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The interplay of social orientation and social conformity in neighbourhood support

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Abstract. Social mobilisation for neighbourhood support may be conceptualised as the collective provision of a public good. The success of such a collective action is driven by individual preferences of the members of the providing group. In the presented model preferences are represented in terms of a set of goals that guide individual behaviour in the dilemma situation. Heterogeneity is represented by assigning agent-individual weights to the goals. Social structure is included by allowing agents to observe the behaviour of other agents within their acting group and by information exchange through social networks that may span groups. With the model we show what effect individual balancing between possibly conflicting goals has on the level of the collectively provided public good.

1 Introduction and Motivation

One of the recurring questions policy makers pose to social scientists (or: to social simulation) is how their measures may take effect in a target population. Strict measures like the prohibition of certain behaviours (along with legal enforcement) are very effective in terms of the achieved change in behaviour (assuming individual legal conformity). Thus, the effects of such measures are rather predictable. The assessment of soft measures that draw on social mobilisation as the emergent outcome of partly voluntary individual behaviour is a more challenging field of research. In the latter context, the decision making situation of the individuals has the structure of a social dilemma [1], i.e. under the assumption of purely rational actors social mobilisation will not occur. On the other hand, collective action is observed in many contexts. To assess this phenomenon the explicit consideration of heterogeneous individual preferences and social structure plays a key role.

In this paper we report on an agent based model that represents social mobilisation as the collective provision of a public good [2]. The public good is provided locally on the level of sub-groups of the population (e.g. neighbourhoods). Individual preferences are represented in terms of a set of goals that guide individual behaviour in the dilemma situation. Heterogeneity is represented by assigning agent-individual weights on the goals. Social structure is included by allowing agents to observe the behaviour of other agents within their acting group and by information exchange though social networks that may span groups. With the model we aim to demonstrate what effect individual balancing between possibly conflicting goals has on the level of the collectively provided public good.

The empirical background of the presented model is the case of adaptation to climate change in the region of Northern Hesse. For the target region it is expected that in particular increased health care for older people is an important adaptation requirement under conditions of more frequently occurring heat waves caused by climate change. This expectation is backed by a number of medical studies on the health impact of heat waves in European Countries and in the US [3, 4] and by the outputs of regional climate models that predict more frequent and more severe heat waves for the modelled region. Experts expect that public health service will likely not be able to provide the required comprehensive and area-wide health care. Therefore, neighbourhood support that helps older people during heat waves is considered as an important local provider of the required care-taking activities. Local neighbourhood support is conceptualised as a public good that requires social mobilisation of local groups of potential helpers in order to work effectively. It is expected that local neighbourhood support differs in its respective quality (potential) or capacity depending on the prevalent preferences in the providing group of people in local neighbourhoods.

2 Abstraction and theoretical context

In order to represent the situation characteristics outlined in the previous section in an ABM we start with the extraction of the abstract properties of social mobilisation for the provision of a public good. Based on these characteristics, we then motivate why the provision of neighbourhood support imposes a social dilemma situation on the potential helpers and provide a brief review of the relevant literature.

The central characteristics of local neighbourhood support that the ABM is to capture can be summarised as follows:

1. Provision: Neighbourhood support has to be provided by a group of potential helpers from a local neighbourhood.
2. Potential: The potential (or capacity) of neighbourhood support depends on the sum of the “investments” (e.g. in terms of time devoted to the task) by the potential helpers.
3. Shared social benefit: We assume that the social benefit of well established neighbourhood support is visible and valuable to all potential helpers, i.e. the positive effect of neighbourhood support is “shared” among all potential helpers within a neighbourhood group, not only between those actively contributing.
4. Timing: Up to a certain level of individual investments there will be no perceivable benefit from the neighbourhood support (i.e. the provided level of support will have a negligible potential). Above that level the capacity of the neighbourhood support rises more steeply with increasing individual investments up to a certain maximum.
5. Maximum condition: The provision of neighbourhood support with maximum capacity does not require maximum investments by all potential helpers.

