Towards an understanding of membership in youth organizations: Sudden changes in the average participation due to the behavior of one individual.

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Acknowledgment: This material is based upon work supported by the National Science Foundation Grant No. NSF PHY 01-40179 and NSF DMS 03-25939 ITR. A.H. thanks the Santa Fe Institute for support.

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Towards an understanding of membership in youth organizations: Sudden changes in the average participation due to the behavior of one individual.

Peer pressure can induce sudden unexpected changes in the behavior of a group. With agent based simulations we study impact of one individual on the behavior of a social network of people. We find that an individual with the largest benefit dominates the group behavior. If that individual happens to have a leadership role, the impact is particularly strong. The model suggests that even if the average benefits for the group changes slowly, the average participation changes suddenly and with a delay. The delay is shorter if the network is subject to large unpredictable outside influences. Further we find that incentives which target leaders are more effective than unspecific incentives. We discuss applications of the model to the dynamics of membership in an agricultural youth organization.

Introduction

In recent years, both the FFA and 4-H have faced concerns on declining enrollment and membership (Hoover & Scanlon, 1991; Talbert & Balschweid, 2004). Decreases in program membership may have widespread effects on local, state, and national chapters and programs through potential losses in chapter funding, lowered teacher salaries due to reduced responsibilities, fewer new position openings, and decreased support and maintenance to current programs (Hoover & Scanlon, 1991). Previous studies on enrollment and retention issues in FFA and 4-H have shown that some contributing factors for not joining agricultural youth programs include peer influence, lack of time or money, lack of student interest as well as a negative image of the organizations and/or the agricultural industry (Croom & Flowers, 2001; Hoover & Scanlon, 1991; Stoller & Knobloch, 2005; Talbert & Balschweid, 2004).

While image has long been a popuplar issue for reduced participation in agricultural youth programs, other factors may also have an impact on student participation. Larson and Seepersad (2003) investigated the different ways in which American adolescents spend their leisure time. They found that 40-60% of high school students are employed part time, an average much higher than other countries. The amount of time spent working after school results in less time the students could dedicate to other pursuits (Larson & Seepersad, 2003). On average, 40-50% of boys and girls daily time is considered free time; the other half being dedicated to chores, jobs, and schoolwork. Of the proposed free time, unsupervised free time is thought to be the riskiest time when adolescents may engage in delinquent behaviors (Riggs & Greenberg, 2004; Roffman, Pagano, & Hirsch, 2001). In comparison, adolescents may choose to utilize free time to partake in the over 400 national, or tens of thousands of local, structured youth programs (Larson & Seepersad, 2003). Agricultural youth programs are just one option among many school, community, religious and sport-based youth activities, and therefore must compete for members. While programs may vary depending upon context and purpose, the question of how to recruit and retain members remains of high importance.

Besides recruitment and retention, an additional challenge facing agricultural youth programs is the changing student demographic. The original purpose of agricultural youth organizations such as FFA and 4-H was to establish a place for agriculture in public school and provide learning experiences that would improve farming techniques and practices (Brown, 2002). For much of the history of the FFA, the "typical" demographics of agricultural students, and subsequent FFA members, were white males from a farming background. In 1989, however, recommendations to change the image of the FFA to one appealing to all students interested in agriculture were implemented and have expanded today's FFA members to include a mix of youth from various upbringings, ethnicities and gender (Hoover & Scanlon, 1991). However, while a study on minority enrollment in Ohio 4-H programs report that minority youth have a faster growth rate than non-minority youth, and account for one-third of the total youth in America, minority membership in agricultural youth organizations has continued to decline (Cano & Bankston, 1992; U.S. Census Bureau, 2003; Wakefield, 2003).

Several attempts have been made to model the emergence and evolution of non-profit organizations with agent based models. Smith (2004) suggested using complexity theory to model the evolution of sports organizations in Australia. Moldoveanu (2004) introduced a quantitative agent based model to study the complexity in organizations. In 2004, Fioretti and Visser added a theory of decision making to agent based models for organizations. While the above models are successful in describing complex structures in organizations, much less attention has been given to the dynamics of organizational change (McKelvey, 2004). Recently agent based models have been used to illustrate that a sequence of symmetry breakings from the largest to the smallest scales leads to phenomena which are typically described with the phrase "the whole is more than the sum of the parts" (Hubler, 2005). Physical implementations of agent based systems show the growth of fractal hierarchical emergent structures (Jun & Hubler, 2005).

