Social Motives in Network Formation: An Experiment.

Dennie van Dolder and Vincent Buskens

Abstract—**Literature on network formation typically assumes that people create and remove relations as to maximize their outcome in the network. It is mostly neglected that people might also care about the outcomes of others when creating and removing links. In the current paper, we develop an experiment to investigate whether people show preferences that involve the outcomes of others during network formation. We find varying evidence for effects of social motives in the settings we compare in the experiment. In the final part of the paper, we discuss some explanations for these findings.**

I. Introduction

People form relations and these relations constitute a network. Within this network people maintain different positions, and this is not without consequences. Labor market outcomes, job satisfaction, and health outcomes are just a few examples of outcomes that are influenced by a person's network position [1]-[4]. Given that network positions matter and that people have an idea of the pattern of relations between others, it is argued that they try to maneuver themselves into optimal positions [5], [6]. It is typically neglected that in the complex system that networks provide a person's decisions do not only influence one's own position and outcomes in the network, but also the positions and outcomes of others. Experimental evidence indicates that people manifest social motives in many decision situations. Next to their own outcomes, they take the outcomes of others into account [7]. Given that people manifest such motives in a wide range of decision situations [8]-[10] and that in a network their decisions influences the outcomes of others, the question becomes to what extent social motives play a role in network formation.

Applying the assumption of purposive behavior, game-theoretic models of network formation have been developed [11], [12]. These models allow for investigation of stable networks and the formation process leading to these networks. Experimental tests of the game-theoretic models indicate that the models predict well when the outcomes are equal for all actors in the predicted networks [13]-[15], but that the predicted networks are seldom observed if they provide unequal outcomes over actors [13], [14], [16]-[18]. Most of the theoretical models to predict network dynamics assume myopic self-interest on the side of the actors. Myopic implies that actors do not take into account that their decisions influence the incentives of others to invest in specific relationships, which likely causes further changes in the network. Due to the complexity of interdependencies that exists within networks this assumption is difficult to relax. Relaxing the assumption of self-interest is less problematic, and seems reasonable given that subjects are found to display social motives in a wide range of decision situations. Therefore, relaxing the assumption of self-interest is the dominant approach to explain the experimental findings in network experiments [13], [17], [18].

Social motives can be operationalized in many different ways [19], [20]. A large part of the literature focuses on two specific motives, namely, the concern for others absolute outcomes, often denoted as a concern for efficiency in the economic literature [21], [22], and a concern for equality [10], [23]. Past network formation experiments provide evidence that both efficiency and equality concerns are of importance in network formation. It has been reported that subjects are more likely to change relations if efficiency, in terms of the sum of outcomes over all actors, is low [18] and if networks provide unequal outcomes [13], [18]. Next to this, it has been reported that subjects try to minimize their disadvantage relative to other subjects in the network [18]. In the present paper, we investigate to what extent we can understand individual decisions of subjects in a network formation experiment by assuming that they are myopic but in addition to selfish preferences also have preferences for efficiency and equality. These results might differ compared to other contexts because the effects of one's decisions during network formation often have heterogeneous effects. Creating or deleting a link might increase the payoffs of some, while decreasing that of others. Similarly, it may increase equality between some actors, while decreasing equality between other actors. These inherent complexities in network formation can be expected to reduce the salience of social motives.

II. Theory

The prominent approach in the literature to construct non-standard utility models is assuming that actors take the outcomes of others' into account in a specific manner. Kelley and Thibaut [24] already provided several ways in which actors might make such a transformation, stating that actors may try to maximize own outcomes, others' outcomes, the sum of own and others' outcomes or try to maximize or minimize the difference between own and others' outcomes.

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D. van Dolder is master student at the Nottingham School of Economics, University of Nottingham (e-mail: d.vandolder@gmail.com).

V. Buskens is with the Department of Sociology / ICS, Utrecht University, Heidelberglaan 2, 3584 CS, Utrecht, The Netherlands (e-mail: v.buskens@uu.nl).

This work sparked a large stream of literature on the role of social motives. Two forms of these social motives dominate the literature. The first is a concern for the absolute outcomes of others, or *efficiency*, next to a concern for own outcomes. Starting with [25], this motive has received considerable empirical support in the literature. The second is a concern for equality, which has received considerable attention in the psychological literature on justice and equity [26]. Recently, equality arguments have also been applied to explain major patterns in data deriving from experiments in economics [8], [10]. If we add these two social motives to the utility related to one's own outcome, the utility function of an actor i can be written as $U_i = W_{i1} \cdot (\textit{Own outcome}) + W_{i2} \cdot (\textit{Efficiency}) + W_{i3} \cdot (\textit{Equality})$, where W_{i1} represents the weight given by actor i to the own outcome, W_{i2} is the weight given by actor i to efficiency and W_{i3} is the weight given by actor i to equality [23]. While maintaining the assumption that actors change links in a myopic way, we can formulate the following three hypotheses if actors value all three motives positively:

H1. An actor is more likely to create or maintain a link, the more this link increases his or her outcomes in the network;
H2. An actor is more likely to create or maintain a link, the more this link increases the efficiency in the network;
H3. An actor is more likely to create or maintain a link, the more this link increases equality in the network.

