Dynamics of Bridging and Bonding in Social Groups: A Multi-Agent Model

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Abstract

Bridging and bonding are concepts that come from social capital discourse. In this paper, we describe a novel multi-agent model of social evolution, called Statistical Evolution of Social Groups (SESG). We use the model to simulate and monitor the generation and evolution of social communities that exhibit bridging, bonding, or a mix of both.

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1 Introduction

We present a general-purpose software system called Statistical Evolution of Social Groups (SESG) to simulate and monitor the evolution of social groups that function in a society. The SESG interface is developed around a notion of functions and parameters that are switchable between the domains of computer science and social science [7]. In our work social science research is used to define functions and arrange these functions in relation to one another. The architecture of SESG has been developed based both on social science and the potential for reverse engineering to discover new social science theories from the observed social phenomenon. In this paper we present an overview of the model and its application to the social phenomenon of bridging and bonding.

The purpose of SESG is two-fold. First, it can be used to model different social science discourses (i.e. the perspectives of scientists-in-discussion on how human social activity works). Here the computer model facilitates theory-building in the social sciences by generating new ways of talking about, visualizing, and representing social phenomena. Second, the model can be used to predict how a given community will evolve. Given initial conditions for machine learning (observing the evolution of a real community for a length of time), the model could then be run with this as a starting point to provide a statistical prediction of some future state. The results can then be validated against data on the real future state of the community.

In this paper we present aspects of the model that we found to be most relevent to bridging and bonding. These aspects involve two sets of functions that describe,

1. A logic for social capital returns and losses that is applicable to every actor
2. A structure of social capital investment

By suitably altering the parameters that control these aspects of the model we can investigate different types of bridging and bonding behavior.

2 Social Capital

The notion of social capital has received considerable scholarly attention in the last fifteen years (see, for example, [8, 4, 5]) and we will not provide a review here. In this paper we take social capital as the access to and/or the presence of markets (formalized social, physical, and human resources) embedded in social structures and cultures [3, 1]. In the model, groups are where these resources are accessed.

In this paper we begin building a framework for interpreting and exploring the dimensions of bridging and bonding as it pertains to how communities evolve. There are two tasks we are embarking on here. First, how do we detect bridging and bonding? Second, what settings and parameters give rise to bridging and bonding in the simulation?

2.1 Bonding and Bridging Social Capital

In a 1998 article, Borgatti, Jones, and Everett formalize a single notion of social capital [2]. Increasing *degree*, the number of relationships an individual has with other people, adds to social capital while increasing *density*, a measure of how related an individual's relatives are, takes away from social capital. For our purposes we wish to distinguish between bridging and bonding as two different forms of social capital [6]. In this case *degree* describes bridging social capital, while lack of *degree* describes bonding social capital. Similarly, *density* describes bonding social capital, while lack of *density* describes bridging social capital. Before we go on, a short sociological description of bonding and bridging is in order.

Bonding social capital exists when actors spend time creating in-groups [6]. This is known as an exclusive form of social capital because where bonding social capital exists there tends to be divisions in the community. To illustrate bonding social capital, Schurrman gives the example of Catholic and Protestant communities in Northern Ireland. Both of these communities have high social capital but it is formed internally and, often, made more salient because there is division between the groups.

Bridging social capital, on the other hand, exists when connections are systematically made across social divisions within a community. The ways in which this activity is constituted is widely debated in the social sciences. Robert Putnam, who is usually credited with originating the notion of bridging and bonding social capital, famously uses the example of bowling in the United States [6]. Bowling was once a social institution that facilitated bridging across a community. This is because of the presence of league play. Today, Putnam notes, bowling is now a bonding activity where groups of friends go to the bowling alley and rarely interact with the other groups. The experience involves one lane and no mixing and matching. On the other hand, league play required switching lanes and interacting with other groups.