The decision-making of potential helpers on investing in local neighbourhood support has the structure of a social dilemma [1]. Clearly, characteristics 3 to 5 describe a situation "…in which each member of a group has a clear and unambiguous incentive to make a choice that, when made by all members, provides poorer outcomes for all than they would have received if none had made the choice." [5]. More specifically, potential helpers face a Public Good Dilemma [2, 6, 7]. Such public goods are defined by two features: collective provision (in line with characteristics 1 and 2) and non-excludability (in line with characteristic 3). More precisely, neighbourhood support has the nature of a step-level public good [7] that requires a certain "critical mass" of contributions in order to generate any benefit at all (see characteristic 4) and that does not increase in quality if contributions go beyond some threshold (see characteristic 5).

3 Model Description

Algorithmic representation of neighbourhood support as a public good

We assume that neighbourhood support exists (or emerges) in spatial neighbourhoods in the target region. These neighbourhoods are inhabited by a number of sub-populations. Each of the sub-populations is characterised by a number of people potentially in need of help and a number of potential helpers (a subset of those not in need of help). Our focus is on the decision dynamics of the potential helpers. We assume that the local capacity of neighbourhood support depends only on the contributions of individual group members to neighbourhood help. High capacity neighbourhood supports provide high degrees of protection during heat waves and thus high social benefit for all potential helpers (independent of their respective contribution to the provision, see characteristic "shared social benefit").

It is assumed that each group has n members and that group size remains constant over time. Agents decide individually on the fraction x ($0 \leq x \leq 1.0$) of a given time budget to invest in the provision of a neighbourhood support. This time budget may be thought of as the maximum amount of time that could be devoted to neighbourhood help (e.g. available spare time). We represent the investment behaviour as one of 11 distinct behavioural options that reflect investment proportions of 0.0, 0.1 up to 1.0 in steps of 0.1. Based on the contributions of the n agents we determine the level of the generated public good, i.e. the achieved capacity of neighbourhood support.

Equation 1 (adapted from [8]) is used to calculate the support capacity c provided by a group of n agents. In the equation parameter m is the minimum number of helpers required to provide full support in a local neighbourhood. It reflects the local ratio of helpers and people in need of help. For low individual investments x_i the value of c is close to 0. For x_i=1.0 (for all i) and reasonably large γ c approaches 1.0. Parameter γ describes the shape of the investment-capacity-curve.

$$c = \frac{\left(\sum_{i=1}^{n} x_i\right)^{\gamma}}{\left(\sum_{i=1}^{n} x_i\right)^{\gamma} + \left(\frac{m}{2}\right)^{\gamma}} \quad (1)$$

Capacity c of neighbourhood support generated by n agents. Agent i contributes fraction x_i of its time budget to neighbourhood support. At least m agents are required to provide full support.

Figure 1 shows the curve for γ=5 (which is used in the rest of the paper) assuming equal individual contributions by all agents. The curve describes a continuous version of a step-level PG [7]. Substantial levels of support capacity are only generated for individual investments above 0.15 (i.e. for n=18 above a group investment of 2.7 units). Support capacity approaches 100% for individual contributions of at least 0.4 (group investment of 7.2 units).

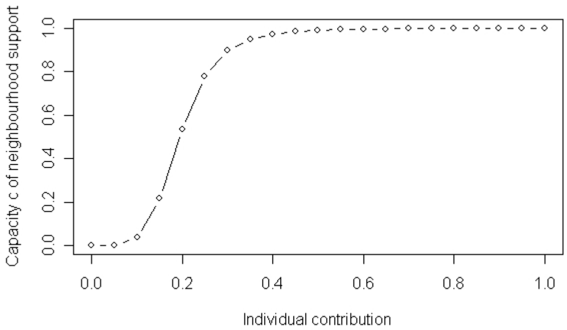

Fig. 1. Capacity of neighbourhood support generated by 18 agents (n=18, γ=5, m=7) assuming equal individual contributions x_i.

Notice that in figure 1 it is assumed that all group members provide identical investments. As for the capacity of neighbourhood support only the sum of the investments of all group members is crucial, unequally distributed contributions may yield identical support capacities. A case of free riding would occur e.g. if substantial support capacity was provided by a majority of group members and a minority refuses to invest but shares in the obtained social benefit. Qualitatively, the s-shape of the curve fits well the characteristics of neighbourhood support as outlined in the previous section.

