions and due to which forms of social control mobilization occurs.

As a consequence of these factors, a social trap of a different kind might arise. Should both groups become involved in a collective action, then this could be mutually harmful. From the community perspective, this is an outcome that is best avoided. Among structural conditions, it is particularly interesting to study under which circumstances *segregation* leads to intergroup clashes. In this chapter, we will investigate which forms of social control are responsible for the strengthening of the segregation effect. We will demonstrate how the relative size of selective incentives and behavioral confirmation (normative pressure versus confirmation pressure) influences the effect of segregation on the likelihood of conflict and hence the chance that residential policy can help conflict resolution.

Furthermore, for exact model predictions, we have to specify assumptions about individual consciousness and access to information. Assumptions in the relevant literature contain perfect rationality (e.g., Chwe, 1999) as well as considerations of motivations that are beyond egoistic incentives (cf. Caporael et al., 1989). There are various models that assume bounded rationality or limited access to information in different forms (e.g., Ellison, 1993; Morris, 2000; Fearon and Laitin, 1996; Gould, 1993a; Rapoport and Bornstein, 1987; Macy, 1991b). Since there is no generally accepted view on what level of rationality can be assigned to individual action and on what kind of information people use for their decisions, we will consider four models with different levels of consciousness and access to information. We do not claim that any of these models reflect the appropriate view on the logic of individual action. We also think that there is no such a view: the level of rational consciousness in individual action varies, depending on the framing and importance of situations (Lindenberg and Frey, 1993). Individual access to relevant information also alters in different circumstances.

The effect of network structure on intergroup conflict will be compared under the different specifications. Different behavioral models can also be considered as robustness tests to check whether normative pressure in general strengthens the segregation effect on intergroup conflict more than confirmation pressure. Examples of typical structures will demonstrate how the success of local mobilization can be dependent on the behavioral assumptions on individual "rationality". We will investigate whether under certain structural conditions "rational" individuals are more willing to contribute to collective action or are they the ones who always abstain from participation.

In the following section, we introduce the Intergroup Public Goods (IPG) game as a model of competitive intergroup relations. As a major theoretical contribution of this chapter, we incorporate dyadic effects of social control in the model in Section 2.3. This new, structurally embedded model provides an explanation as to why segregation often supports the emergence of intergroup conflict. In Section 2.4 we show that participation in conflict can even be a dominant individual strategy that leads to a suboptimal outcome of harmful clashes. In order to derive exact predictions, we introduce four different behavioral models in Section 2.5. These models differ in their assumptions about how much rationality is assigned to individual actions.

The conditions under which segregation leads to intergroup conflict are investigated in the four behavioral models by using computer simulation. Section 2.6 describes the simulation design. Section 2.7 clarifies the interpretation of segregation and its measurement in the simulations. Simulation results are presented in Section 2.8. Examples of other structural effects are discussed in Section 2.9. Finally, we summarize the simulation results and conclude this chapter in Section 2.10.

2.2 The Intergroup Public Goods game

There are two exclusive groups A and B of size n_A and n_B ($n_A \geq 2$ and $n_B \geq 2$), with contradictory collective interests. Inside both groups, members face the dilemma of providing a step-level public good (cf. Bornstein, 1992). A step-level public good is only provided, if a certain level of contribution has been reached. This level is determined by the number of contributors in the other group.

We assume that group members are anonymous and can gain (lose) the same rewards from the intergroup context with identical action. For instance, we suppose that everyone is equally proud after a victory and equally ashamed after a defeat.[2] If the number of contributors in group A exceeds the number of contributors in group B, then each member in A receives a reward v (a piece of a *victory*-cake, temptation

[2] More precisely, since we do not make any interindividual comparison, it is enough to assume that everyone values his or her share relatively the same way in comparison to other rewards and costs of him or her.

reward) and members of *B* receive a reward of *d* (*defeat*, the sucker's payoff). If the number of contributors is equal, then everyone receives a reward *c* (*clash*, reward for a draw). The relation between these rewards is $v>c>d$. For instance, let us consider a team sport in which members of the two teams decide whether they help their team with low or high effort. High effort can be regarded as contribution to the provision of the public good that is a win in the competition.

We assume that a free riding action (low effort in the previous example) results in an extra positive reward of *e* (*endowment*, $v>e>d$). As an example, consider that the group of Republican voters are all happy if a Republican president is elected, but those who refrain from voting gain more, they could otherwise occupy themselves instead of going to the polls (opportunity cost of voting). Table 2.2.1 represents the payoffs from the IPG game for player $i \in A$.

Table 2.2.1 Possible payoffs from the IPG game (Rapoport and Bornstein, 1987)

	(I)	(II)	(III)	(IV)
Outcome	*Unconditional defeat*	*One for the draw*	*One for the victory*	*Unconditional victory*
Conditions	$k_{A-i}<k_B-1$	$k_{A-i}=k_B-1$	$k_{A-i}=k_B$	$k_{A-i}>k_B$
Contribution	d	c	v	v
No contribution	$d+e$	$d+e$	$c+e$	$v+e$

Notes: k_{A-i}= the number of contributors in group *A* (excluding player *i*); k_B= the number of contributors in group *B*.

As Table 2.2.1 shows the IPG game is not a perfect social dilemma. In a game of continuous provision of public goods not to contribute is a dominant strategy, but this is not the case for a step-level public good (cf. Frohlich and Oppenheimer, 1978; Hardin, 1982). In the IPG game shown in Table 2.2.1, when $c>d+e$, in state (II) *i* is better off by contributing and when $v>c+e$, in state (III) contribution is a better choice. Given the lack of a dominant strategy Rapoport and Bornstein (1987) assumes that individuals order expected values to the actions and maximize this expected value. Critical probabilities (cf. Caporael et al., 1989) concerning states (II) and (III) show the likelihood that the single individual action of *i* has an influence on the overall outcome. Denote the subjective probabilities for *i* of the four states with P_I, P_{II}, P_{III} and P_{IV}, respectively ($P_I+P_{II}+P_{III}+P_{IV}=1$). It can be shown, that contribution is a better choice for player *i* if

$$P_{II}\,c + P_{III}\,(v - c) > e. \qquad (2.2.1)$$

If group sizes are large, then critical probabilities are small and the structure of the game is close to being a pure in-group social dilemma (cf. Bornstein and Rapoport, 1988, 127). Consequently, peace is very likely to be the outcome of intergroup opposition (cf. Fearon and Laitin, 1996; Gould, 1999).

However, the social trap character of a stalemate is not incorporated in the original IPG model. Therefore, that model can be applied to different intergroup competition situations in which a tied outcome does not have a harmful character. An example is an election in two-party democracies. A tie can be embarrassing and can lead to lengthy and costly recounting and law suites, but it is not worse than if nobody voted. Similarly, in team sports a scoreless draw at a boring match is definitely not better than a draw with many goals, where all players gave their best. Competitions between ethnic groups, urban gangs, or pupil groups have a different character. A draw means a mutually harmful clash that is worse than the lack of collective action (peace). To explain the emergence of such outcomes, we implement modifications that are borrowed from the IPD game (see Section 1.4).

Another change is a generalization of the original model. In the Rapoport and Bornstein (1987) model, for all draws the size of public payoffs are equivalent, irrespective of how many individuals contribute. Since in the situations we would like to model, mutual mobilization significantly differs from mutual lack of mobilization, we should specify how the payoffs depend on the number of contributors, if contributors in the two groups are equal in number. If a couple of Serb civilians shoot at Bosnian civilians, this would not yet be a civil war situation, but would be treated as an attempt of murder. Ethnic clash starts, if the number of contributors is large enough. For this reason, besides the endogenous threshold (the number of contributors in the other group), we introduce an exogenous minimal contributing set (MCS) in the game (cf. van de Kragt, Orbell, and Dawes, 1983). This means that less than a specified number of contributors no collective action will be established in the group and consequently provision of the victory and clash public goods is not possible. Since groups can differ in their internal structure of norms, one group can exhibit a more patient attitude in intergroup relations. Therefore we allow minimal contributing sets to be different in the groups and we denote them by k_A^* ($0 \leq k_A^* \leq n_A$) in group A and by k_B^* ($0 \leq k_B^* \leq n_B$) in group B.

If the number of contributors is equal and both groups are above the minimal contributing set, then everyone receives a negative reward c (*clash*, punishment payoff). We suppose that the clash of collective actions is worse than the outcome of *peace*. Peace is the collective outcome in which no collective action is established in the groups. For the sake of simplicity the reward for peace p is a reference value and assumed to be zero. Hence, the relation between the different payoffs is $v>p=0>c>d$. If groups were unitary entities and they could choose between either collective action or no action, collective action would be their dominant strategy. Both sides following the dominant strategy would lead to a suboptimal outcome. On the basis of Definition 1.2.1.1, we will call all outcomes in this game *intergroup conflict*, where collective action is established at least in one of the groups.

We retain the assumption that a free riding action results in an extra individual reward of e (*endowment*, $v>e>0$). Table 2.2.2 gives a complete typology of possible outcomes of the IPG game and represents the payoffs for player $i \in A$.

The IPG game in this form is intended to model group competition situations in which collective action of equal strength leads to mutually harmful outcomes (clash punishment). Examples are civil war, conflicts between pupil groups, fights between football supporters or urban gangs. In the case of only a few initiators, nothing happens and the status quo is preserved. If, however, the number of contributors exceeds a certain threshold, a collective action is established and this can mean victory for the group. A group wins if more contributed to the collective action than in the other group. Defeat is the worst case scenario: just imagine the frustration experienced by gang members having lost a street battle.