3 The Model

In the model, attributes of the entire community (called *macro-variables*) change and evolve through the demarcation of membership. Actors and groups associate or disassociate through three discrete processes: join/accept, stay, or leave[1]. The process is structured by agent preference (called *micro-laws*) and the configuration of resources available at given time to a specific actor.

For the purposes of our model, social capital represents the resource gained and lost through different levels of actor-group-community configurations. Therefore, social capital is the parameter that translates between *macro-variables* and *micro-laws*. Social capital is divided into two parts: investment and returns and losses.

3.1 Social Capital Investment

When an actor spends time in a specific social configuration [2] social capital is invested to maintain that configuration. In the model a social configuration might change because of an actor's action or the activity adjacent to the said actor. In the simulation, during one time-step, and after all actors have engaged the community, *excess social capital*, C_i^E, is calculated for each actor's resulting social configuration. C_i^E is then taken as an input into a set of statistical controls that determine the *action parameters* JOIN (p_+), STAY (p_0), and LEAVE (p_-) (see *Figure 1*):

[1] Later versions of this architecture can represent the ability of the group to expel an actor. However, currently the model only represents the actors choice to leave and to stay in a group.

[2] Here we take 'social configuration' in relation, for example, to actor i to be understood as: (1) number of groups actor i is a member and (2) length of time actor i has persisted in a group compared to other members.

- $p_+ = \frac{A_+}{1+e^{-\rho_+ * \left(\frac{C_i^E}{threshold}-1\right)}}$, where A_+, ρ_+ and *threshold* are constant.

- $p_0 = A_0 * e^{-\rho_0 * \frac{|C_i^E|}{threshold}}$, where A_0, ρ_0 and *threshold* are constant.

- $p_- = \frac{A_-}{1+e^{\rho_- * \left(\frac{C_i^E}{threshold}+1\right)}}$, where A_-, ρ_- and *threshold* are constant.

After the action parameters are determined the *choice parameters*, Act_s and Act_r, are chosen as follows: $Act_s = Maximum(p_+, p_0, p_-)$ and $Act_r = Random(p_+, p_0, p_-)$. Based on the action parameters, Act_s represents the highest probability of joining, leaving, or staying while Act_r represents the actor's *choice* to join, leave, or stay. Act_s and Act_r then feed into a *social capital returns and losses matrix.*

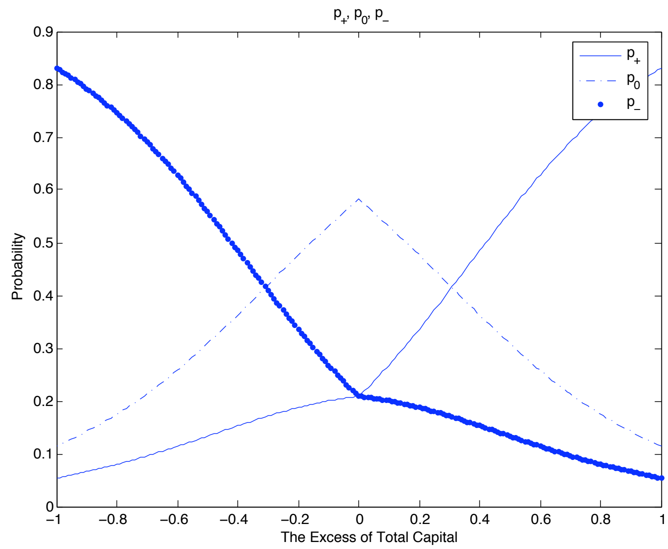

Figure 1: the normalizing probability of the resulting action parameters compared to excess total capital of an actor where $A_+ = A_- = 1.0$, $A_0 = 0.75$, $\rho_+ = \rho_0 = \rho_- = 1.0$, and $threshold = 0.5$.