Agent goals and preferences

In line with [9] we represent an agent's knowledge about the effectiveness of its available behavioural options with regard to the pursuit of its goals (in a very broad sense, i.e. anything the agent aims at or desires to be the case) as a utility matrix. In general terms, the utility matrix associates the possible means known to the agent to the ends desired by the agent (bounded, multi-dimensional rational choice). To represent the agent's knowledge about the basic effectiveness of a particular behavioural option when it comes to attaining a particular goal, the matrix holds one numerical value for each pair of behavioural option and goal.

In the context of neighbourhood support, we assume that agents possess 11 different behavioural options that represent 11 different time investment levels from 0.0 to 1.0. An agent's selection of a behavioural option is guided by the four different goals shown in table 1. It is important to always view an agent's knowledge about the effectiveness of its behavioural options against the background of its subjective preferences. These preferences reflect the sensitivity of the agent to particular goals, i.e. which goals are given priority over others. Preferences are agent-specific profiles reflect the basic orientations of the agent (life style, milieu properties and the like). The actual, effective goal preferences of an agent at a particular time step may differ from its basic orientations in light of the current situation, e.g. when the present state of an environment increases the urgency to attain a particular goal. In the context of neighbourhood support the preference for goal *maxSupportCapacity* will e.g. increase during a heat wave. Goal preferences are represented as numerical values. For the rest of the paper we name the goal preferences by substituting "max" in the name of the goal by "imp" (for "importance"). Thus, *impSupportCapacity* is the preference an agent has for goal *maxSupportCapacity*.

#	Goal	Description
1	*maxSupportCapacity*	Strive for working neighbourhood support
2	*maxOwnSpareTime*	Be egoistic: try to minimise own investment
3	*maxOthersSpareTime*	Be altruistic: strive for low investments of other group members.
4	*maxSocialConformity*	Achieve social conformity: behave like peers in social network.

Table 1. Agent goals. An agent's preference is represented as a set weighting factors for the goals. E.g. the way agents satisfy goal 1 may differ in their subjective balancing between goals 2 and 3 which allows representing social orientations in the sense of [10]. Goal 4 draws on an agent's preference to behave in a way that conforms to the behaviour of its important peers in its social network (e.g. agents with similar goal preferences or spatially close neighbours).

Agent decision making

With a given low probability of 1% agents take a random decision on their investment ("experimentation", uniform random distributed). Otherwise, the final decision-making of the agents is based on a subjective estimation of the utilities of their behavioural options as regards their goals and preferences. We assume, that each agent knows the present capacity of the local neighbourhood support and supposes that the n-1 other agents in its group keep to their previous investment decisions in the next time step. Hence, each agent can estimate the new capacity of the neighbourhood support associated with each of its possible next investment decisions. Furthermore, we assume that an agent knows the average level of contributions to neighbourhood support within its neighbourhood group. Finally, agents consult their social network and determine the average level of contributions by their peers.

In turn agents determine the expected utilities of each investment option x with respect to each of their goals and preferences which results in one row of their utility matrix per behavioural option. The expected overall utility u(x) of investment option x is calculated by adding up the matrix entries of one row (see equation 2).

$$u(x) = \mathit{impSupportCapacity} * c(x) + \mathit{impOwnSpareTime} * (1 - x) + \mathit{impOthersSpareTime} * (1 - \text{mean } x \text{ of other group members}) - \mathit{impSocialConformity} * \mathrm{abs}(x - \text{mean } x \text{ of peers}) \quad (2)$$

Expected overall utility of investment option x. c(x) stands for the expected support capacity, abs() calculates the absolute value.

The final selection of an investment option is represented by a probabilistic choice model (see e.g. [11]) based on the expected overall utilities for each of the behavioural options. This decision process is triggered if there is at least one behavioural option with higher expected utility than the utility achieved by the agent in the previous time step. Else the previous investment decision is kept.

4 Results and Discussion

We first report on the influence of the agents' social orientation (i.e. the weighting between egoistic and altruistic preferences) on the collectively provided neighbourhood support. This is done in terms of a sensitivity analysis of the respective goal preference parameters. We then investigate the influence of the social conformity on an individual run with heterogeneous agent profiles. In all simulation runs presented here agents are initialised with investment levels of 0.0. Furthermore, we assume an ongoing heat wave as external condition and therefore set *impSupportCapacity* to 1.0 in all simulations. Simulations are composed of 20 neighbourhood groups of size 18 and 300 decision cycles of each group member.