In this paper we study the dynamics of the participation in an organization with agent based models. We investigate the impact of youth with leadership skills. We assume that all agents are subject to peer pressure. The amount of peer pressure is a system parameter. We assume youth with leadership skills can create larger peer pressure. First we study populations with no pronounced leaders and determine the participation and appreciation of the organization as a function of the incentives. We do not differentiate between the incentives given family, teachers, and counselors but consider only the total amount of incentives. However we consider the fact that the individuals have different personal situations and therefore have different barriers for participating. Then we study the impact of leadership among the youth. Finally we explore a situation where the incentives are slowly increased or decreased to determine effects on participation.

An agent based model of a social network

The following model describes the participation in a youth organization as a function of the leadership skills of the youth and peer pressure. We consider a group of M agents. We model the level of participation of agent i in the youth organization during n^{th} business cycle, where $n = 0, 1, \ldots$. We assume that the rate at which the participation increases depends on the current participation, the appreciation factor and the peer pressure. The participation of agent i during the next business cycle is a function of the current participation and the peer pressure, the *participation dynamics* is assumed to be $p_i^{(n+1)} = b_i^{(n)} p_i^{(n)} + P_i^{(n)} + r^{(n)}$, where $i = 1, 2, \ldots, M$. $p_i^{(n)}$ is the level of participation of agent i in the youth organization during the n^{th} business cycle. $b_i^{(n)}$ is the appreciation factor of that agent. $P_i^{(n)}$ is the peer pressure on agent i. The level of participation is between 0% and 100%, i.e. $0 \leq p_i^{(n)} \leq 1$. We assume that the participation is subject to some random fluctuations. This is modeled by the term $r^{(n)}$. $r^{(n)}$ are small random numbers which are equally disrupted between $-r$ and r, i.e., where $0 \leq r \ll 1$. The following equations states that the *peer pressure* on agent i at time step n from other agents depends on the participation levels of the other agents and increases exponentially with the difference in leadership skills between the agents; $P_i^{(n)} = S\, p_1^{(n)} \exp(L_1-L_i) + S\, p_2^{(n)} \exp(L_2-L_i) + \ldots + S\, p_{i-1}^{(n)} \exp(L_{i-1}-L_i) + S\, p_{i+1}^{(n)} \exp(L_{i+1}-L_i) + \ldots + S\, p_M^{(n)} \exp(L_M-L_i)$, where L_i is a positive number which measures the leadership skills of an agent i. A leader is a person who acts as a role model for other youth. The quantity S measures the strength of the interactions between the agents, where $0 \leq S < 1/(M-1)$. For $S = 1/(M-1)$ peer pressures in the network are very high. In contrast, for $S=0$ this model describes a group of individualists who do not respond to peer pressure. Further we assume that the appreciation decreases when the participation reaches *100%,* due to time constraints, money constraints, etc. We use the logistic map to model *diminishing returns*: $b_i^{(n)} = a_i^{(n)} (100\% - p_i^{(n)})$, where $a_i^{(n)}$ is the appreciation of agent i at small participation levels. The personal situation of each agent is slightly different. The quantity s_i describes how much the personal situation of an individual affects the appreciation of the organization. For instance the child of a farmer may see more benefits in a youth organization for farmers, than the child of a teacher. We introduce a measure for the barriers to participation in the organization, $s_i = r_i\, s$, where $s > 0$ is the spread of the barriers and r_i is a random number between 0 and 1, i.e. $0 \leq r_i \leq 1$. s is a measure for the diversity of the group.

Good memories and the quality of the program contribute to the appreciation of the organization and incentives increase its appreciation. Hence we use the following equation to model the *dynamics of the appreciation*: $a_i^{(n+1)} = \lambda\, a_i^{(n)} + q\, p_i^{(n)} + f - s_i$, where f is the net effect of incentives, provided by the youth organization, teachers, parents, and other advocates. f describes those aspects of the appreciation which do not depend of participation in the organization, including advertisements. In contrast, the term $q\, p_i^{(n)}$ describes the impact on the appreciation due to participating in the program. q is a measure for the quality of the program, compared to other youth programs. $q = 1$ means that the quality is high, and $q = -1$ means that the quality is low, whereas $q = 0$

means that the quality of the program is similar to other youth programs. The quantity λ describes the impact of past experiences, where $0 \leq \lambda \leq 1$. $\lambda = 1$ means that memories have a strong impact on the current level of appreciation, whereas $\lambda = 0$ means that memories have no impact on the current level of appreciation. $a_i^{(n)}$ is assumed to be within the parameter range of the logistic map, i.e. $0 \leq a_i^{(n)} \leq 4$.