Table 2.2.2 Possible payoffs from the IPG game with clash punishment[3]

	(I) *Peace*	(II) *Un-conditional defeat*	(III) *One for the clash*	(IV) *One for minimal contribution*	(V) *From defeat to victory*	(VI) *One for the victory*	(VII) *Un-conditional victory*
	$k_{A-i}<k_A^*-1$ and $k_B<k_B^*$	($k_{A-i}<k_B-1$ or $k_{A-i}<k_A^*-1$) and $k_B \geq k_B^*$	$k_{A-i}=k_B-1$ and $k_B \geq k_B^*$ and $k_{A-i}+1 \geq k_A^*$	$k_{A-i}=k_A^*-1$ and $k_B<k_B^*$	$k_{A-i}=k_A^*-1 \geq$ $\geq k_B \geq k_B^*$	$k_A^* \leq k_{A-i}=$ $=k_B \geq k_B^*$	($k_{A-i}>k_B$ or $k_B<k_B^*$) and $k_{A-i} \geq k_A^*$
C	*0*	*d*	*c*	*v*	*v*	*v*	*v*
D	*e*	*d+e*	*d+e*	*e*	*d+e*	*c+e*	*v+e*

Notes: k_{A-i}= the number of contributors in group A (excluding player i); k_B= the number of contributors in group B.

We need assumptions about how individuals reach their decisions so as to predict which outcome will be realized. Similar to the original IPG game, there is no dominant strategy in the modified game. In states III, IV, V, and VI (cf. Table 2.2.2) contribution is a better choice. In these states a single individual decision is *critical* for the outcome. Using the argument of Rapoport and Bornstein (1987) again, given the lack of a dominant strategy we could assume that individuals order expected values for actions and maximize this expected value.

Denote the subjective probabilities for i of the seven states in correspondence with states (I)-(VII) in Table 2.2.2 by P_z's ($\sum_{z=\mathrm{I..VII}} P_z = 1$). For the sake of simplicity, let us assume that rewards are numerical and individual utility is a linear function of rewards. The expected value (EV) of contribution for player i is:

[3] State (V) is the exceptional case and only relevant if $k_A^*>k_B^*$. In this state there are an equal number of contributors in both groups. Collective action is established only in group B, but the contribution of player $i \in A$ means that the outcome is victory of group A. State (I) is not relevant, where less than two contributors can establish group collective action and state (IV) is not relevant, where the minimal contributing sets are zero. States (VI) and (VII) are irrelevant, if $k_A^*=n_A$.

$$EV(C) = P_{II}d+P_{III}c+(P_{IV}+ P_V+ P_{VI}+ P_{VII})v,$$

whereas the expected value of not contributing is

$$EV(D) = e+(P_{II}+P_{III}+P_V)d+ P_{VI}c+ P_{VII}v.$$

Contribution is a better choice if $EV(C) > EV(D)$, thus

$$P_{III}(c-d)+P_{IV}v+ P_V(v-d)+ P_{VI}(v-c) > e,$$

where P_{IV} is zero, if $k_A^*=0$, P_V is zero, if $k_B^*\geq k_A^*$, and P_{VI} is zero, if $k_A^*=n_A$.

In this model, critical probabilities concerning states III, IV, V and VI indicate the likelihood that the decision of *i* has an influence on the overall outcome. If group sizes are large and the minimal contributing sets are relatively high, then the likelihood is extremely small and the structure of the game is close to being a perfect social dilemma. Similar to the original IPG game, peace is still the expected outcome of intergroup opposition (cf. Fearon and Laitin, 1996; Gould, 1999).

A specific example of the game is represented graphically in Figure 2.2.1. In this example group sizes and the minimal contributing sets are equal. Bullets indicate Nash equilibria. In general (if minimal contributing sets are larger than one), pure strategy Nash equilibria are the situations in which there are {0; 0}, {k_A^*; 0}, or {0; k_B^*} contributors. Overall defection is an equilibrium, because a single contribution cannot break the peace, but involves the loss of endowment *e*. Another Nash equilibrium is when the number of contributors in one group equals to the MCS and in the other group there are no contributors. In this case, no contributor would be better off by free riding, because $v>e$. For defectors, it would not make sense to change their decisions, because they cannot improve on the outcome alone. In addition to these equilibria, clash with overall participation is also a Nash equilibrium, if group sizes are equal and $d+e<c$. This equilibrium is never Pareto-optimal.

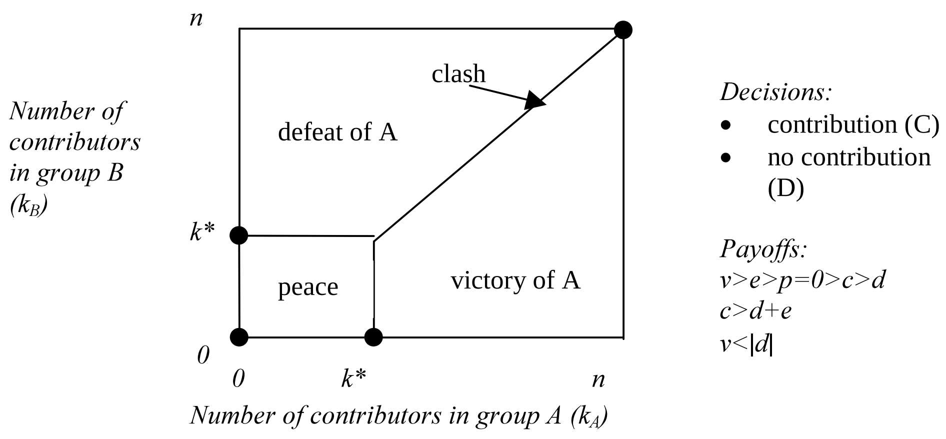

Figure 2.2.1 Graphical representation of an example and Nash equilibria (bullets)

Although concerned about the simplifications made, we will nevertheless use this simple model throughout this study as the solid ground of modeling intergroup conflict. We will leave issues such the size of payoff parameters, additional incentives, non-linear utilities, risk preferences, social orientations, third party or institutional interventions for later discussion. These are all factors that can introduce complications to the model. Discussion of these will be however strictly limited, as they are not in the main interest of this research.

2.3 Interdependencies between neighbors and friends: the structurally embedded IPG game

As individuals are able to free ride on the effort of others, beneficial collective action is difficult to achieve within the groups. However, individuals can be mobilized for participation, if effective social control, norms, or selective incentives exist in the group (Olson, 1965; Coleman, 1990; Heckathorn, 1990). In this section we will incorporate three different forms of social control that are transmitted by network ties in the model of intergroup conflict. These are *traitor rewards, behavioral confirmation*, and *social selective incentives*. As a consequence of dyadic social control, under certain network structures harmful collective action is likely to emerge.

If their neighbors or friends are from the other group, individuals are rewarded for not participating in the collective action. We assume that everyone receives a $t>0$ *traitor* reward in the case of no contribution for each tie that connects this person to members of the opposite group. Hence the traitor payoff is a selective incentive rewarding defection and distributed locally conditional on the number of ties with the other group. The traitor reward provides an additional incentive for people who, living close to members of the opposite group to restrain from participation in collective action. For instance, supporters surrounded by fans of the other club are rewarded for remaining silent in a stadium.

Ties connecting members of the same group transmit different social incentives. People receive *behavioral confirmation* ($b>0$) from each relation by acting similarly to their fellow friends. This reward is a mutual positive externality, which drives towards uniform action. Irrespective of behavioral confirmation, contribution is rewarded by fellow neighbors or friends. They appreciate group-beneficial action by social *selective incentives.* We assume that all contributors receive a selective incentive $s>0$ from each fellow neighbor. The provision of these incentives does not require separate decisions as they always accompany choices made in the intergroup game. This assumption is plausible for certain social rewards such as respect or status that can be by-products of intergroup relations. The relationship between fellow neighbors or friends can be represented as a local coordination game (see Table

2.3.1).[4] Unlike public goods ("bads") *v*, *c* and *d*, bestowing the three types of social incentives is not conditional on the outcome of the intergroup competition.

Table 2.3.1 Local coordination game between fellow neighbors

		neighbor from the same group	
		contribute	do not contribute
individual i	contribute	$b+s$, $b+s$	s, 0
	do not contribute	0, s	b, b

The structurally embedded IPG game is the *extension of the IPG game* (Table 2.2.2 and Figure 2.2.1) *with the incentives* (*t*, *b*, and *s*) *from the network environment*. Individuals must choose a single action (contribution or no contribution) and cannot tailor their behavior to each neighbor.[5] A formal expression of individual payoffs in the structurally embedded IPG game can be found in the Appendix 2.A.1.

2.4 Social dilemma of a different kind

In the structurally embedded IPG game, contribution can even be the dominant strategy. For this, selective incentives have to exceed rewards for defection in the "worst case" scenario, i.e. when no fellows neighbors are contributing and a single contribution does not change the outcome. That is, contribution is a dominant strategy of player $i \in$ A, if

$$g_i t + e < f_i (s - b), \tag{2.4.1}$$

where f_i denotes the number of fellow neighbors of i and g_i stands for the number of neighbors from group *B*. Although the decision of *i* is not likely to be critical, contribution can be highly beneficial due to social incentives. For instance, many individuals join tribal wars although the gains from these conflicts are only symbolic and single contributions make no difference. One reason is that warriors can attain high status in the group and can easily become "heroes". We can argue in a similar way in order to explain redundant contribution choice (Caporael et al., 1989). People seek social rewards when they sacrifice their contribution to the production of a public good that has already been established.

[4] For the sake of simplicity, we assume that selective inventives and confirmation payoffs are held constant through all pairwise games. Although it is sufficient to assume that all individuals relate social rewards to other rewards and costs in the same way.

[5] It is also the assumption of the literature on local interaction games (see Morris, 2000: 57).

At the other extreme, no contribution is the dominant strategy of *i*, if defection provides higher rewards than contributing even if all fellow neighbors are contributing and a single additional contribution would change the outcome of the game. That is, defection is a dominant strategy of player $i \in A$, if [6]

$$g_i t + e > f_i(s+b) + v - d. \tag{2.4.2}$$

Nash equilibria in the structurally embedded game can be very different from the original IPG game, depending on the exact network structure. Social networks decisively shape conditions under which social incentives can generate solutions for the in-group collective action problem. In a highly segregated network with dense in-group and scarce out-group relations overall participation is likely to be an equilibrium. Full contribution can be a dominant strategy equilibrium and a suboptimal outcome in which every individual payoff is smaller than in overall peace. The unusual social dilemma that traps groups in harmful contribution emerges, if

$$|c| > f_i s - g_i t - e > f_i b \tag{2.4.3}$$

holds for every individual.