In order to contrast the different motives, we distinguish four contexts for which we know that following only selfish motives can run against one or both social motives distinguished above. We apply a truncated version of the connections model as well as the co-author model [11]. Using two levels of linking cost for each of the models gives us four contexts in total. In both models links are considered to be undirected and require consent of both actors involved. In other words, actors i and j have to agree to form the link between them. We denote the number of direct contacts of actor i with n_i, and the number of contacts to which actor i is not directly but indirectly connected through *one* intermediate contact with n_{2i}.

We start with the connections model truncated at distance 2 with low linking cost [11]. We denote the value of a direct contact by α, the value of an indirect contact at distance two by β, and the linking cost by c. The payoff $p_i(g)$ of actor i is given by $p_i(g) = \alpha \cdot n_i + \beta \cdot n_{2i} - c \cdot n_i = (\alpha - c) \cdot n_i + \beta \cdot n_{2i}$. We use $\beta > \alpha - c > 0$ (specifically, $\alpha - c = 1$ and $\beta = 5$) for the first experimental condition. We term this condition ***CONLOW,*** where "low" indicates the relatively low linking cost. In this condition, a self-interested actor prefers to connect to actors who have many relationships. By connecting to an actor with many links, one gains valuable indirect contacts. Such behavior is also beneficial for the group as a whole; the star network not only being consistent with selfish utility maximization, but also being the efficient network in this condition [11]. Equality, however, is low in the star network because in centralized networks the central actors are considerably worse off than the less central actors. Therefore, although one would expect star networks in this context under purely selfish motives (possible supplemented with efficiency motives), equality preferences can prevent actors from reaching these star networks.

In the second connections model condition, $\beta > 0 > \alpha - c$ (specifically, $\alpha - c = -1$ and $\beta = 5$). We term this condition ***CONHIGH***. In this condition, a self-interested actor still wants to connect to actors who have many connections in order to maximize the number of indirect contacts. Now, however, actors no longer benefit from direct connections and (assuming myopic self-interest) structures as the star, which is still the most efficient network, are not anymore stable for self-interested actors. The reason is that the central actor in the star is not anymore prepared to keep the links. Therefore, we expect to end up in more equal networks if actors are self-interested, and the contrast between own outcomes and equality decreases. On the other hand, a contrast between own outcomes and efficiency arises. If an actor attaches a high value to efficiency he or she might be willing to take a central position, even though this causes negative own outcomes and pronounced inequality. Note that, starting from an empty network, purely myopic self-interested actors will not initiate any links. In this sense, the empty network is stable. Other stable networks are networks in which each actor has at least two links, and are thus characterized by circle shaped structures [11].

In the co-author model [11], there are, opposite to the connections model, negative externalities from links others have. The payoff $p_i(g)$ of actor i in the co-author model is given by

$$p_i(g) = \sum_{i \neq j | ij = 1} \left[\frac{1}{n_i} + \frac{1}{n_j} + \frac{1}{n_i \cdot n_j} - c \right] = 1 - n_i \cdot c + \left(1 + \frac{1}{n_i} \right) \cdot \sum_{i \neq j | ij = 1} \frac{1}{n_j}$$

if $n_i > 0$ and $p_i(g) = 0$ if $n_i = 0$. Here, ij indicates that there is a link between actors i and j. The payoff shows that the added value for i of a link with j decreases with the number of links j has.

In the first co-author condition, we set linking cost $c = 0$. We term this condition ***COALOW.*** As is shown in [11], the network that maximizes the sum of group outcomes consists of separate pairs of connected actors if the number of actors is even. In the case of an uneven number of actors the optimal network consists of a three-actor line and separate dyads between the remaining actors. The network formation process resemblance a prisoners' dilemma or public good game; i.e., it is in the interest of the ego that alter does not create more partnerships, and collectively it is best if no actor builds more than one link. Each actor, however, has the incentive to create more links. Because each actor has the incentive to create as much links as possible, the situation will cascade towards the complete network, which makes everybody worse of in the long run. So although the network with all separate dyads is efficient and equal, it is not in correspondence with myopic self-interest. Adding additional links in the network decreases efficiency faster than that own outcomes of the actors involved increase. If actors value efficiency, this might facilitate the formation of mutually exclusive dyads, and thereby resolve the social dilemma.

In the second co-author condition, we set $c = 0.3$, and term this condition ***COAHIGH***. In this case the efficient and equal structure of mutually exclusive dyads is stable. Simulations in which actors, in a random order, were allowed to add and remove links indicated, however, that under myopic self-interest it is very unlikely that people actually reach dyads in large groups. The reason is that there are other inefficient stable networks that might be reached because in the beginning of the process individual actors try to become better off than in the dyad by connecting to multiple others.