Average quality youth groups with no strong leaders

First we study the consequences of peer pressure in an average quality youth program with no strong leaders, i.e. $q = 0$ and $L_i=0$ for all i. If the incentive f is small, only the agent with the smallest barrier develops a positive attitude and the participation and appreciation of the agent's approach a stable fixed point, i.e. over time the participation of the agents approaches a constant value. In the following m is the subscript of the agent with the minimum barrier, i.e. $s_m \leq s_i$ for $i \neq m$.

If the incentive is smaller than the smallest barrier, i.e. $f<s_m$, the fixed point appreciation of all agents is zero, i.e. $a_i = 0$ for all i. Consequently none of the agents participates, i.e. $p_i^{(\infty)} = 0$ for all i .

However if the incentive f is between the lowest barrier and the second lowest barrier sm2, i.e. $s_m < f < s_{m2}$, then the fixed point appreciation of agent m is greater than zero, $a_i^{(\infty)} = B_m/(1 - \lambda)$ for $i = m$ and $a_i^{(\infty)}=0$ else, where $B_i = f - s_i$ is the benefit. The participation of the agents is still zero, i.e. $p_i^{(\infty)} = 0$ for all agents. Only if the benefit B_m

exceeds a certain threshold B_c then a bifurcation occurs: the fixed point at zero becomes unstable and another fixed point becomes stable. The threshold incentive is $B_c = (1- \lambda)(1 + S - M S)(1 + S)/(1 + 2S - M S)$. This means if $B_c \leq B_m \leq B_{m2}$ then the limiting participation of agent m is $p_i^{(\infty)} = 100\%$ if the peer pressure S is larger than $S_c = 1/(M-1)$ and $p_i^{(\infty)} = 1 - (1 + S - M S)(1+S)/(a_m(1 + 2 S - M S))$ for small peer pressure, i.e. $S<S_c$. And for the other agents, $i \neq m$, the limiting participation of agent is $p_i^{(\infty)} = 100\%$ as well, if the peer pressure S is larger than S_c and $p_i^{(\infty)} = 1 - p_m^{(\infty)} S/(1 + 2 S - M S)$ for small peer pressure, i.e. $S < S_c$.

Hence if the peer pressure is greater the threshold S_c then the limiting participation of all agents jumps from zero to 100% when the benefits exceed the critical value B_c. If the peer pressure is greater than the threshold S_c then the limiting participation of all agents increases gradually to 100% as soon as the benefits exceed B_c. appreciation. Despite of the fact that the appreciation of the other agents is zero they start to participate due to the peer pressure from agent 6. The limiting values of the simulation for the participation and the appreciation of the agents are in excellent agreement with the theoretical values given. Figure 1 shows the limiting participation versus the benefit of the agent with the smallest barrier and versus the peer pressure for a network $M = 10$ agents for the agent with the smallest barrier (a) and the other agents (b). If the incentive is less than the threshold indicated by the continuous blue line, then the benefit is less than the critical benefit B_c, and the limiting participation is zero for all agents. If the peer pressure exceeds the threshold S_c, indicated by the dashed line, then the participation of all agents is equal to one.

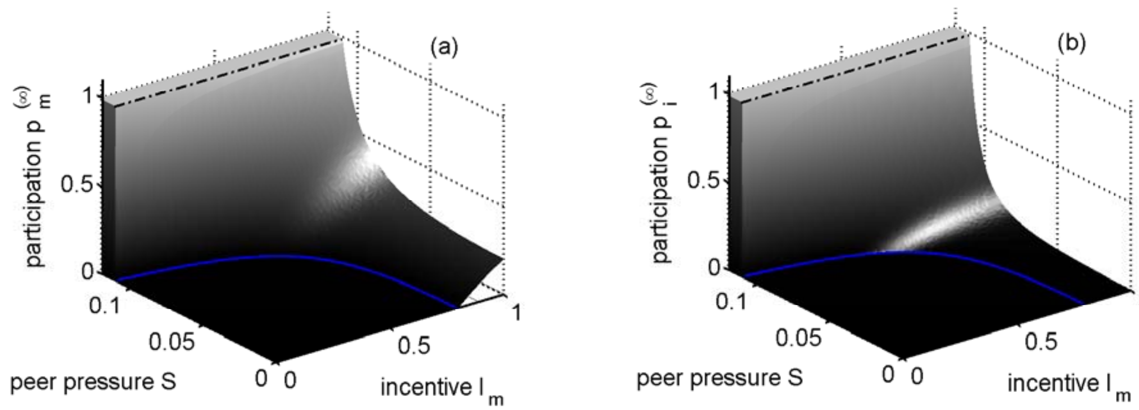

Figure 1 The limiting participation versus the benefit of the agent with the smallest barrier and versus the peer pressure for the agent with the smallest barrier (a) and the other agents (b).