2.5 Model predictions under different decision algorithms

In order to derive exact model predictions, we need auxiliary assumptions on individual behavior. In this section we introduce four behavioral models and describe the effect of segregation on intergroup conflict under the different assumptions. The discussion of these four models has an illustrative purpose and does not mean a commitment to related behavioral disciplines. In all four models, however, we assume a certain level of rationality. We also bring strategic thinking back into consideration, which would not be present if we had assumed that people order expected values for actions and maximize this value (cf. Rapoport and Bornstein, 1987). On the other hand, the models also deviate from classical game theory by avoiding the assumptions of complete information and perfect rationality.

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[6] If $k_B^* \geq k_A^*$, then the less strict conditions

$$g_i t + e > f_i(s+b) + c - d$$

and

$$g_i t + e > f_i(s+b) + v - c$$

are sufficient to hold for defection (no contribution) to be a dominant strategy.

By considering four decision models, we can analyze the effects of individual consciousness and access to information on the likelihood of contributing and the interaction effect of behavioral assumptions and segregation on intergroup conflict. In Model 1, we only assume that individuals choose their dominant strategy, if they have any. This is a simple strategic model, in which individuals take those actions that are beneficial under all circumstances. In Model 2, in addition we assume that individuals are also able to recognize the dominant replies to the dominant strategies of their neighbors. This is still a simple strategic model that introduces local information into the analysis. In Model 3, we assume that such obvious actions are common knowledge between neighbors and optimal replies are chosen accordingly. In Model 4, an expected value element is added to all these assumptions. This model still assumes bounded rationality, since we control for a tendency of overestimation of criticalness (cf. perceived efficacy at Kerr, 1989). These four models are easily comparable as their assumptions are added step by step. The most rigid assumptions on individual behavior are used in Model 4 and the least rigid ones in Model 1. All the assumptions will be discussed in detail in this section. We intend to show that rigid assumptions strengthen the predicted relationship between segregation and the likelihood of intergroup conflict.

2.5.1 Model 1: Dominant strategy rule

In the first model, only a limited rationality of players is assumed. We presume that actors choose their dominant strategy, if they have one. Everyone lacking a dominant strategy contributes with a fixed probability. These behavioral assumptions allow for a derivation of hypotheses from equations (2.4.1) and (2.4.2). As far as the main payoff parameters are concerned, a smaller difference between victory and defeat and a smaller reward for free riding will increase the likelihood of intergroup clash. With regard to structural effects, extensive fellow connections (larger f_i's) support contribution, therefore collective action will be more likely in a clustered population.

Already this simple model generates empirically plausible implications. However, there are empirical examples that contradict our predictions and show that isolation can sometimes be an effective way to avoid intergroup clash. Isolation in these cases could mean a termination of the interdependent situation (e.g., building a wall in Belfast, destruction of a bridge in Mostar, or blocking a bridge in Kosovska Mitrovica). These are external or artificial solutions of intergroup conflict that might require the deployment of armed forces for monitoring. When there are no external solutions and interdependencies are unavoidable, *we predict a strong effect of segregation on the likelihood of conflict between groups, where selective incentives are relatively more important than behavioral confirmation* (see equation 2.4.1).

The model has interesting implications for group size effects. In a physical clash or battle, larger groups can obtain success easily. If the minimal contributing sets are equal in the groups, the larger group has a higher chance to win from the intergroup opposition. The lower the minimal contributing set, the more likely it is that collective action emerges. In this case, only a little noise is needed to destroy the peaceful equilibrium. Empirical examples of noise are mistakes, misinterpretations, drunkenness, or sudden passions (Fearon and Laitin, 1996). It is more remarkable that even if minimal contributing sets are given proportionally to group size, the larger group still has the advantage. It follows from the fact that if group *A* is larger than group *B*, then the expected proportion of fellow ties in group *A* is higher than the relative size of group *A*. Hence, the chance of being in a neighborhood, in which normative pressure restricts the individual to contributing action, is exponentially higher by increasing group proportion. For instance, there is evidence of nonlinearly increasing voting participation (and votes) with higher levels of residential segregation (Butler and Stokes, 1974). In other cases this prediction may contradict real life experience. Larger groups tend to be more sparse and less organized (Olson, 1965). Furthermore, if there is a large inequality in the strength of the groups, the minority may try to avoid intergroup opposition by choosing assimilation. As a consequence, group borders might fade away.

2.5.2 Model 2: Dominant reply rule

In the second model we formulate more rigid assumptions about individual behavior by introducing access to local information. Every actor follows his or her dominant strategy, if there is one. Furthermore, since people know their neighbors to some extent, they can also attain information about their possible actions. Let us assume that people can recognize when their neighbors have a dominant strategy and can give an unconditional best (dominant) reply, if there is one.[7] Denote the number of fellow neighbors who have a dominant strategy of contribution by f_{ic} and the number of fellow neighbors who have a dominant strategy of defection by f_{id}. From Table 2.2.2 and equations (2.4.1) and (2.4.2) it can be derived that contribution is the unconditional best (dominant) reply of $i \in A$, if

$$g_i t + e < f_{ic}(s+b) + (f_i - f_{ic})(s-b) \tag{2.5.2.1}$$

holds and defection (no contribution) is the dominant reply, if

$$g_i t + e > (f_i - f_{id})(s+b) + f_{id}(s-b) + v - d \tag{2.5.2.2}$$

[7] We call a strategy unconditional best (dominant) reply, if it is a pure best reply against all pure strategy profiles that contain the dominant strategies of neighbors. It involves the assumption that every actor is capable of assessing information about the number of ties and about the relative value of social rewards *b* and *s* for all fellow neighbors.

is satisfied.[8] Everyone without a dominant strategy or dominant reply is assumed to contribute with a fixed probability.

Model 2 generates further insights into structural effects. Compared to Model 1, the existence of relatively closed “ghettos” increases the likelihood of conflict. The periphery of these network segments acts in line or together with the initiators as they have dominant reactions. The higher the relative size of social incentives (*s*+*b*), the more likely it is that the periphery will also be encouraged to contribute. A large relative difference between selective incentives and behavioral confirmation (*s*-*b*) helps key contributors to arise (see Model 1), but their additive value (*s*+*b*) is important for the mobilization of the periphery (Model 2). On the other hand, if confirmation rewards are relatively important, peaceful behavior might diffuse to radical defectors. Hence in Model 2, centralized networks are efficient in spreading both behavioral patterns (cf. Marwell, Oliver, and Prahl, 1988; Gould, 1993a).

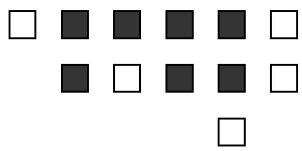


Figure 2.5.2.1 Imaginary map of a small village with mixed population

Consider for instance the following example. An imaginary map of a small village is represented in Figure 2.5.2.1. Five members of group *A* (white houses) and seven members of group *B* (black houses) inhabit the village. In this example members of group *A* live at the periphery of the village. Assume that groups are involved in a competition situation that can be described by the structurally embedded IPG game. Let us suppose that everyone is in close connection only with neighbors to the East, West, South, and North. Group *B* has the advantage of size but also has a structural advantage, since its members are located mainly in the center of the village. Consequently, collective action is more likely in this group. One player has a dominant strategy of contribution in group *B*, if $e+3b<3s$. Three other members living in black houses have a dominant reply of contribution in this case, if $e+t<2s$. If a stronger condition of $e+t+2b<2s$ is satisfied, then five members of group *B* have

[8] If $k_B^* \geq k_A^*$, then the less strict conditions

$$g_i t + e > (f_i - f_{id})(s+b) + f_{id}(s-b) + c - d$$

and

$$g_i t + e > (f_i - f_{id})(s+b) + f_{id}(s-b) + v - c$$

are sufficient to hold for defection to be a dominant strategy.

contribution as a dominant strategy. If the condition of $e+t<s+b$ is also met, then the remaining two members of group B may contribute to the collective action, since it is their dominant reply. *In none of these cases does anybody from group A have a dominant strategy or a dominant reply of contribution.* In this village only high opportunity costs of contribution (high rewards for free riding) and low importance of selective incentives can help to avoid conflict and the exploitation of group A.

2.5.3 Model 3: Local common knowledge

If we assume extensive contacts in the neighborhood, we can also suppose that individuals are not only capable of recognizing dominant strategies of their neighbors, but also dominant replies, best replies to dominant replies, and so forth. In Model 3 we assume that people cannot only anticipate obvious actions of their neighbors, but also the neighbors' perceptions about their own behavior and the neighbors' perceptions about their own perceptions. That is, having a dominant strategy or reply of any order is common knowledge between neighbors. Under this decision rule, it is also assumed that everyone who has a dominant strategy or reply of any order acts in accordance with this strategy. In the absence of such a strategy, individuals are assumed to contribute with a fixed probability. Model 3 goes far beyond the previous models in the sense that it also takes indirect network influence into consideration. In this model, hesitating people can be influenced by neighbors who have in turn been convinced by their neighbors. At high levels of clustering, contribution spreads easier and at low levels defection does. Consequently, in this model we expect a stronger effect of segregation on the likelihood of conflict. The stronger relationship originates in the more exhaustive recruitment of peripheral areas next to the initiators of collective action. Completely isolated individuals are not assured by the action of fellow group members and are not rewarded for traitor action, therefore they remain indifferent in the intergroup game (their decision is probabilistic).