III. Experiment

In order to test our hypotheses we ran a computerized experiment in which subjects anonymously interacted with a given number of other subjects in a "network formation game." Most network formation experiments aim at testing macro-level predictions. Since our aim is not on the macro, but rather on the micro-level, we diverged from common practices within such experiments. First, we allowed subjects to change their relations in *continuous time* with complete knowledge about the current links present in the network. This was realized by instantaneous updating of all screens as soon as a link was changed. Most experiments use a discrete time linking protocol that only allows subjects to change their entire subset of linking decisions at *discrete times*, without knowing what others are doing [13], [14], [17], [18], [27]. It has been reported that such a process causes coordination problems [14], [17], which makes this approach less optimal for the analysis of individual decisions, because individual decisions can be strongly affected by unobservable expectations about others' decisions.

Second, we decided to calculate and award payoffs in continuous time, and also continuously update information on these earnings this on the screen. The alternative is to calculate payoffs at discrete points in time [14], [15]. In such an environment, although subjects continuously make decisions, payoffs are only awarded at certain time intervals; the position that the subjects maintain at these time points determines their payoffs, the positions that they maintain in between are basically irrelevant. This method can be considered suboptimal when one is interested in individual decisions, because there is no *direct* incentive attached to link changes, which is crucial for our analysis of decisions as will become clear below.

Third, we allowed subjects to form networks in larger groups than are typically employed. Most experiments use groups of between 4 to 6 subjects, while in our experiment groups are between 9 and 15 subjects. The reason for is that we obtain more individual decisions than we would observe in smaller networks, because it is much more difficult for subjects to reach a network in which everyone is satisfied with the current position. The disadvantage of having fewer networks is not that problematic because we do not test hypotheses at the macro-level and we control for dependence of observations using a multi-level approach.

Fourth, we conceptualize links as being two-sided. Both parties have to agree for a link to form. This makes our analysis of individual decisions slightly more complex, because there are now two people deciding on the creation of a link. Still we decide for this approach because most theoretically interesting relations, such as "friendships, co-authorships in research papers, collaboration between firms in R&D, links between buyers and sellers, and free trade agreements between nations" [28, p. 199] can be considered two-sided.

Our experiment was programmed and conducted using z-Tree [29]. Fig. 1 shows an example of a screen subjects saw in this case in the ***COAHIGH*** condition. In the experiment, subjects were depicted on the screen. Each subject saw him or herself depicted as a (blue) hexagon, while he or she saw the others depicted as (black) circles. This allowed the subjects to clearly distinguish between themselves and the other subjects. A subject could propose links and delete existing proposals for links by clicking on the other subjects. We only considered a link present if both subjects agreed on this, a proposal thus had no effect on payoffs; it merely provided a way in which a given subject could show another subject his or her interest in forming a link. A proposal was depicted as a blue directed arrow from the given subject, making the proposal, to the other subject. Because proposals did not matter in determining actual network position and payoffs, a proposal was only visible for the two subjects involved. Given that a proposal existed, it was possible for a link to form. In a situation in which a given subject had made a proposal for a link to another subject, this other subject could create the link by clicking on the former subject. A link was depicted as a thick double-headed arrow, colored blue on the screens of the subjects involved in the link and black on the screens of the other subjects.

In the upper right corner of the screen the amount of seconds left in the current network formation round was shown. The scenario and round were also stated at the top of the screen. The ordering of payoff functions differed between sessions because learning effects might occur. The scenario corresponded with the explanations of the specific payoff functions in the instructions. In the result section we investigate whether placing of a payoff function in the experiment influences our results. All subjects participated for three rounds in all four conditions. First, they participated in a trial round in which they could get some experience with network formation without it influencing their actual monetary payoffs. After this, they played two "real" rounds that did affect their monetary payoffs. Trial rounds lasted 90 seconds while the paid rounds lasted 300 seconds. The