Figure 2 shows the time dependence of a system with ten agents with random barriers, $s_1=0.76$, s_2=0.92, $s_3=0.89$, $s_4=0.41$, $s_5=0.35$, $s_6=0.11$, $s_7=0.64$, $s_8=0.36$, $s_9=0.49$, $s_{10}=0.73$, the incentive $f=0.3$, and memory λ =0.8. The peer pressure is high, but below S_c, i.e. $S = 0.1 < S_c$. For this set of barriers, agent 6 has the lowest barrier, i.e. $m=6$. For this parameter set agent 6 is the only agent which has a positive benefit, i.e. $B_m > 0$, whereas $B_i < 0$ if $i \neq m$. Figure 2 shows that agent 6 is the only agent which develops a positive appreciation. The top curve is the participation of the agent with the lowest barrier, the lower curves are the participation levels of all other agents. The dashed lines are the theoretical values.

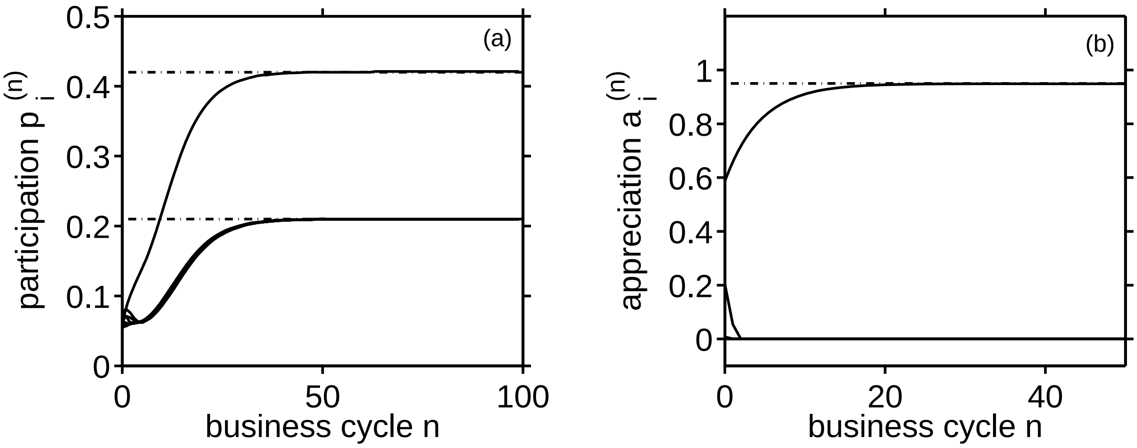

Figure 2. The participation and appreciation versus time. The top curve is the participation of the agent with the lowest barrier; the lower curves are the participation levels of all other agents.

Average quality youth groups with strong leaders

Next we consider the impact of leadership. We consider a system where the agent with the smallest barrier is a strong leader as well, i.e. $L_m=1$ and $L_i=0$ for $i \neq m$, and an average quality youth program, i.e. $q=0$. The dynamics of the participation is $p_i^{(n+1)} = a_i^{(n)}\, p_i^{(n)}\, (1 - p_i^{(n)}) + P_i^{(n)}$, and the dynamics of the appreciation is $a_i^{(n+1)} = \lambda\ a_i^{(n)} + B_i$. We find that the limiting value of the appreciation is $a_i^{(\infty)}=B_i/(1-\lambda)$ if $B_i > 0$ and $a_i^{(\infty)}=0$ else.

If the incentive is smaller than the smallest barrier s_m, i.e. $f < s_m$, then the benefit is negative for all agents, i.e. $B_i \leq 0$ for all i, and the fixed point appreciation of all agents is zero too, i.e. $a_i^{(\infty)}=0$ for all agents. However if the incentive f is between the lowest barrier and the second lowest barrier s_{m2}, i.e. $s_m < f < s_{m2}$, then agent m has a positive benefit $B_m > 0$ and the fixed point appreciation of agent m is greater than zero, whereas the appreciation level of the other agents is still zero. In the following we will consider this case. Since agent m is the only agent with non-zero appreciation we treat agent m separately from the other agents. Since the other agents have the same equation, we make the assumption that their fixed point values are the same and equal to the fixed point values of the agent with the second smallest barrier m_2. With the constraint $0 \leq p_i^{(\infty)} \leq 1$ we find

$$p_m^{(\infty)} = 0, \text{ if } 0 \leq B_m \leq B_c;$$

$$p_m^{(\infty)} = 1 - (1 + S - M S)(1+S)\}/(a_m^{(\infty)} (1 + 2 S - M S)), \text{ if } B_c \leq B_m \leq B_d \text{ and } S \leq S_c;$$