2.5.4 Model 4: Expected value calculation

Decision models 1-3 allowed individuals to make strategic calculations, but involved a pure probabilistic element in the case of the absence of a dominant strategy or a dominant reply. However, under certain circumstances it is reasonable to presume a calculative choice for these individuals. In Model 4, we assume that everyone who has a dominant strategy or reply of any order acts in accordance with this strategy, just as in Model 3. Those who do not have such a strategy will base their decision on an expected value calculation that involves estimating the number of contributing fellow neighbors and a subjective forecast of probabilities of possible outcomes (similar to Rapoport and Bornstein, 1987).

To make the model more realistic, we incorporate a certain tendency in the model that is found in experiments and is in accordance with bounded rationality. Social psychologists often claim that people usually overestimate the criticalness of their own decision (e.g., Kerr, 1989). Even if their beliefs about critical probabilities are correct, they contribute to the collective action more likely than what would follow from expected value calculations based on these probabilities (Rapoport, Bornstein, and Erev, 1989). This striking gap is also present in experimental conditions, where confirmation incentives can be excluded (cf. Caporael et al., 1989). Such a positive error can originate in people's preferences for not being responsible for the group decision and can be labeled as responsibility aversion. We incorporated this tendency in Model 4. The exact specification of the expected value rule that is adjusted for responsibility aversion can be found in Appendix 2.A.2.

In Model 4, collective action might be established in a segregated setup, even where rewards of intergroup opposition are not salient. In less segregated settings, not only direct neighborhoods, but also fellows of a larger network distance can be enforced to contribute because they might forecast contribution in the close neighborhood of initiators. On the other hand, highly mixed networks are still likely to avoid conflict.

We are also able to derive predictions about the effect of a certain type of cognitive interdependency between the players. When at least in one group there is a widespread belief that the local area is a leader in the establishment of group collective action (for instance, in many districts of the city, Serbs believe that only "good" Serbs live in that district), collective action will be more likely realized. The more people who expect a high level of contribution (conflict), the more likely it is that conflict will happen. On the other hand, expectations of peace will help the occurrence of a peaceful outcome. Hence, cognitive beliefs have an inflating effect in both directions.

2.6 Simulation design

In the previous section we introduced four models of individual behavior and we discussed general model predictions under different assumptions. We noticed that segregation increases the likelihood of intergroup conflict in all models, especially in the presence of strong selective incentives. Besides the derivation of transparent analytical results, we use simulations to derive precise predictions and provide comparative statics for all possible networks in specific settings. In the simulations, network ties represent relations between neighbors and other relations are omitted.[9] People are seldom able to escape interacting with neighbors and being influenced by them. As a consequence, different neighborhoods have different influences on

[9] Simulation programs were written in Delphi 3.

individual behavior. The empirical relevance lies in the fact that unlike other ties, neighboring connections are symmetrical (undirected) and easily mapped. Residential structures are visible and therefore our results can be interpreted easily. Furthermore it is known, that residential segregation often goes together with other forms of segregation (e.g., Whyte, 1986). The simplicity of neighborhood maps makes it possible to apply a *cellular automata* (von Neumann, 1966) alike design. Cellular automata have become useful in understanding the relation between structural embeddedness and individual choice in an interdependent situation (e.g. Messick and Liebrand, 1995; Hegselmann, 1996).

In the simulations, a grid of a rectangular grid modeled residential locations. Every location in the grid (each cell) could have three different states: occupied by a member of group A, by a member of group B, or empty. No restrictions were applied about the location of the empty cells. For instance, corner areas of the rectangle could be empty. In this way the model could also resemble cross-shape or amorphous settlements. However, simulation could provide only a simplification of residential configurations observed in reality. Simplification was also made with respect to an upper bound on neighborhood size. The usual assumptions of cellular automata based research were embraced and at most four (South, West, North, East) or eight (also SW, NW, NE, SE) adjacent cells were considered to represent neighbors (von Neumann or Moore neighbors). As in reality, at the edges of the grid, neighborhood was smaller in size. Empty adjacent cells at central locations could represent, for instance, uninhabited buildings, squares, or parks.

2.7 Measures of segregation

Since the central interest of this chapter is the relationship between structural configurations and the likelihood of conflict, it is important to describe the network structure with appropriate measures under the model settings. Therefore we briefly summarize the measurements used in computer simulation.

In the limited scope of simulations, ties connect two adjacent cells. We measured *density* by the proportion of ties that connect two nonempty cells. This measure of density approaches a simple quadratic function of the proportion of nonempty cells as grid size increases to infinity, regardless of the definition of neighborhood. The proof of this is outlined in Appendix 2.A.3 (Lemma 2.A.3.1).

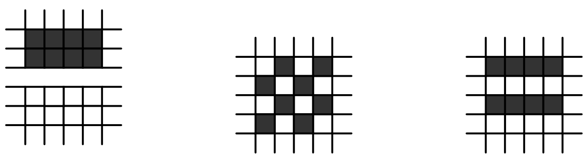
The concept of segregation is central in this research. In general, we mean by the level of segregation in a network the following:

Definition 2.7.1 The *level of segregation* in a network is defined as the proportion of relations between two members of the same group relative to all ties in the network. If this proportion is higher, then segregation is also higher.

Segregation levels are comparable given a certain level of density in the network. The definition corresponds with how the concept of *clustering* is used in the empirical literature (Lieberson and Carter, 1982). The level of clustering measures the extent to which members of one group have connections only among each other (cf. Willms and Paterson, 1995; Lieberson, 1980). On the other hand, segregation is also related to the level of *exposure* that indicates to what extent members of one group are exposed to members of the other group (Lieberson, 1980). If exposure is higher, then segregation is lower in the network. In empirical research, segregation indexes are computed from grouped data (e.g., group proportions in census tracts). As Grannis (1998) stresses, in this way the indexes provide a biased measure of neighborhood compositions. Individual behavior is influenced mainly by contacts embedded in smaller units of residential structure, hence tertiary residential-type streets or merely the closest neighbors comprise the lionshare of the explanatory focus.

In the simulations, we need to specify exactly how we measure segregation. As our simulations contain individual-level data, we can rely on micro-level indexes that are close in interpretation to the empirical isolation and exposure measures. The proportion of fellow ties (from all non-empty relations) will be used as an index of *segregation* (clustering). This measure is closely related to the individual f_i values. As in the empirical isolation index, high values indicate high levels of clustering. As grid size increases to infinity, the expected proportion of fellow ties approaches the sum of squares of the group proportions. The proof of this statement can be found in Appendix 2.A.3 (Lemma 2.A.3.2).

If a grid is more clustered than another under the von Neumann neighborhood definition, this does not necessarily mean that this grid is also more clustered under the Moore neighborhood definition. A striking example is a chessboard-like settlement, in which black and white fields represent members of the two groups respectively. In such a residential structure the segregation index is zero, if neighborhood is defined by von Neumann neighbors, but it is close to the average level, if neighborhood is defined by Moore neighbors (see Figure 2.7.1).



neighborhood definition (maximum number of neighbors)	4	8	4	8	4	8
isolation index	1	1	0	0.5	0.5	0.25
exposure index	0	0	1	0.5	0.5	0.75

Figure 2.7.1 Simple patterns of different levels of clustering

Note: Indexes are calculated for infinite grid sizes with these patterns

The proportion of opposite ties that connect members of the competing groups could be used as an index of *exposure*. This measure is closely related to the individual g_i values. High values of exposure indicate high levels of mixing. It is important to note that extreme mixing is not equivalent to a random residential structure. The proportion of fellow and opposite ties (segregation and exposure) always sums to one. The constructed segregation and exposure indexes fulfill the proposed criteria and are appropriate for the simulation analysis based on complete information. In our next examples clustering will be operationalized by the value of the segregation index.

2.8 Simulation results

2.8.1 The effect of group size and neighborhood definition

The aim of this section is to provide precise predictions about the effect of segregation on the expected likelihood of conflict under different behavioral models. In the simulations, structurally embedded IPG games were played between two groups of equal size. We considered a 10×10 grid, in which 90% of the cells were inhabited. Thus, there were 45 members in both groups. Under each decision model, a homogenous population was assumed in the sense that every player used the selected decision rule. The probability element of each decision rule was fixed to 25% of contribution.

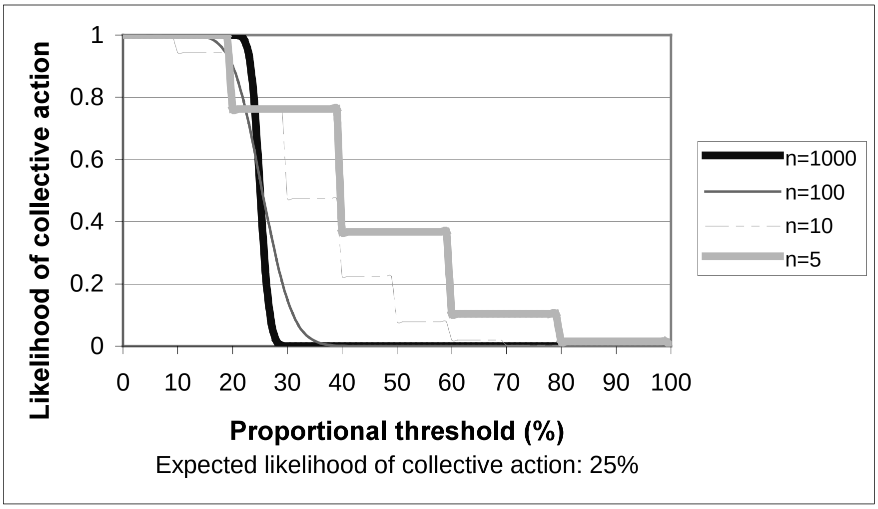


Figure 2.8.1.1 The effect of proportional threshold (MCS) on the expected likelihood of collective action

Note: Individual contribution chance is 25%.