Goal preference	Preference value
impSupportCapacity	1.0
impOwnSpareTime	0.0 to 0.4, resolution 0.05
impOthersSpareTime	0.0 to 0.4, resolution 0.05
impSocialConformity	0.0

Table 2. Agent goal preferences used in the sensitivity analysis.

For the sensitivity analysis we set the preference for the social conformity goal to 0 and vary the social orientation of the agents. Table 2 shows the parameter ranges considered. In total 81 different social orientations (9x9 combinations of egoistic and altruistic preferences) are investigated. Furthermore, we assume identical profiles for all agents, i.e. fixed settings of the goal preferences. For each social orientation 5 independent simulations were performed (different random seed initialisations).

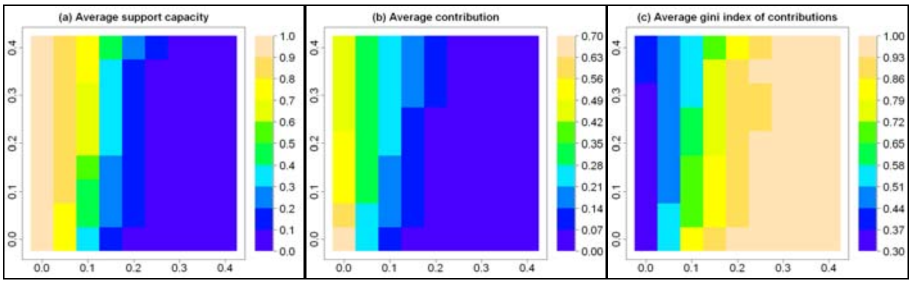

Fig. 2. Results of the sensitivity analysis: Each square represents mean values over 5 runs with a fixed parameter setting but different random initialisations for *impSupportCapacity*=1.0, *impSocialConformity*=0.0. Abscissa shows *impOwnSpareTime*, ordinate *impOthersSpareTime*.

Figure 2 shows the results of the sensitivity analysis. Figure 2 (a) shows that if egoistic preferences are high (*impOwnSpareTime*>0.2) no support is generated independent of the weight put on altruistic tendencies (*impOthersSpareTime*). For lower egoistic tendencies the generated capacity increases with increasing consideration of the investments of other group members. Vice versa for fixed altruistic tendencies capacity decreases with increasing consideration an agent's own investments. For *impOwnSpareTime*=0.0 highest support capacity is achieved – agents only strive for high support capacity (*impSupportCapacity*=1.0) and do no care about their contribution level. Contributions even exceed the maximum required level to achieve full support capacity (Figure 2(b)). When contributions of other group members are considered (*impOthersSpareTime*>0.0) random reductions in the contribution level by other agents ("experimentation") trigger a "re-thinking" of investments which in the long run reduces investments (still remaining on a high level). For *impOwnSpareTime*>0.0 contributions always increase when *impOthersSpareTime* increases - it becomes more attractive to invest if others do not invest. The Gini index of contributions (see figure 2(c)) increases with increasing *impOwnSpareTime*. Likewise it decreases with increasing *impOthersSpareTime*. Highest inequality is observed in areas where no support capacity is generated – mainly zero contributions but isolated and unsuccessful experimentation (random decisions). In summary, the sensitivity analysis shows that model plausibly describes the macro level outcomes of micro level preferences assigned to the agents. Furthermore, suitable parameter ranges for further investigations may be identified.

For the second set of results we do an in-depth analysis of two different settings derived from the sensitivity analysis and include social conformity. We consider a heterogeneous population that is composed of 60% of rather altruistic agents (*impOwnSpareTime*=0.1, *impOthersSpareTime*=0.3, named group 1) and 40% of rather egoistic agents (*impOwnSpareTime*=0.3, *impOthersSpareTime*=0.1, named group 2). In other words 40% of the population have preferences that if followed by all of the population would not yield substantial levels of the public good (see figure 2 a). Agents are distributed to the 20 simulated neighbourhoods such that the 60/40 ratio of preference sets persists within the neighbourhoods. Furthermore, agents are embedded in are social network that links each agent randomly to 5 agents within its neighbourhood group and to 5 agents with the same preference set randomly selected from whole population.