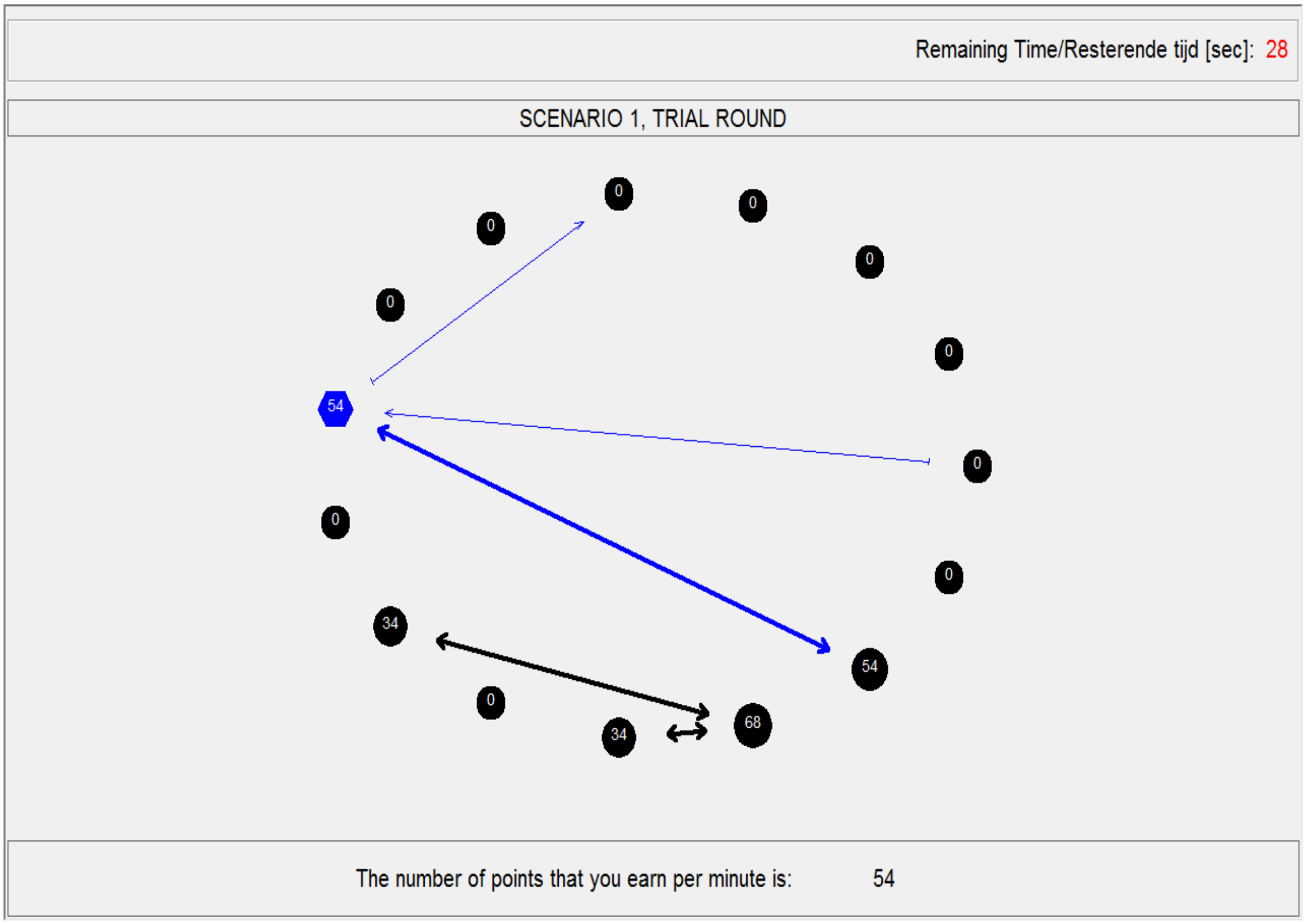

FIGURE 1

SCREEN SHOWN DURING THE NETWORK FORMATION EXPERIMENT IN THE ***COAHIGH*** CONDITION

information on the scenario and round allowed subjects to easily locate where they were in the experiment at any point in time. After each round subjects were reshuffled on the screen, insuring anonymity between rounds.

The screen also provided insights in the payoffs that subjects earned. While payoffs were calculated per second they were shown per minute because the payoffs per second were very low. Subjects were clearly explained that payoffs were calculated per second and that if, for example, they would earn 90 points per minute for 10 seconds they would receive 10/60 times 90 = 15 points for these 10 seconds. The payoff that a given subject earned per minute was shown at the bottom of his or her screen and in his or her blue hexagon. The number of points that the other subjects earned were shown in the black circles representing these subjects on the screen. Next to this, the size of both the hexagon and the dots changed with the number of points that the subjects earned: larger in size meaning that the particular subject earned more points per minute. These shifts in sizes were made to allow subjects to take the outcomes for others into account in a more intuitive way than looking at their numeric outcome. The subjects only saw what they and the others were earning individually at that point in time and did not see any aggregate measures on sum of outcomes for the group or equality of outcomes.

In total we ran 16 experimental sessions, each of them having between 9 and 15 subjects. Subjects were contacted using the Online Recruitment System for Economic Experiments (ORSEE) [30] to participate in a study called "Let's Connect." They were offered on average €16 but were informed that the exact amount depended on their own and others' decisions. A total of 227 subjects subscribed for one of the 16 sessions, of which a total of 205 subjects participated. The exact number of subjects in a session was partly determined by chance. We tried to get as many subscriptions as possible (maximum of 16) and every registered subject who showed up in time was allowed to participate. The majority of subjects were students at Utrecht University from a wide range of different disciplines and nationalities, although non-student subjects also participated. Subjects were between 17 and 60 (mean age being 21.6), 68.3% female, and 78.5% Dutch. Complete instructions are available from the authors.

IV. METHODS AND MEASUREMENT

The network formation experiment generated a tremendous amount of data. In total we collected 117,715 decisions (clicks by subjects on other subjects) made by the 205 subjects in all network formation rounds. In our analyses we neglect all decisions made in the trial rounds and all decisions to create or remove proposals, because these decisions did not influence actual payoffs. After excluding these cases we are left with 67.917 decisions.