Although we fix the parameter values of group size and minimal contributing sets in all simulations, we can briefly demonstrate the effect of these parameters on the likelihood of intergroup conflict. For this purpose, let us consider a probabilistic world in which every individual contributes with a 25% chance. Figure 2.8.1.1 shows the effect of varying the minimal contributing set on the expected likelihood of collective action of the group. The minimal contributing set is given in proportion to the group size and different lines indicate different group sizes. If the minimal contributing set is higher than the expected value (25%), then small groups can establish collective action easier than large groups. The analytical calculation of the likelihood of conflict becomes highly complicated if individual decisions are not randomly taken. This is an additional reason why we need to use computer simulation.

Before discussing the effects of segregation and individual decision rules, let us also illustrate how the definition of neighborhood influences the expected likelihood of conflict. If the same levels of clustering are considered, the expected likelihood of conflict is usually higher in the von Neumann neighborhood. Figure 2.8.1.2 shows two comparisons in decision Model 1. As a grid with Moore neighborhood represents a denser network, the examples illustrate that given a certain level of segregation, contributions and *intergroup conflict is more likely in a sparse network*. The reasons can be found in the structural conditions of having a dominant strategy. In the confirmation pressure condition only defection can be a dominant strategy. Furthermore, it can be a dominant strategy only under the Moore neighborhood definition, which means a higher likelihood of peace in this case. If local selective incentives are important, then contribution is more likely to be a dominant strategy in dense networks (cf. equations 2.4.1 and 2.4.2).

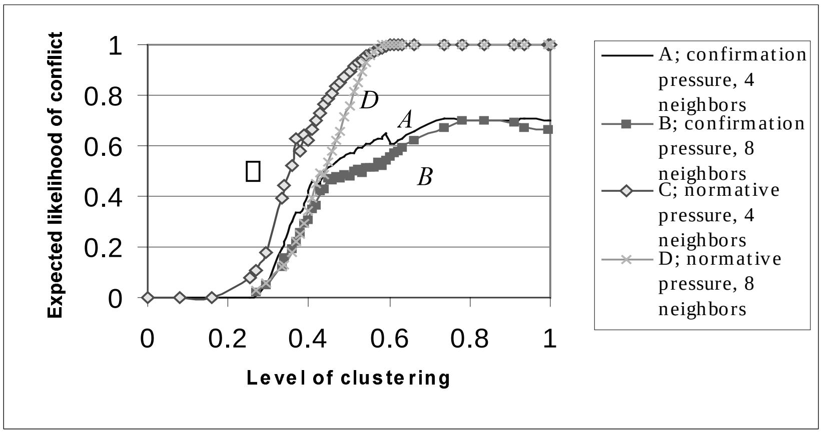


Figure 2.8.1.2 The effect of segregation on the expected likelihood of conflict, if neighborhoods are defined differently

Notes: In confirmation pressure condition: *b=2, s=1*; in normative pressure condition: *b=1, s=2*. Other parameter values: *v=5*, *e=2*, *c=-1*, *d=-5*, *t=2*. Minimal contributing set: 12 members (25%) in both groups.

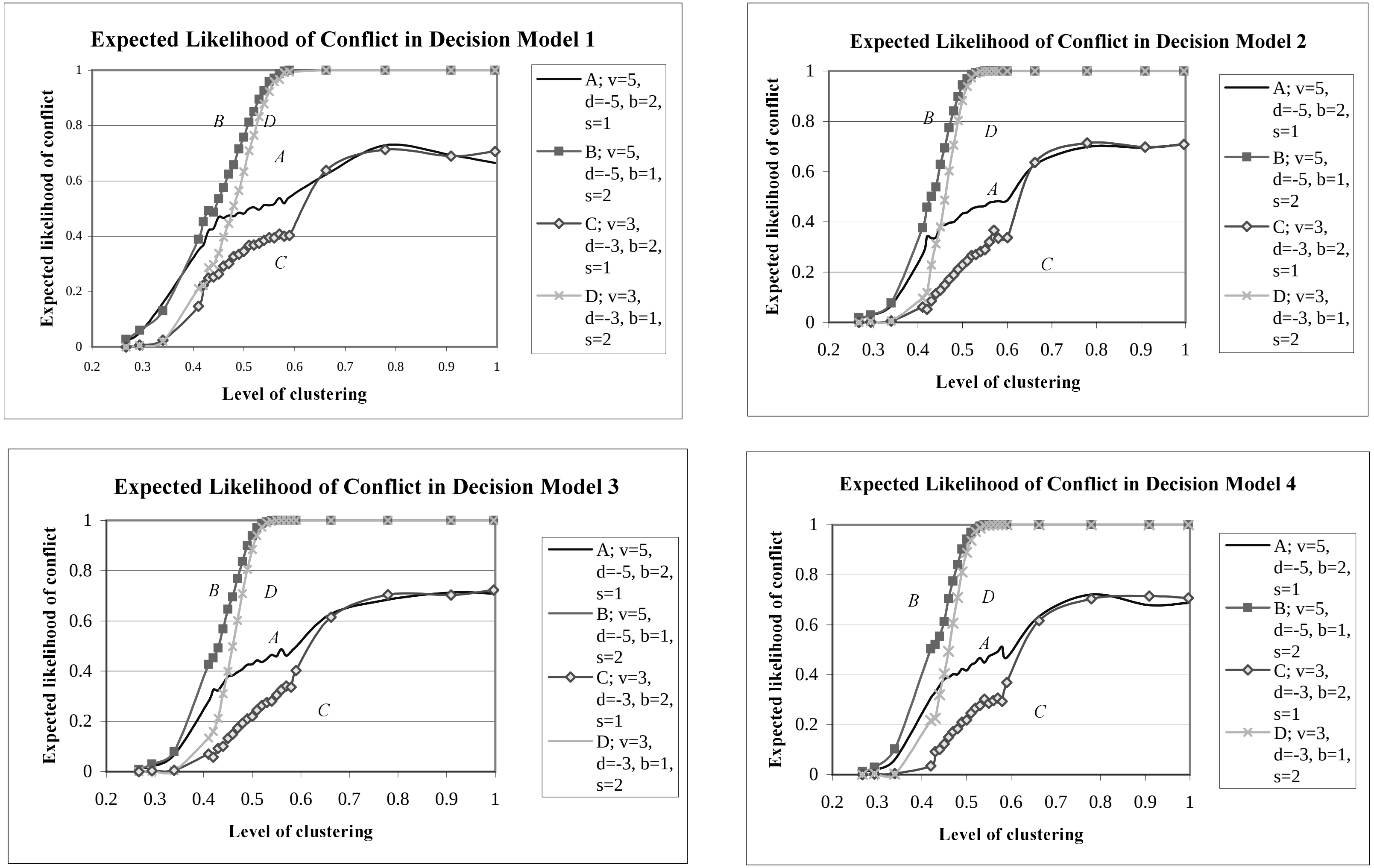


Figure 2.8.2.1. The Expected Likelihood of Conflict by Clustering, if the Minimal Contributing Set is 12 Members

Note: Curves A, B: salient; curves C, D: non-salient rewards of intergroup opposition. Curves A, C: confirmation pressure condition; curves B, D: normative pressure condition.

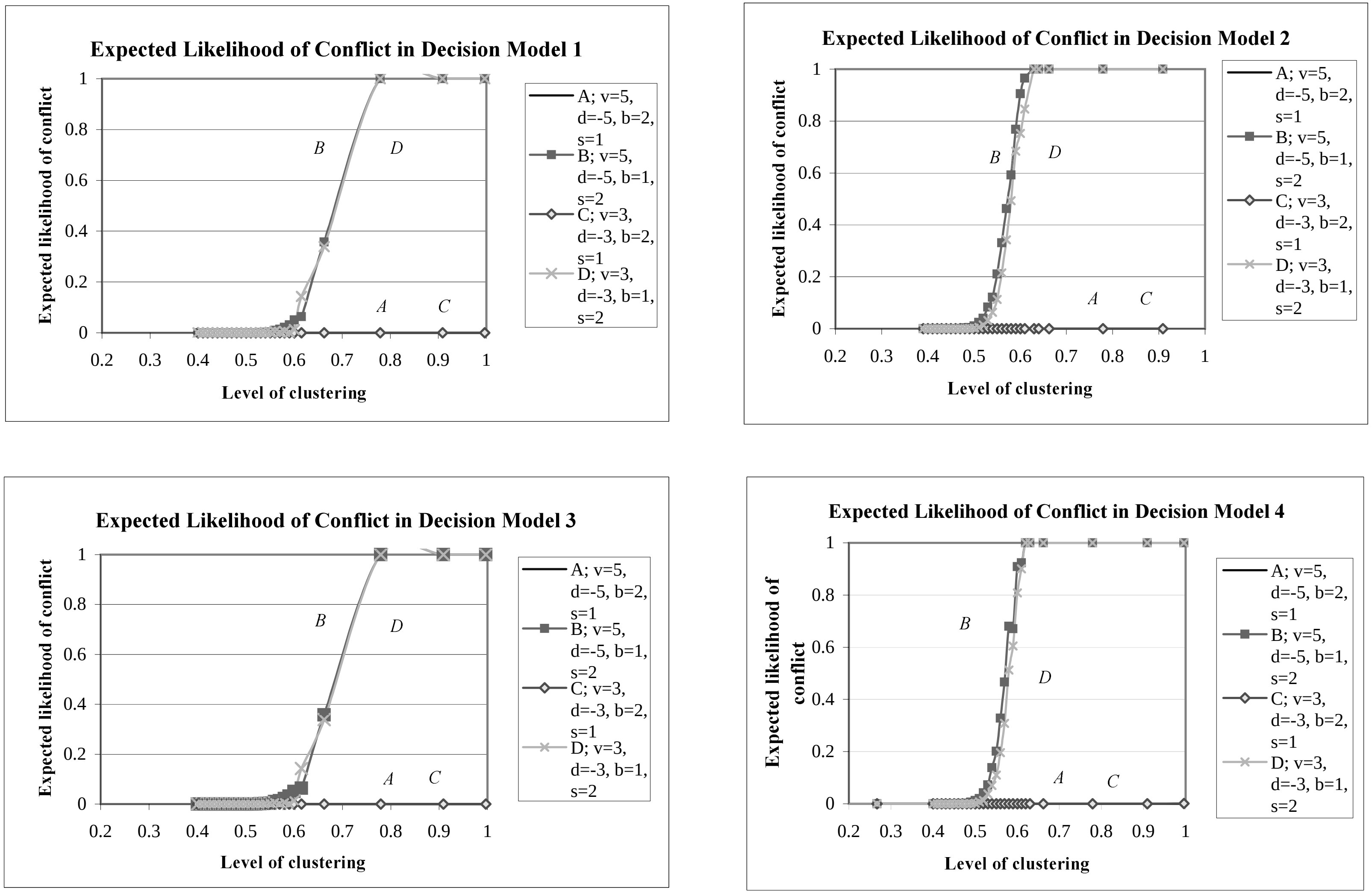


Figure 2.8.2.2. The Expected Likelihood of Conflict by Clustering, if the Minimal Contributing Set is 23 Members

Note: Curves A, B: salient; curves C, D: non-salient rewards of intergroup opposition. Curves A, C: confirmation pressure condition; curves B, D: normative pressure condition.