3.2 Social Capital Returns and Losses

Our experiments focus on the social capital returns and losses function, $f_{\Delta SC}$, to drive the emergence of bridging and bonding behavior. Therefore we have a notion of social capital internal to the model, C_i^S, and an external view of social capital, which is defined by density and degree measures. In this experiment we compare four different configurations of $f_{\Delta SC}$. First, we alter the functional form of the return and loss functions into two approaches: (1) diminishing returns and losses and (2) constant returns and losses. Second, we apply two different approaches to change: (1) *ideal liberalism* and (2) *real liberalism.* These terms are referring to the perception of capital return in two different ideological communities.

3.2.1 Diminishing and Constant Social Capital

Changes to C_i^S are defined as constant returns or losses (C_i^S*$constant$) or dependent on the actor's current C_i^S (return: C_i^S*(1-C_i^S); loss: C_i^S*C_i^S) thus creating diminishing returns and losses.

3.2.2 Social Capital of Ideal and Real Liberalism

The two notions of $f_{\Delta SC}$ are based on stereotypical claims about how capital operates in political economy. First, liberalism as an ideology focuses on the faith that flows of capital create the best economic circumstances and the best social contracts. In this view the rich are burdened with more responsibility and must stay active in society to maintain their wealth. Furthermore, increased effort by the rich will still yield some returns. On the other hand, the poor have the most opportunity to gain but are still burdened losses if they are not active. Second, liberalism as an observed phenomenon is said to create stratification and favor the wealthy. Ideal liberalism we construe as the *rich-have-most-to-lose, poor-have-most-to-gain* social capital change functions and real liberalism as the *rich-get-even-richer, poor-get-poorer* social capital change functions (see *Figure 2*).

Social capital change is based on the action parameters: $f_{\Delta SC}(C_i^S, Act_s, Act_r)$ where C_i^S is the current social capital of actor i. Social capital change is the *perceived* social capital change because Act_s and Act_r are calculated before the actor enters or exits a group.

Rich-have-most-to-lose, Poor-have-most-to-gain			
Act_s \ Act_r	LEAVE	STAY	JOIN
LEAVE	-	-	--
STAY	+	0	-
JOIN	++	+	+

Rich-get-even-richer, Poor-get-poorer			
Act_s \ Act_r	LEAVE	STAY	JOIN
LEAVE	-	-	0
STAY	-	0	+
JOIN	0	+	++

Figure 2: Two approaches to social capital gains and losses (- is loss, - - is large loss, + is return, ++ is large return, and 0 is no change)

4 Results and Preliminary Conclusions

Four total experiments were ran using all four possible configurations of two change logics (real and ideal liberalism) and two change rates (diminishing and constant). The data is analyzed based on degree and density network measures, which are our two litmus tests for bridging and bonding, and through sampling the entire population of agents at one time step and over the period of one hundred time steps (see *Figures 3-6*).

The results raise many questions about the nature of social capital as bridging and bonding and the varying structures it may take. In our data there are signs of the emergence of actors that

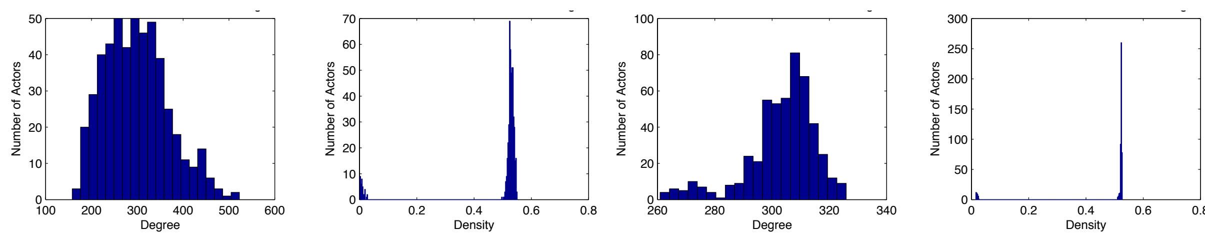

Figure 3: Diminishing returns/ideal liberalism (1 time-step left graphs, 100 time-steps right graphs)