$$p_m^{(\infty)} = (a_m^{(\infty)} -1+((a_m^{(\infty)} -1)^2+4 a_m^{(\infty)} S (M-1) e^{-Lm})^{1/2})/(2 a_m^{(\infty)}) \text{ if } S \leq S\_c;$$

$$p_m^{(\infty)} = 1 \text{ else.}$$

The condition $p_{m2}^{(\infty)} = p_m^{(\infty)} (S e^{Lm})/(1 + 2 S - M S) \leq 1$ is true if $B_m \leq B_d$ where $B_d = (e^{Lm}(1- \lambda)S(1+S)(1-(M-1)S))/((1-(M-2)S)(1-(M-2+e^{Lm})S))$. The condition $p_m^{(\infty)} \geq 0$ means $1 - ((1 + S - M S)(1+S))/(a_m^{(\infty)} (1 + 2 S - M S)) \geq 0$. This is true if $B_m \geq B_c$ where $B_c = (1-\lambda)(1 + S - M S)(1 + S)/(1 + 2S - M S)$. The condition $p_m^{(\infty)} \leq 1$ means $1 - ((1 + S - M S)(1+S))/(a_m^{(\infty)}(1 + 2 S - M S)) \leq 1$. This is true if $S \leq S_c$ where $S_c = 1/(M-1)$. With these equations we obtain for the participation if all agents, except for agent *m:*

$$p_i^{(\infty)} = 0, \text{ if } 0 \le B_m \le B_c;$$

$$p_i^{(\infty)} = (S\, e^{Lm})/(1 + 2\,S - M\,S)(1 - ((1 + S - M\,S)(1+S))/(\,a_m^{(\infty)}\,(1 + 2\,S - M\,S))), \text{ if } B_c \le B_m \le B_d \text{ and } S \le S_c;$$

$$p_i^{(\infty)} = 1, \text{ else.}$$

Figure 3 shows the time dependence of the participation and the appreciation of a system with ten agents where the parameters are the same except that agent 6 has the leadership level $L_6 = 1$. Again agent 6 is the only agent which develops an appreciation. The limiting participation of agent 6 does not depend on the leadership skills as long as the participation of the other agents is less than one, but the limiting participation of the other agents do increase if the leadership of agent 6 increases. The lower curve is the participation of the agent with the lowest barrier; the upper curves are the participation levels of all other agents. The dashed lines are the theoretical values.

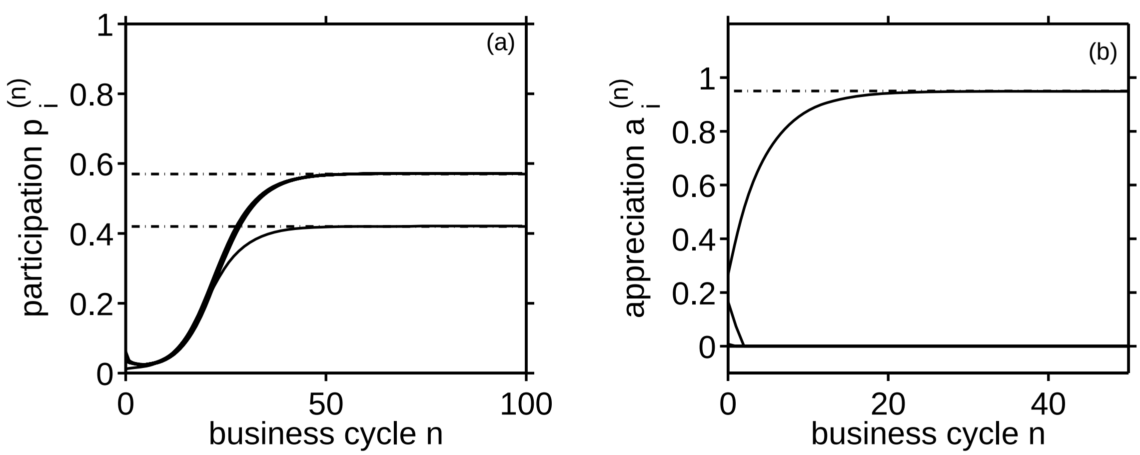

Figure 3. The participation and appreciation versus time for a system with a strong leader. The lower curve is the participation of the leader, the upper curves are the participation levels of all other agents. The dashed lines are the theoretical values.