Next to being large in size, the dataset is rather complex. Subjects were allowed to create and remove links in continuous time. In order to be able to analyze this data statistically we impose a number of assumptions to transfer the clicks into analyzable decisions. We do not pretend to know what subjects are doing if they do not make changes. It can be that they are evaluating their relations and actively deciding not to do anything; it can also be that they are simply distracted. If a subject creates or removes a link, however, we assume that this signals that the link is under *evaluation*. Due to the complexity of the game it is unlikely that people will calculate the effect of a change for themselves and others accurately before clicking. It is much easier, and almost without cost, to make the change and evaluate whether or not the result is satisfactory.[1] Therefore, we assume that if a change is made in the network, the subject(s) involved evaluate the situation with and without the link and choose from these two situations the best one according to their preferences. By making this assumption we can reorganize the data into a series of *pairwise comparisons*.

If a change leads to an undesirable result, it can be reversed immediately. Naturally, such a reversal must be made within a short time period after the initial change. If a person removes the link multiple seconds or even minutes after the initial change, this decision cannot reasonably be interpreted as the result of a paired comparison of the situation with and without the link, because many other changes will probably have happened in between. We, therefore, analyze whether or not a change is reversed *within a short evaluation period, after the initial change*. The computer program observed time in discrete seconds, so we chose the period in which a change could be reversed as either being the second in which the change is made or the consecutive second. In the result section, we investigate whether increasing the length of the evaluation moment matters for our results.

When a subject *removes a link*, the *pairwise comparison* process and its interpretation are quite straightforward. If a subject removes a link and does not reverse this decision this indicates that this subject prefers the situation without the link to the situation with the link. If a subject removes a link and reverses this decision this indicates that the subject prefers the situation with the link to the situation without the link.

[1] This assumption was supported by several short talks with subjects, who indicated that they made their decisions on a trial and error basis. It also seems reasonable because the blank sheets we provided the subjects so that they could make notes did not contain any calculations on how specific network positions would transfer to outcomes.

When a subject *creates a link*, both subjects involved in the link can decide to reverse it because mutual consent is needed. If the creation of a link is reversed, this indicates that the subject that reverses the link prefers the situation without the link to the situation with the link. If the link is maintained, however, this signals that *both* subjects involved in the link prefer the situation with the link to the situation without the link. In our model we cannot add variables for both subjects because in all other cases there is only one subject who makes the decision. Therefore, we have to somehow combine the variables over the two subjects or to select one subject as the "crucial" decision maker. We decided to take the person who initialized the actual change as the crucial decision maker. Given that many changes are going on simultaneously on the screen, it is unlikely that the subject who did not initialize the change is focused enough on this particular change to undo the change quickly enough. The subject who initializes the change, on the contrary, will immediately notice the change it causes and can be expected to undo the change if it is not satisfactory. Alternatively, we also considered taking averages on independent variables over both players, but this is problematic. A profit of 2 for one actor and 0 for the other from a link, would lead to the same average as an increase of 102 for the one actor and -100 for the other from a link. We would, however, expect that the latter link is much less likely to be maintained than the former, because the actor with -100 would be far less likely to maintain the link. Therefore, we investigated whether it would matter if we took the person who earned the least from the link as the crucial decision maker. In the analyses this decision mainly mattered for the connections model conditions. We will elaborate on this after the discussion of the main results.

In order to analyze these paired comparisons statistically, we apply a random utility model for paired comparisons [31], [32]. It is assumed that a subject assigns a utility U to the situation with and the situation without the link. The probability that the situation with a link is chosen over the situation without a link can then be written as

$$\Pr(U_{link} > U_{nolink} \mid z_{link}, z_{nolink}, \beta) = \Pr((z_{link} - z_{nolink})'\beta > \varepsilon_{nolink} - \varepsilon_{link}),$$

where z is the vector of values for the independent variables with and without the link and β the vector of estimated coefficients. If we assume that the random terms are "independently and identically distributed with the type I extreme-value distribution" [33, p. 59], the probability that a subject chooses having the link over not having the link is given by

$$\Pr(U_{link} > U_{nolink} \mid z_{link}, z_{nolink}, \beta) = \frac{e^{(z_{link} - z_{nolink})'\beta}}{1 + e^{(z_{nolink} - z_{link})'\beta}}$$

This corresponds to a binary logit model in which the independent variables are the differences between the two options; having the link and not having the link. Because our independent variables are differences between the two situations (i.e., with and without the link), main effects of variables that do not vary between these situations (such as personal characteristics) are not identified.

We run separate analyses for each experimental condition. Also, we take into account that the observations are nested. Decisions are nested within directed dyads, which are nested within decision makers, which are nested within sessions. In order to take this into account we run hierarchical four-level logistic regression models in which we estimate random intercepts at each level [34]. By focusing on one decision maker as explained above we neglect some dependence between observations. In particular, we neglect dependence related to the other subject in the dyad. Alternative specifications of the random effects did not change the results.