Curves in Figure 2.8.1.2 and in subsequent figures connect discrete cases of clustering levels. It is possible that when the average number of fellow neighbors is higher, the number of people who have enough fellow neighbors to have contribution as a dominant strategy is smaller. This causes quite a big fluctuation, especially for high and low ranges of clustering. To avoid graphic confusion, averages of expected likelihood of conflict are shown by 0.01 interval sizes in the medium range of clustering and by 0.025 interval sizes for extreme cases. However, it could be interesting to investigate what structural configurations are behind these fluctuations and what are the structural conditions that result in a high likelihood of conflict in a mixed setting or the opposite, resulting in a low likelihood of conflict in a segregated setting. We will return to this point in Section 2.9.

2.8.2 The segregation effect under different decision algorithms

Figures 2.8.2.1 and 2.8.2.2 illustrate how different individual decision rules (Models 1-4) influence the effect of segregation on the expected likelihood of conflict. The figures demonstrate this effect for two minimal contributing sets. In these examples, we considered Moore neighborhoods. In both figures, behavioral models are represented separately. On each figure, curves display the expected likelihood of conflict for four combinations of parameter values: whether rewards from the intergroup opposition are *salient* ($v=5$, $d=-5$) or *non-salient* ($v=3$, $d=-3$), and whether behavioral confirmation is more important than selective incentives (*confirmation pressure* condition; $b=2$, $s=1$) or not (*normative pressure* condition; $b=1$, $s=2$). Values of other parameters were fixed in all cases ($e=2$, $c=-1$, $t=2$).

Figures 2.8.2.1 and 2.8.2.2 show that segregation has a crucial effect on the expected likelihood of conflict in the normative pressure condition.[10] Salient payoff parameters are always associated with a higher expected likelihood of conflict. This effect is never as crucial as the difference between the confirmation pressure and normative pressure conditions. This is not surprising, since social incentives originate from network relations; meanwhile payoff parameters of the IPG game are independent from social structure. If contribution can be a dominant strategy ($s>b$), then the relationship between segregation and the expected likelihood of conflict is best described by a steep S-shape curve. In the normative pressure condition, clustering has a crucial effect on conflict in a certain critical range. This range *ceteris paribus* moves to the right (compare Figures 2.8.2.1 and 2.8.2.2) if the minimal contributing set for

[10] In the confirmation pressure condition, contribution cannot be a dominant strategy (cf. equation 2.4.1). In these cases the expected likelihood of conflict is smaller. If $b=1$ and $s=2$, then contribution is a dominant strategy for individual i, if $g_i=0$ and $f_i \geq 3$; or if $g_i=1$ and $f_i \geq 5$. If rewards from the intergroup opposition are salient ($v=5$, $d=-5$), then not to contribute is a dominant strategy for individual $i \in A$, if $f_i=0$ and $g_i \geq 3$; or if $f_i=1$ and $g_i \geq 4$; or if $f_i=2$ and $g_i=6$. For non-salient payoffs, not to contribute is a dominant strategy for individual $i \in A$, if $f_i=0$ and $g_i \geq 2$; or if $f_i=1$ and $g_i \geq 3$; or if $f_i=2$ and $g_i \geq 5$.

collective action is higher, which means that the overall likelihood of conflict is always smaller. Under certain conditions, there is no critical range. There are examples in which conflict is certain even in a grid of minimum clustering. There are also cases in which peace is expected with certainty even in a grid of maximum clustering (cf. confirmation pressure in Figure 2.8.2.2).

Within Figures 2.8.2.1 and 2.8.2.2, comparisons can be made between the effects of segregation under different decision models. The segregation effect somewhat increases and the critical range of clustering decreases, as we go towards models with more rigid behavioral assumptions. In the low ranges of clustering, the expected likelihood of conflict is lower, if a rigid decision rule is applied. In these cases, peace can be achieved easier, if the community consists of "rational" individuals with extensive information attainment. This success of calculative action can be explained by "negative" block recruitment. In the high ranges of clustering, the opposite process (positive block recruitment) can be traced. In the normative pressure condition, more and more people will have a dominant strategy (and a dominant reaction) of contributing in a segregated network. These two processes of block recruitment result in steeper curves on the figures.

However, curves only become *slightly* steeper. The processes discussed above are only present in some networks. In most of possible network structures very few individuals have a dominant reply of any order. This implies that assumptions on individual consciousness and local information are *not crucial* to determine segregation effects on conflict. However, we will see in the next section that in some specific structures more rigid assumptions on rationality definitely change predictions.

2.9 Anomalies: when segregation does not have the predicted effect

In this section we try to illustrate with examples when rational consciousness and access to additional information makes a significant difference for our model predictions. We also try to provide an explanation for the fluctuations in Figures 2.8.2.1 and 2.8.2.2. These curves are constructed by connecting discrete data points. One data point shows the expected likelihood of conflict under a given level of clustering. There is a high variation of how many network configurations belong to the same level of clustering. Furthermore, the expected likelihood of conflict might be very different for two networks with the same level of clustering. Obviously, segregation is not the only network characteristic that influences the likelihood of conflict between groups. As a short illustration, we mention here the relevance of bridges, minority hostages, and subgroups.

Bridges are believed to be of central importance in social network analysis (Granovetter, 1973). Chain reactions in collective action also require bridges that link socially distant actors (Macy, 1991a). A bridge is defined as a connection between otherwise separated units or subgroups of the network. In the intergroup context, bridges are connecting otherwise separated portions of the *same* group. Our analysis shows that bridges do not always help to diffuse contribution or defection and sometimes do not play any role in intergroup conflict. Whether bridges play brokerage or not, depends on the importance of social rewards, on the width of the bridges, and also on the environment of bridging ties. The size of social rewards determines what compositions of the individual neighborhood would allow dominant strategies or replies. Let us consider the normative pressure condition of Figures 2.8.2.1 and 2.8.2.2 with the same parameter values. The first three network segments in Figure 2.9.1 are examples of low clustering levels. In these segments, a single bridge, a double bridge, and a double bridge with bridgeheads are represented for the black group in a residential setting in which network ties are assumed to exist between Moore neighbors.

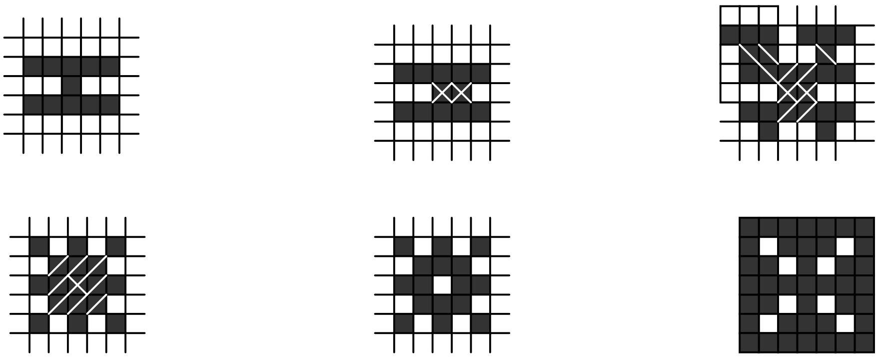


Figure 2.9.1 Examples of a single bridge, a double bridge, and bridgeheads (above) and examples of suppression of collective action by minority hostages (below)

Note: A white X denotes a dominant strategy of contribution, a white "/" stands for a dominant reply of a first order and a white "\" indicates a dominant reply of a higher order.

The examples demonstrate that under the given parameter conditions a single bridge "does not make a summer" (cf. McAdam, 1986; McAdam and Paulsen, 1993). If mediators are not alone, at least they will be active contributors to collective action. However, they can only influence the connected subgroups, if sufficient people receive their message. That is, bridges are capable of transmitting contribution incentives, if they are "wide" enough and bridgeheads are built to receive and forward these incentives. From Figure 2.9.1 we can also get an idea how a flow of contribution can be established between loosely structured subgroups that are connected by wide bridges and bridge-heads, if the local common knowledge rule (Model 3) is applied.

Another central issue in social network analysis is the role of structural holes (Burt, 1992). In the intergroup context, we redefine structural holes as empty or minority connections in a local environment that is dominated by one group. Empty cells in a homogeneous neighborhood harm neither contribution, nor defection, unless there are not many of them. In a dense structure, abandoning some fellow ties and creating structural holes has a low marginal influence on contribution, since dominant strategy and reply is more dependent on the homogeneity than on the size of the neighborhood. However, if structural holes are filled with minority "hostages", then they form a serious threat for contribution. If they have central location, they can nip collective action in the bud. As an example let us take a look at the normative pressure condition, with the same parameter values as in previous figures. In this case, minority hostages have a good chance of suppressing collective action if they are not completely alone (see Figure 2.9.1, network on the bottom right). The network on the bottom left of Figure 2.9.1 indicates the situation where the direct influence of a single individual is maximal (all neighbors have a dominant reply of contribution). The feature in the middle of the second row shows that contribution is suppressed if a structural hole is inserted at a central location.

segregation index	0.5088	0.5088
Model 1	0.88	0.49
Model 2	0.88	0.96
Model 3	0.88	1
Model 4	1	1

Figure 2.9.2 Expected likelihood of conflict in networks with equal level of clustering

Notes: The expected likelihood of conflict is indicated for salient intergroup rewards in the normative pressure condition with a minimal contributing set of 13 members (Moore neighborhood). In each decision model, the probabilistic element is 25%.