Systems with slowly changing incentives

Next we consider the situation where the incentives are changing slowly, i.e. $f = f^{(0)} + n\, \Delta f$, and determine the average level of participation $p^{(n)} = (p_1^{(n)} + p_2^{(n)} + \ldots + p_M^{(n)})/M$. Figure 4 shows a numerical simulation of a social system for $f^{(0)}$ = 0\$ and Δf=0.0007. All other parameters are as in Figure 2. The parameters are $S=0.1$, $M=10$, and $s=1$. The average participation changes suddenly. As soon as the agent with the lowest barrier starts to participate a second order phase transition occurs. This phase transition may be less pronounced if the system is less social, i.e. if S is small.

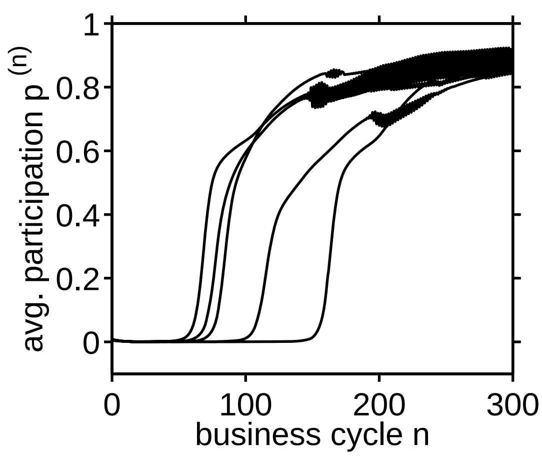

Figure 4. The average participation versus time for five different sets of agents. Despite of the fact that the incentives grow at a constant rate, the average participation changes suddenly and at a different time.

We find that the participation starts to grow if the benefits of one of the agents are positive. However if the noise level is r is small, it may take many time steps before the growth in participation becomes noticeable. For small noise levels there is a significant delay between the time when the limiting participation becomes positive and the time when the participation is actually significantly different from zero. This means, that the participation may stay zero for a long time, unless youth participates accidentally in the youth organization. We conclude that the larger the accidental participation the faster the *growth* of the youth organization. Even if the potential for growth is there, the organization may not grow, unless there are significant accidental fluctuations in participation.

Discussion

We study impact of one individual on the behavior of a social network of people with agent based simulations. We find that peer pressure can induce sudden unexpected changes in the behavior of a group. Figure 1 shows that the participation stays zero unless the benefits exceed a threshold. Figure 4 shows that these sudden changes may occur after a long delay. The length of the delay depends on the noise in the system. Further we find that the individual with the largest benefit dominates the group behavior. If that individual happens to have a leadership role, the impact is particularly strong. Further we find that incentives which target leaders are more effective than unspecific incentives. Since youth organizations are typically organized in small local groups, we expect these groups to grow suddenly if incentives target youth which (i) is likely to participate and (ii) has leadership skills. Similarly we expect these groups to disappear suddenly unless incentives target such youth. We expect both the growth and disappearance of these local groups to occur rather unexpectedly long after the incentives have changed.

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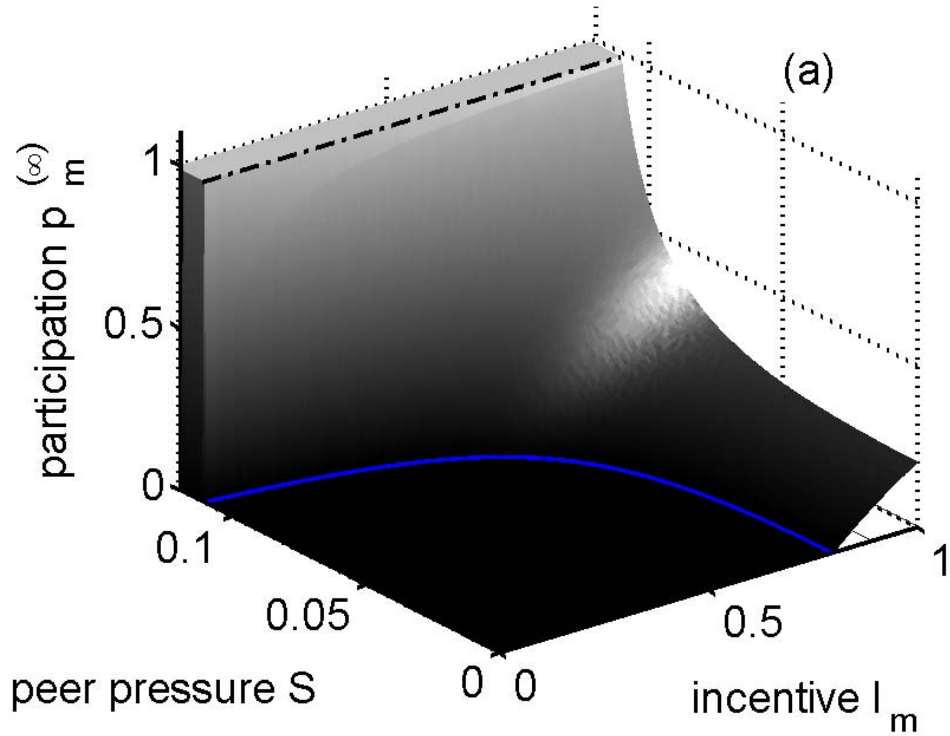
(a)
participation $p_m^{(\infty)}$
1
0.5
0
0.1
0.05
0
peer pressure S
0
0.5
1
incentive I_m