Our dependent variable is whether or not a link is present after the evaluation moment. The three main independent variables that are part of the vector z indicated above are own outcome, efficiency, and inequality. Own outcome refers to the subject's monetary payoff in a specific network. Efficiency we compute as the sum of outcomes for the others:

$$Efficiency_i = \sum_{j \neq i} p_j \ .$$

We leave out the own outcome in the calculation of efficiency to achieve a clear distinction between self-interest and a concern for efficiency. For own outcome and efficiency we compute the natural logarithm of the differences between the situation with and without the link, because the distributions of these variables have long and thin tails.

Finally, we operationalize equality:

$$Equality = -1 \cdot \sqrt{\frac{1}{N} \sum_{i=1}^{N} (p_i - \overline{p})^2} \ ,$$

i.e., −1 times the standard deviation in outcomes in the group. The standard deviation provides a measure for inequality, and reversing it thus provides a measure for equality. We use the standard deviation because it has some naturally appealing qualities. First, it does not heavily rely on *own payoffs* of the subject. Some other measures do and because we want to avoid strong correlations between our variables we chose a calculation of equality that was not heavily dependent on own outcome. Second, the standard deviation increases more sharply if differences become higher. While in some cases this is a drawback, because it makes the standard deviation sensitive to outliers, we believe it is a positive aspect in our current study. It seems likely that subjects will not care too much about small differences in payoffs, independent of their motives, but these motives will be increasingly important if inequality increases.

Although we take care of the clustering of observations and we have chosen payoff functions in which all three utility arguments can hardly be optimized simultaneously, it is questionable whether our analysis can control for all path dependencies of the network formation process and the correlations between some of the independent variables. Therefore, we also ran a baseline simulation model in which actors myopically update their ties in order to maximize their payoff. Parameters in this simulation such as for payoffs and network size were chosen as in the experiment. Actors start from the empty network. On average one hundred times per actor in the network, a decision maker was randomly chosen to make a decision on one of his (also randomly chosen) ties. This decision maker decides whether or not to change the randomly chosen tie by comparing his own outcome in the situation with and without the tie. The agent decides based on his own myopic self-interest, while we add some normally distributed noise as well as a positive bias to stick to the change as we find it in the experiment (see below). The parameters for the amount of noise and bias are chosen to resemble the results that we find in the experiment. We ran 160 simulated sessions per condition to reduce the standard errors for these baseline estimates compared to the estimates from the experiment. We varied network size in de simulations from 11 to 14. Finally, we analyzed the simulated data in exactly the same way as the experimental results to see whether we find effects of efficiency and equality even if we consider myopic actors who are only motivated by their own outcome. We discuss the results together with the experimental results below.

V. RESULTS

The experimental results are shown in Table I. First, we analyze the connections model with low cost (***CONLOW)***. A positive effect implies that a subject is more likely to prefer a network position in which the related independent variable has a higher value than in a network position in which this variable has a lower value, while we always compare networks with one link more or less. To control for whether subjects treat link removals differently from additions, we add the "creation of link" dummy and the constant. The constant indicates the likelihood that a subject recreates a link if the initial decision was to delete it. The "creation of link" dummy indicates the additional effect on the likelihood that a subject maintains a link if the initial decision was to create it. We see that subjects have a tendency to stick to the initial decision. The constant is negative indicating that if the initial decision was to remove a link there is a tendency not to recreate it. The "creation of link" effect is large and positive, indicating that if a link is created subjects have a tendency to maintain it. These effects are largely stable over analyses, and since they do not pertain to our hypotheses, they will not receive further attention.

TABLE I
HIERARCHICAL FOUR LEVEL LOGISTIC REGRESSION ON THE PRESENCE OF A LINK AFTER AN EVALUATION MOMENT IN THE FOUR CONDITIONS

	CONLOW		***CONHIGH***		***COALOW***		***COAHIGH***	
Fixed effects	coeff.	s.e.	coeff.	s.e.	coeff.	s.e.	coeff.	s.e.
Initial decision								
Creation of link	1.737***	.035	1.833***	.036	2.695***	.049	2.402***	.057
Constant	- .482***	.034	-.760***	.038	-.316*	.132	.961**	.368
Payoff influences								
Own outcome	.487***	.012	.477***	.011	.792***	.052	.602***	.027
Efficiency	.014	.009	-.019*	.009	.506***	.057	.611***	.107
Equality	-.073***	.011	-.062***	.010	-.078**	.025	-.060*	.024
Random effects								
Session	.035	.047	.000	.036	.119	.074	.000	.093
Decision maker	.181	.033	.231	.027	.487	.041	.279	.047
Directed dyad	.490	.032	.406	.034	.274	.059	.399	.055
Number of sessions	16		16		16		16	
Number of decision makers	205		205		202		200	
Number of directed dyads	3786		3678		2877		1898	
Number of decisions	21231		20012		14495		8865	
log likelihood	-11246.73		-10483.859		-6960.8121		-4596.5602	

* p < 0.05; ** p < 0.01; ***p < 0.001 (two-sided test)

We see that subjects are more likely to choose for links the more these links increases their own payoffs. Next to this, there is no evidence for the claim that subjects are more likely to create and maintain links the more these links increase efficiency, the effect of efficiency being insignificant. Contrary to our predictions, however, equality has a significant negative effect. This indicates that the more a link increases the equality in the network, the less likely it is to be created and maintained. From the simulation of purely myopic actors, we find small and positive effects for both efficiency and equality. The efficiency effect of the analysis shown is also not significantly different from the effect of the baseline model and the effect of equality is indeed a significant deviation from a model that assumes myopic actors in the opposite direction from our expectation.