Left side: a network with small cohesive subgroups, right side: a network with a large, loosely connected subgroup. A white X denotes a dominant strategy of contribution, a white "/" stands for a dominant reply of a first order and a white "\" indicates a dominant reply of a higher order.

For the discussion of anomalies, we would like to emphasize another important point: the role of subgroup structures. What helps intergroup collective action more: many small, cohesive, but isolated subgroups or few large, loosely connected subgroups? The answer depends on the behavioral assumption we apply. If people can recognize only their dominant strategies or have very limited local information (Model 2), then isolated, but dense subgroups are more efficient in the establishment of collective action. However, if people are capable of assessing high quality information regarding their neighbors (Model 3), then large, loosely connected subgroups are more effective in mobilizing group members. Individuals at the periphery of the large group can be convinced to participate in collective action. However, key contributors are always necessary to initiate mobilization. Two networks with equal level of clustering are represented in Figure 2.9.2 as an example. In the network on the left, there are two small cohesive subgroups of black cells. In the right network, there is a loosely connected large subgroup. The expected likelihood of conflict is larger in the left structure under Model 1, but it is smaller under the assumptions of Models 2 and 3.

2.10 Discussion

The aim of this chapter was to construct a theoretical model of intergroup conflict that is based on the interdependency of individual decisions and integrates sociological insight into the analysis. The latter was achieved by focusing on social incentives that, besides the rewards from the intergroup context, influence individual decisions. Social incentives are transmitted through social ties; consequently the network structure has a strong impact on the emergence of group conflicts.

Previous research found that intergroup competition, the local assurance process, and the application of selective incentives are possible structural solutions to social dilemmas. By integrating these different ideas in a general model, we showed that *a different social dilemma might occur in which overall contribution traps the groups in a mutually harmful outcome*. Further investigation in the chapter concerned structural conditions that can help to avoid lethal conflicts. Particular attention was paid to the direct and interaction effects of network segregation. *Results indicate that segregation is likely to increase the likelihood of conflict, but not under all circumstances. Depending on other parameters, certain ranges of clustering are decisive in the determination of the outcome of intergroup competition*. This result will help us to derive hypotheses for the experiments that are discussed in the subsequent chapters. Furthermore, our findings might also have implications for real conflict management, e.g. for residential policy.

Besides aggregated consequences, our main research questions concerned underlying mechanisms on the interpersonal level (cf. Section 1.8). We were interested in the effects of social control on individual decisions and we intended to explore how different forms of social control are responsible for the segregation effect and what is the impact of their relative size. In general, *our model predicts a strong positive effect of segregation, if normative pressure is more important than confirmation pressure of neighbors and friends*. We were also interested if our results were valid under different behavioral specifications. We demonstrated that the intensified effect of segregation under strong normative pressure was present in all of our behavioral models. We showed that by assuming higher consciousness of individual decisions and better access to local information, the segregation effect becomes stronger. On the other hand, *more rigid assumptions on "rationality" made a difference only in certain network configurations*.

Possible applications of the model include ethnic conflict in neighborhoods, villages, or cities under different residential structures; conflict between football supporters in a stadium or between pupils in a classroom under different seating patterns; and participation in voting in two-party democracies. Empirical evidence from different areas provides support for many of our model predictions. For instance, residential segregation and separate education was found highly responsible for repeated conflict in Northern Ireland (Whyte, 1986). In studies of voting behavior, the classical work of Tingsten (1963 [1937]) has shown that socialist party choice is disproportionally more likely in working class districts. Further evidence of a nonlinearly increasing effect of segregation on voting was found by Butler and Stokes (1974) and Ragin (1986).

The model might have many important societal implications that will be discussed in Section 6.2. On the other hand, there is a valid concern about the limited applicability of the model to empirical situations. The ecological validity would be enhanced significantly if some of the parameter values were based on empirical data. However, the measurement of payoff parameters (especially social selective incentives and behavioral confirmation) is highly problematic. Numeration of public good rewards (e.g., social identity and nationalist pride) is also often impossible. Furthermore, the model is based on far too simple assumptions to be sufficiently competent to describe the complexity of reality. We should also mention some of the limitations. The focus on single-shot games results in the neglect of time. In the model, simultaneous actions of individuals are assumed, although in many empirical situations there are long-term delays and people can obtain information about the decision of others. The introduced dominant reply and common knowledge decision rules could however be interpreted as decisions with a certain time lag. Using this interpretation our model allows new insight also regarding the threshold models of collective action (Granovetter, 1978; Oliver, Marwell, and Teixeira, 1985; Macy, 1991a; Gould, 1993a; Chwe, 1999). More strikingly, we did not attempt to include the history of intergroup relations, which is the root of many empirical conflict situations. The neglect of history will be relaxed in Chapters 4 and 5 by iterating the game over time.

Appendix

2.A.1 Model specification using matrix algebra

Individual payoffs in the modified IPG game can be expressed as follows. Formally, the set of possible strategies (ω_i) for player $i \in A$ are {0,1}, where 1 stands for the contributing action. Let us denote the number of contributors in group A and B respectively by k_A and k_B and the minimal contributing sets (MCS) by k_A^* and k_B^*. Given the strategy combination vectors $\boldsymbol{\omega}_{\mathbf{A}}$ and $\boldsymbol{\omega}_{\mathbf{B}}$ (dimensions of $n_A \times 1$ and $n_B \times 1$), the payoff for i is determined by:

$$h_i(\omega_A, \omega_B) = e(1 - \omega_i) + \iota_{k_A+1}' \mathbf{H} \iota_{k_B+1},$$

where ι_{kA+1} is a $(n_A+1) \times 1$ vector of zeros with 1 in the k_A+1-th place. The expression $\iota_{kA+1}'\mathbf{H}\iota_{kB+1}$ points to the $\{k_A+1;\ k_B+1\}$ element of matrix $\mathbf{H}$. The $(n_A+1) \times (n_B+1)$ dimension $\mathbf{H}$ matrix contains the payoffs from the intergroup context for individual $i \in A$. If there are k_A contributors in group A and k_B contributors in group B, then the $\{k_{A+1};\ k_{B+1}\}$ element of the $\mathbf{H}$ matrix shows the reward for individual $i \in A$. In general, the $\mathbf{H}$ matrix can be partitioned into four submatrices. The $k_A^* \times k_B^*$ dimension $\mathbf{H}_1$ submatrix contains zeros as elements, the $k_A^* \times (n_B - k_B^* + 1)$ dimension $\mathbf{H}_2$ submatrix contains d's as elements, and the $(n_A - k_A^* + 1) \times k_B^*$ dimension $\mathbf{H}_3$ submatrix contains v's as elements. In the $(n_A - k_A^* + 1) \times (n_B - k_B^* + 1)$ dimension $\mathbf{H}_4$ submatrix, there are c's, if the row number equals the column number in matrix $\mathbf{H}$. Furthermore, there are v's if the row number exceeds the column number and there are d's if the column number is higher. For example, if there are five members in group A, seven in group B, and the minimal contributing set is the minimal majority, then the 6×8 size $\mathbf{H}$ matrix is:

$$\mathbf{H} = \begin{bmatrix} \mathbf{H}_1 & \mathbf{H}_2 \\ \mathbf{H}_3 & \mathbf{H}_4 \end{bmatrix} = \begin{bmatrix} 0^* & 0 & 0 & 0 & d^* & d & d & d \\ 0 & 0 & 0 & 0 & d & d & d & d \\ 0 & 0 & 0 & 0 & d & d & d & d \\ v^* & v & v & v & d & d & d & d \\ v & v & v & v & c & d & d & d \\ v & v & v & v & v & c & d & d \end{bmatrix}$$

Payoffs with an asterisk indicate rewards from a Nash equilibrium outcome. There are three Nash equilibria: one in which nobody contributes, one in which there are three contributors in group A and none in group B, and one in which there are no contributors in group A and there are four in group B. To facilitate the interpretation of the $\mathbf{H}$ matrix, this latter equilibrium belongs to the fifth element in the first row of the matrix. The corresponding payoff d denotes that group A is defeated.

In the structurally embedded IPG game, these payoffs are extended by rewards from interpersonal relations (local coordination games). The strategy set of player $i \in A$ is again {0,1}, where 1 stands for the contributing action. Let us denote the number of i's neighbors from group A by f_i and the number of neighbors from group B by g_i. The individual payoff for $i \in A$, given the strategy combination $(f_i \times 1)$ vector ω_f for the fellow neighbors, is determined by:

$$h_i(\omega_A, \omega_B, \omega_f) = (e + g_i t)(1 - \omega_i) + \iota_{k_A+1}{}' \mathbf{H} \iota_{k_B+1} + s f_i \omega_i + b\{\omega_i \omega_f{}' \omega_f + (1 - \omega_i)(f_i - \omega_f{}' \omega_f)\},$$

where ι, the **H** matrix and the other elements are the same as before.

2.A.2 Detailed specification of the expected value calculation (*Model 4*)

In Model 4, we assume that everyone who has a dominant strategy or reply of any order acts in accordance with this strategy. Those who do not have such a strategy, will base their decision on an expected value calculation that involves an estimation of the number of contributing fellow neighbors and a subjective evaluation of probabilities of possible outcomes.