Figure 1a

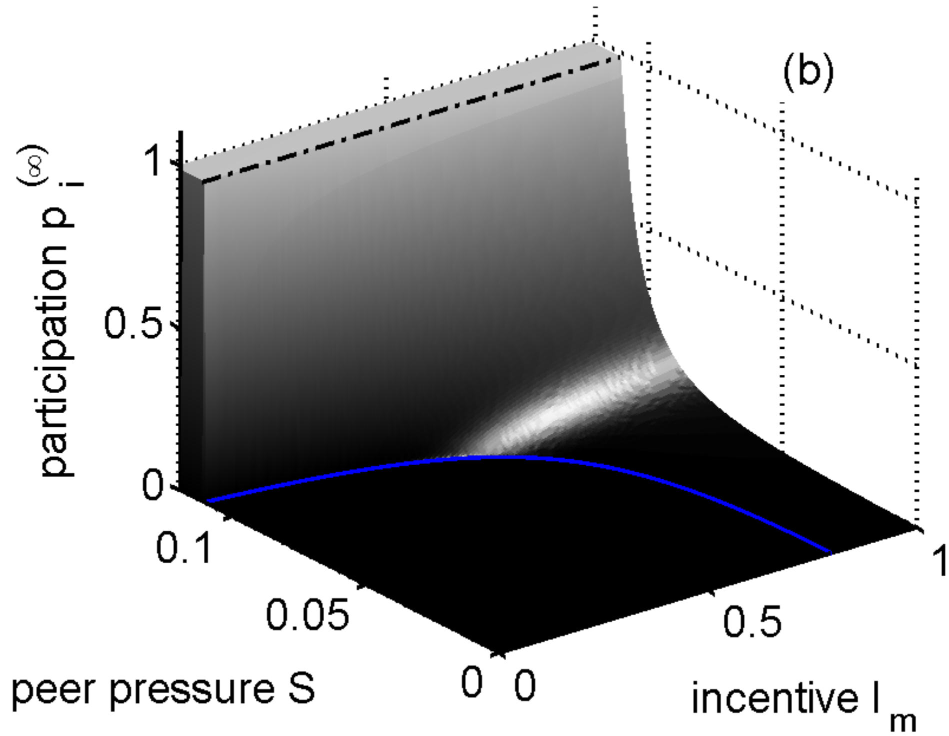
(b)
participation $p_i^{(\infty)}$
1
0.5
0
0.1
0.05
0
peer pressure S
0
0.5
1
incentive I_m