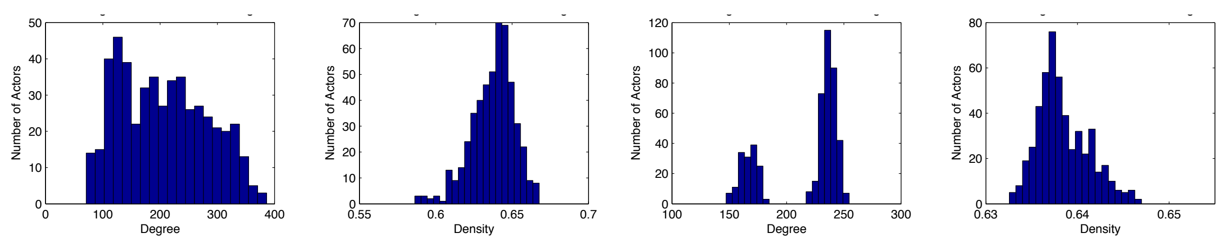

Figure 4: Diminishing returns/real liberalism (1 time-step left graphs, 100 time-steps right graphs)

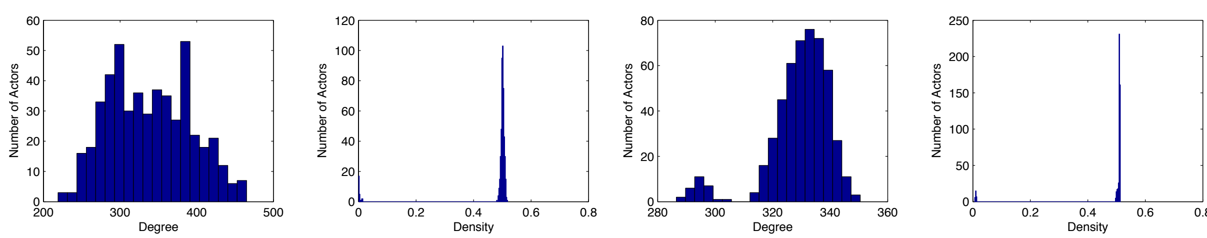

Figure 5: Constant returns/ideal liberalism (1 time-step left graphs, 100 time-steps right graphs)

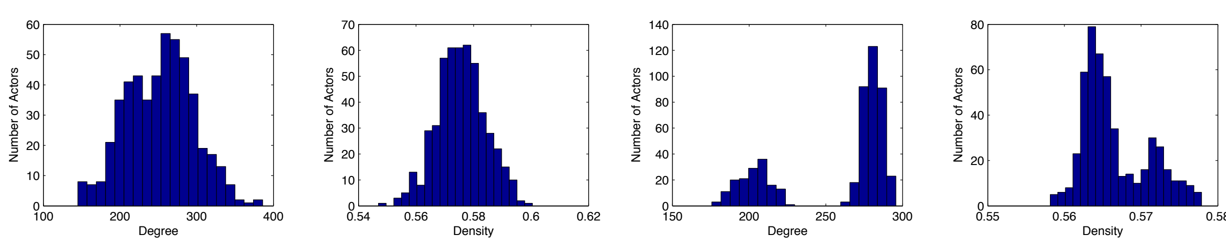

Figure 6: Constant returns/real liberalism (1 time-step left graphs, 100 time-steps right graphs)

bridge and bond especially with a notion of social capital change that fits with real liberalism as implemented in our model. Keeping with the constant returns data, the results show that an ideal perspective on social capital change creates a society with large amounts of bridging and a real perspective creates a society that is mixed with both bridging and bonding activity. Such results require much more analysis. For now the results signal a single question: how does the perception of the value of embedded resources, found in social capital discourse, influence how communities evolve?

A first approach, the one we take here, is to see social capital as binary in form rather than as a unitary measure. This duality needs further theorization which can be greatly facilitated by computational approaches for thinking about how groups evolve based on perception of the value of networks and embedded social groups.

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