The estimation can be based on the following calculation. Denote the subjective probabilities of the seven states by P_z's $\left(\sum_{z=I}^{z=VII} P_z = 1 \right)$ and the estimated number of fellow neighbors for i who will contribute by $\hat{f}_{ic}$. For the sake of simplicity, let us assume that rewards are numerical and individual utility is a linear function of rewards. We obtain that contribution is a better choice, if

$$P_{III}(c - d) + P_{IV} v + P_V (v - d) + P_{VI}(v - c) + \hat{f}_{ic}(b + s) + (f_i - \hat{f}_{ic})(s - b) > g_i t + e. \tag{2.A.2.1}$$

We have to make further assumptions regarding how individuals determine critical probabilities. The calculation could be based on an approximation from the binomial distribution. People however, are unlikely to make calculations in this sophisticated way (cf. experimental results of Rapoport and Bornstein 1989), especially if it is problematic to translate rewards into utilities. On the other hand, in making decisions individuals certainly consider what the probable outcomes of the intergroup opposition will be and how their neighbors will behave. Therefore, results are aimed only at highlighting the tendencies of how the “vision of rational man” can change the predicted likelihood of intergroup conflict and the predicted relationship between segregation and conflict.

To make the model more realistic, we incorporated a certain tendency that individuals often overestimate the criticalness of their own decision (Kerr, 1989; Rapoport, Bornstein, and Erev, 1989). Precisely, we assume that if individuals do not have a dominant strategy or a dominant reply of any order, (local common knowledge is assumed about obvious reactions of neighbors), they will then use an expected value calculation based on inequality (2.A.2.1). Critical probabilities P_{III}, P_{IV}, P_V, and P_{VI} (cf. Table 2.2.2) are obtained from a binomial calculation that sums the probabilities of all possible events for the given outcome:

$$P_{III} = \sum_{j=\max(k_A^*;k_B^*)}^{\min(n_A;n_B)} \binom{n_A-1}{j-1} p_A^{*\,j-1}\left(1-p_A^*\right)^{n_A-j} \cdot \binom{n_B}{j} p_B^{*\,j}\left(1-p_B^*\right)^{n_B-j},$$

$$P_{IV} = \binom{n_A-1}{k_A^*-1} p_A^{*\,k_A^*-1}\left(1-p_A^*\right)^{n_A-k_A^*} \cdot \sum_{j=0}^{k_B^*-1} \binom{n_B}{j} p_B^{*\,j}\left(1-p_B^*\right)^{n_B-j},$$

$$P_V = \binom{n_A-1}{k_A^*-1} p_A^{*\,k_A^*-1}\left(1-p_A^*\right)^{n_A-k_A^*} \cdot \sum_{j=k_B^*}^{k_A^*-1} \binom{n_B}{j} p_B^{*\,j}\left(1-p_B^*\right)^{n_B-j},$$

and

$$P_{VI} = \sum_{j=\max(k_A^*;k_B^*)}^{\min(n_A-1;n_B)} \binom{n_A-1}{j} p_A^{*\,j}\left(1-p_A^*\right)^{n_A-j-1} \cdot \binom{n_B}{j} p_B^{*\,j}\left(1-p_B^*\right)^{n_B-j},$$

where p_A* and p_B* denote the *subjective probability* that a representative individual contributes to the group collective action in group *A* and *B*, respectively. We assume that people think both groups are homogenous in a sense that they order the same subjective probability to each actor's action in the given group (cf. Rapoport and Bornstein, 1987). In the simulations, we assumed both p_A* and p_B* to be 0.25. Responsibility aversion is incorporated in the decision rule as when the procedure described does not result in contribution people are still allowed to contribute with a fixed probability. In the simulations, this probability was set to 0.25.

2.A.3 Statistical properties of network measures

In this part of the Appendix we derive some statistical properties of the network measures used in the simulation. In all simulations, a grid of a rectangle form was considered with *R* rows and *C* columns.

Proposition 2.A.3.1. The total number of dyadic connections T is equal to $2RC$-R-C, if von Neumann neighbors are considered.

Proof. Every cell in the middle (sum (R-2)(C-2)) has four adjacent cells, every cell at the edges (sum 2R+2C-8) has three adjacent cells, and the four cells in the corners have two adjacent cells. Summing this, every dyad is counted twice, thus

$$T = \frac{4(R-2)(C-2) + 3(2R + 2C - 8) + 2 \cdot 4}{2} = 2RC - R - C$$

which completes the proof the proposition.

Proposition 2.A.3.2. The total number of dyadic connections T is equal to $4RC$-$3R$-$3C$+2, if Moore neighbors are considered.

Proof. Every cell in the middle (sum (R-2)(C-2)) has eight adjacent cells, every cell at the edges (sum 2R+2C-8) has five adjacent cells, and the four cells in the corners have three adjacent cells. Summing this, every dyad is counted twice, thus

$$T = \frac{8(R-2)(C-2) + 5(2R + 2C - 8) + 3 \cdot 4}{2} = 4RC - 3R - 3C + 2$$

which proves the proposition.

LEMMA 2.A.3.1. Denote the grid size by S (S=RC) and the population density (the proportion of inhabited cells) by $\pi = n_{A+B}/S$. We assume no restrictions on how the grid is filled, that is every location can be filled with a probability of π. The *density* of network relations is measured by the proportion of nonempty dyads (ties) and it is denoted by δ. Irrespective of the definition of neighborhood (von Neumann or Moore neighbors), the expected density of network relations $E(\delta)$ is obtained by

$$E(\delta) = 2\pi - 1 + (1-\pi)\frac{(1-\pi)S - 1}{S - 1}.$$

The larger the grid size (S) is, the closer the expected value is to π^2, i.e.

$$\lim_{S \to \infty} E(\delta) = \pi^2.$$

Proof. A network relation connects two adjacent cells in the grid. We do not make specific assumptions about the definition of "adjacent" cells; thus our results are valid for any neighborhood definitions. Consider a randomly selected dyad. This dyad is empty when one of the cells it connects is empty. The probability of one cell being empty is 1-π. The same holds for the adjacent cell. However, the two events are not independent given the fixed population density of the grid (the two locations are filled *without* replacement). Therefore, for the calculation of the probability of this dyad being empty the joint probability of the two events have to be subtracted, which is

$$(1-\pi)\frac{(1-\pi)S-1}{S-1}.$$

The probability of this dyad being nonempty is one minus the probability of this dyad being empty, thus irrespective of the definition of neighborhood,

$$P(\delta)=1-\left[(1-\pi)+(1-\pi)-(1-\pi)\frac{(1-\pi)S-1}{S-1}\right]=2\pi-1+(1-\pi)\frac{(1-\pi)S-1}{S-1}.$$

Since the dyad was selected randomly, by applying the expectation of the binomial distribution we get $E(\delta)=P(\delta)$ and the proof is given.

$$\lim_{S\to\infty}E(\delta)=\lim_{S\to\infty}\left[2\pi-1+(1-\pi)\frac{(1-\pi)S-1}{S-1}\right]=2\pi-1+(1-\pi)^2=\pi^2.$$

LEMMA 2.A.3.2. Denote the proportional group sizes by α ($\alpha=n_A/n_{A+B}$) and β ($\beta=1-\alpha$). We assume no restrictions on how nonempty cells are filled, that is every nonempty location can be filled with members of group A with a probability of α. The proportion of fellow ties ϕ (from all non-empty relations) will be used as an index of *segregation* (*clustering*). Irrespective of the definition of neighborhood, the expected proportion of fellow ties $E(\phi)$ from all non-empty relations is obtained by

$$E(\phi)=\frac{\alpha(n_A-1)+\beta(n_B-1)}{n_{A+B}-1}.$$

By enlarging the grid, the expected value gets closer to $\alpha^2+\beta^2$, that is

$$\lim_{S\to\infty}E(\phi)=\alpha^2+\beta^2.$$

The proportion of opposite ties γ (from all non-empty relations) will be used as an index of *exposure*. The index of segregation (clustering) and the index of exposure sums to one. Irrespective of the definition of neighborhood (von Neumann or Moore neighbors), the expected proportion of opposite ties $E(\gamma)$ from all non-empty relations is obtained by

$$E(\gamma) = 1 - \frac{\alpha(n_A - 1) + \beta(n_B - 1)}{n_{A+B} - 1} = \frac{2\alpha\beta n_{A+B}}{n_{A+B} - 1},$$

and

$$\lim_{S\to\infty} E(\gamma) = 2\alpha\beta.$$

For the proof of LEMMA 2.A.3.2, consider the following proposition.

Proposition 2.A.3.3. Without the loss of generality, let us consider group A, with a relative proportion of α. The expected proportion of ties (from all non-empty relations) connecting two members of group A (denoted by ρ) is

$$E(\rho) = 1 - \left[2(1-\alpha) - (1-\alpha)\frac{(1-\alpha)n_{A+B} - 1}{n_{A+B} - 1}\right].$$

Proof of the proposition. The placement of αn_{A+B} individuals to n_{A+B} locations and the determination of the proportion of ties connecting members of group A is equivalent to the placement of πS nonempty fields to S locations and the determination of the proportion of network relations. Thus using LEMMA 2.A.3.1 and substituting α to π, the proof is given.

Proof of the lemma. Fellow ties connect two individuals from the same group. The probability of a randomly selected nonempty tie being a fellow tie is

$$P(\phi) = 1 - \left[(1-\alpha) + (1-\alpha) - (1-\alpha)\frac{(1-\alpha)n_{A+B} - 1}{n_{A+B} - 1}\right] + 1 - \left[2\alpha - \alpha\frac{\alpha n_{A+B} - 1}{n_{A+B} - 1}\right] = \frac{\alpha(n_A - 1) + \beta(n_B - 1)}{n_{A+B} - 1}.$$

Since the tie was selected randomly, by applying the expectation of the binomial distribution we get $E(\phi)=P(\phi)$, which completes the proof.

$$\lim_{S\to\infty} E(\phi) = \lim_{S\to\infty}\left[\alpha\frac{\alpha n_{A+B} - 1}{n_{A+B} - 1} + \beta\frac{\beta n_{A+B} - 1}{n_{A+B} - 1}\right] = \alpha^2 + \beta^2.$$