In the model for ***CONHIGH***, we see that also in this condition subjects tend to create and maintain links that increase their own payoff, and decrease the equality in the network. Next to that, we now find that efficiency actually seems to have a negative significant impact on the creation and maintenance of links in the network. In the simulation, we again find small positive effects for efficiency as well as equality. So in both conditions we find support for hypothesis 1; subjects are found to be more likely to create and maintain links that increase their own outcomes in the network. Hypothesis 2 is not supported; efficiency seems to have no effect (***CONLOW***) or even a small negative effect (***CONHIGH)*** on the creation and maintenance of links in the network. Contrary to our expectations (hypothesis 3), subjects are more likely to create and maintain links that decrease equality. This contradicts the idea that in network formation subjects strive for equality. We should be careful, however, in interpreting the effect of equality as indicating that subjects try to attain inequality. Given past research in other decision making tasks, the argument that subjects strive for inequality seems unlikely. We should keep in mind that in our experiment own outcome, efficiency, and equality are all correlated in specific ways. In the theoretical section we discussed that if subjects would behave according to self-interest, or self-interest combined with a concern for efficiency, they would jump at the opportunity to create links to well-connected others. Although our simulations show that the effect we find cannot be explained just by correlations between the variables if actors would strive purely for their own short-term interests, subjects might use more complex decision rules to determine their set of links than we have introduced in our model. Still, if the argument that subjects have a strong preference for networks that provide equal outcomes was correct, as has been suggested in past literature, we would expect that it would have trumped these other considerations. It did not, and therefore we can take our findings as reasonable arguments against a prominent role of a preference for equality in these network formation conditions.

Now we turn to the co-author model. Similar to the situation in the connections model we find positive effects of own outcomes and a negative effects of equality. However, also in the simulations for the co-author models, we find negative effects of equality even if the actors just follow myopic self-interest. Therefore, these effects do not provide evidence that subjects in the experiment strive for inequality in outcomes. Contrary to the connections model, we find significant positive effects of efficiency on the creation and maintenance of links in the network. This provides support for hypotheses 1 and 2. It should be stressed that the effects of efficiency relative to own outcomes, next to being significant, are quite high in the co-author models. In the simulation, we also find positive effects of efficiency, but these are considerably smaller in size than the effects of the own outcomes. The relative effect of efficiency compared to own outcomes is therefore significantly larger in the experiment than in the simulation with myopic actors. A possible explanation is that subjects might use a more complex decision making protocol than we have assumed thus far. If subjects care about their *long-term* self-interest next to their *short-term* self-interest, this is likely to cause high estimates for efficiency in the co-author model. This is the case because in the co-author model efficiency coincides with *long-term* self-interest, and both these motives conflict with *short-term* self-interest. The relatively large effect of efficiency should thus not be purely interpreted as a concern for others, but rather as also containing a *non-myopic* concern for own outcomes. There again is no support for hypotheses 3: effects of equality are found to be similar to the simulation results with myopic actors.

As indicated above, we had to make some assumptions before being able to perform the analyses described above. We now discuss some additional analyses we performed to investigate the robustness of our results. In all these robustness analyses, the positive effect related to own outcome is positive and highly significant. First, we investigated whether it mattered at what point in the experiment a specific condition was played. Remember that all subjects participated in all four conditions and that we varied the order of the conditions. Most effects are independent of the timing of the condition within the experiment, although the negative effect of equality is not consistently significant in the co-author model conditions. The most striking variation, however, is that the positive effect of efficiency in the co-author model conditions disappears when these conditions are the first in the experiment. This strengthens the story that the positive effect of efficiency found in the co-author model conditions might be due to long-term self-interest, assuming that subjects need some experience in order to be able to foresee what is in their long-term self-interest. In a first condition, it is much more likely that the subjects run into the social trap that exists in the co-author model and establish too many ties. Only after some experience they are able to avoid this social trap.

Second, we investigated whether the length of the evaluation moment affected the results. Originally this length was set to be one second after the initial change; we investigated whether it mattered if we assumed an evaluation moment of 2, 3, 4, or 5 seconds respectively. It turns out that in the co-author conditions, the negative effect of equality loses significance if we lengthen the evaluation time. This is an additional indication that we should not interpret the negative effect of equality too strongly.