Figure 3 illustrates the temporal dynamics of two individual simulations that differ only in the agents' preferences for the goal *maxSocialConformity*. For scenario 1 we set *impSocialConformity*=0.0 for all agents, for scenario 2 the value is set to 0.2. All other initialisations including the social network topology and the random seed initialisation are identical for both runs.

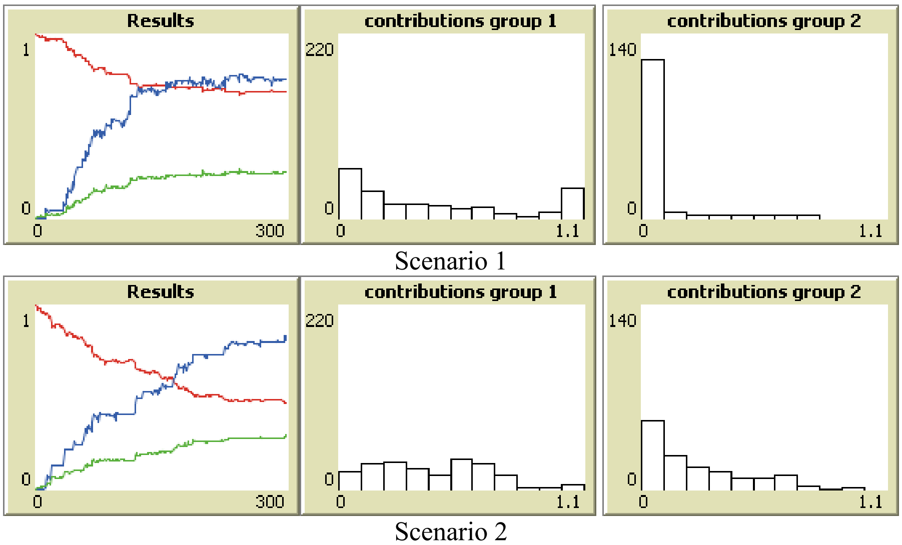

Fig. 3. Average support capacity (blue), average contribution (green), Gini index of contributions (red) over time and histograms of the contributions for group 1 (altruistic) and group 2 (egoistic) at the end of the simulation. Scenario 1 for *impSocialConformity*=0.0 and scenario 2 for *impSocialConformity*=0.2.

The left column of the diagram set in figure 3 shows that in both scenarios substantial levels of the public good are generated (blue lines). With the inclusion of social conformity, mobilisation is slower but the achieved support capacity is slightly higher (0.81, average contribution level 0.29) than without social conformity (0.75, average contribution level 0.25). The slower mobilisation in scenario 2 may be explained by the ongoing social adjustment process of the agents when trying to achieve social conformity. The success of this process is obvious when comparing the development of the Gini indices of contributions (red lines) between the scenarios: In scenario 1 the Gini index settles at 0.7 after 200 simulation steps while in scenario 2 the index continuously decreases to below 0.5 at the end of the simulation. Further insights are provided by the respective histograms of agent contributions: In scenario 1 a big majority of group 2 remains passive (contributes 0.0). This is compensated by a large number of agents in group 1 with extremely high contributions (36 agents contribute 1.0). In scenario 2 contributions are more evenly distributed between agents. This effect not only exists within the groups but also between the two groups (group 2 provides substantial contributions in scenario 2).

In the work reported here we demonstrated the influence of agent goal preferences at the micro-level on the macro-level provision of a public good. The sensitivity analysis provided a first successful validation of the model and allowed extracting plausible parameter ranges for further in-depth analysis. In comparing two individual runs we were able to investigate the interplay of the agents' social orientations and their preference for social conformity on their efforts to provide a collectively desired public good. In the considered runs agents are heterogeneous in terms of their social orientations and in terms of their respective embedding in a common social network. We showed that inter-group coordination based only on social orientation (scenario 1) proceeds faster than with the inclusion of social conformity tendencies of the agents (scenario 2). However, when agents strive for social conformity in addition to following their social orientation, the inequality of contributions is substantially decreased, the level of the provided public good rises further, and even agents with egoistic preferences moderately contribute to the provision of the public good.

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