Third, in the original model we assumed that if a link was kept the subject who initialized the actual change the crucial decision maker. We tried an alternative model in which the subject who earned the minimum payoff from the link was chosen as the crucial decision maker because this subject was the subject with the largest incentive to remove the link. Changing this assumption gives a positive effect of efficiency in both connections model conditions. Given that the payoff of the second decision maker in the link is part of the efficiency variable, we cannot rule out that this positive effect is due to a misspecification of the crucial decision maker. Finally, changing the assumption removes the negative effect of equality (***COALOW***) or even returns a positive significant effect of equality (***COAHIGH***) in to co-author conditions. This strengthens again the claim that the negative effect of equality cannot be interpreted as support for the idea that subjects really strive for inequality.

VI. Conclusion and Discussion

We investigated the role of social motives in network formation. Past laboratory experiments have indicated that subjects seem to care about efficiency, in terms of the sum of outcomes of the group as a whole, and equality when forming links in a network. We investigated whether subjects indeed apply these motives when deciding on links in a network and whether the behavior was stable over different contexts.

As predicted, subjects were found to be more likely to create and maintain links that increase their own outcomes in the network. When it comes to efficiency and equality results are less clear. For efficiency we find no evidence that subjects care positively about efficiency in the connections model, while we find quite high estimates of the concern for efficiency in the co-author model. The findings that subjects are more likely to create and maintain links that decrease equality seem consistent over different contexts. Although we had put effort in disentangling the different motives, it cannot be completely ruled out that these findings might be a side effect of self-interested behavior of the subjects. Our simulation results show that this last explanation is a likely candidate for the co-author model conditions but less for the connections model conditions. Therefore, it might be that in these conditions competition plays a dominant role and that actors indeed are trying to outperform each other rather than just trying to optimize their own benefits. But also alternative explanations might be possible that involve more complex decision making than myopic best-reply behavior, for example, an overly simple decision heuristic to connect to well-connected others.

In the co-author model conditions, *short-term* self-interests conflict with efficiency, but also with *long-term* self-interests. Here, we observe that subjects are not more likely to create links that increase efficiency at the beginning of the experiment. This suggests that in these cases, the fact that links that increase efficiency are more likely to be formed in later parts of the experiment might be due to subjects learning to foresee what is in their *long-term* self-interest instead of a concern for others. Therefore, it seems that our findings certainly for the co-author model can be reasonably explained by the assuming (non-myopic) self-interest on the side of the subjects.

So how can we explain that concerns for efficiency and inequality do not (or not in the predicted direction) play an important role in network formation? A first explanation is the complexity of the situation. In a two-person setting, or the multi-person setting that is provided by a public good game, ones own choices have straightforward consequences for the others; either positive or negative. In a network this is not the case, which makes it more difficult for a person to assess whether a choice is in line with his or her personal motives. What should one do if one cares for others' outcomes, but the outcomes for some others increases while that of others decreases? Or if one cares about equality but the equality between some increases while the inequality between others decreases? Such considerations are complex and might hamper the role of social motives in a network context.

A second explanation for this finding is the responsibility-alleviation effect [36]. This effect implies that if a person can shift the responsibility for an outcome to third parties he or she will be less likely to display pro-social behavior. As Charness states, this can be an important factor in a situation of "substantial personal interaction" (p. 375), of which networks are a natural example. In a network, a number of actors all influence the results. Even if a person would try to increase equality it is likely that the choices of others will undo this, either intentionally or unintentionally. Realizing this, actors will likely focus on their first interest, namely to achieve high outcomes for themselves. Evidence for the role of responsibility-alleviation can be seen in the finding that in the network formation experiment of [18] subjects only seem to dislike when they earn less than others, and not when they earn more than others. In two-person situations and simple multi-person situations such as the public good game, subjects tend to dislike inequality both if they earn less than others and if they earn more than others [10]. This indicates that in more complex situations pro-social motives decrease in importance, and self-interest dominates.

In addition, we know from earlier research on social motives [23] that there are always some subjects who specifically strive for being better off than other subjects. Although the proportion of such subjects is mostly small even a few might cause a negative effect of equality if other subjects are not really striving for equality. Also concerning efficiency one might argue that subjects vary in the extent to which they care about this. To investigate these ideas further, we will extent our analyses in future research by also measuring at the individual level the extent to which subjects care about efficiency and equality. These measurements can be used to see whether the effects of efficiency and equality differ between different types of subjects.

For the current paper we focused on micro-level decision. In the future, further attention should also be given to macro-level outcomes. We found that our individual decisions can, for a large extent, be explained by self-interest. This brings about the question how this is reflected in our macro-level outcomes. Are the networks that are reached in our experiment more efficient and equal than what we would expect assuming self-interest, as was reported in past experiments? Or is the assumption of self-interest sufficient to explain our macro-level outcomes? An investigation of macro-level outcomes in our experiment is possible, but not unproblematic. When performing such investigations, past research focuses on the efficiency and equality of stable states reached in the experiment and compares these to the efficiency and equality in the predicted stable networks. In our experiment, possibly due to the large group sizes, we hardly ever achieve networks that are stable for multiple seconds. This implies that a different approach must be applied in order to compare the experimental data with theoretical predictions. Still, because we choose by design for a set-up with very few observations at the network level, we will not be able to establish much statistical evidence from our experiment on network level outcomes.

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