Figure 1b

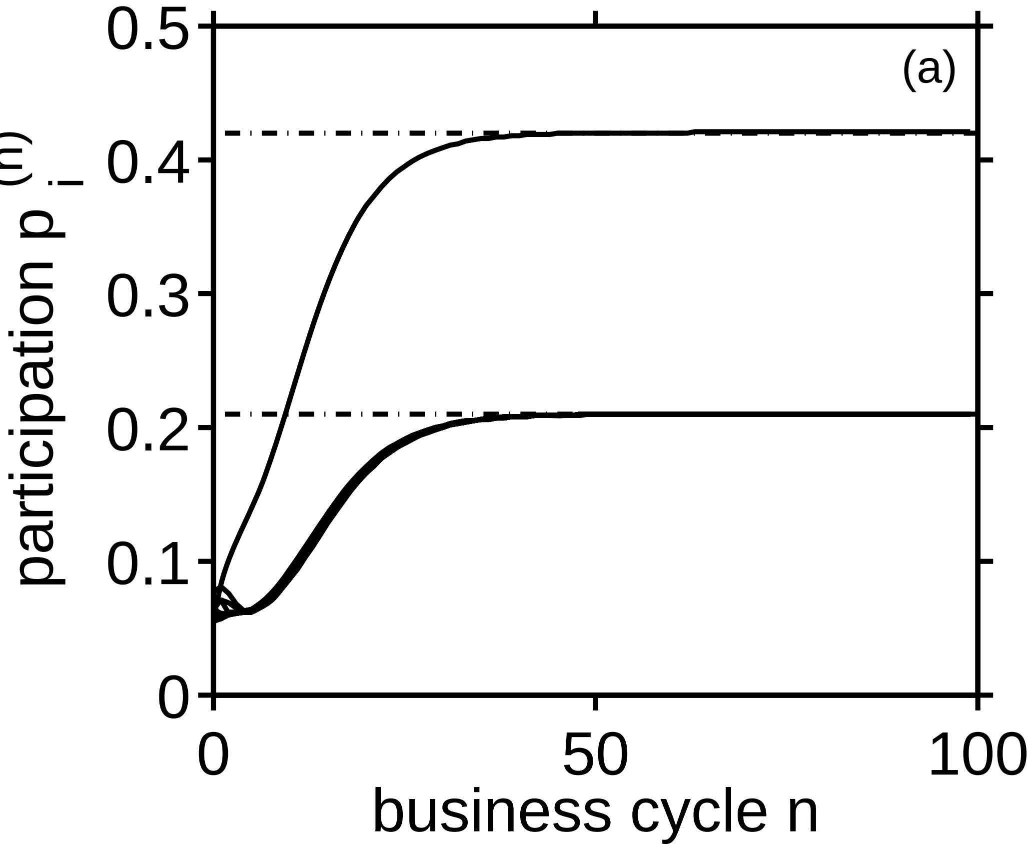

Figure 2a

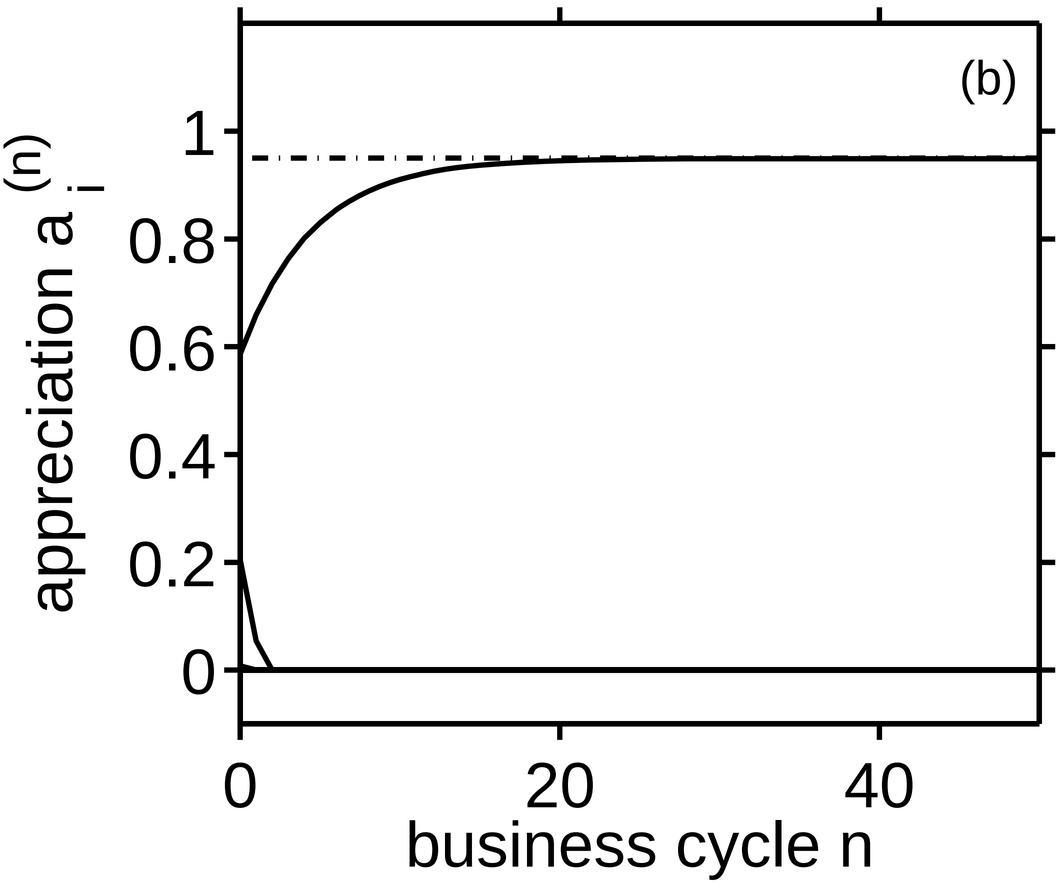

Figure 2b

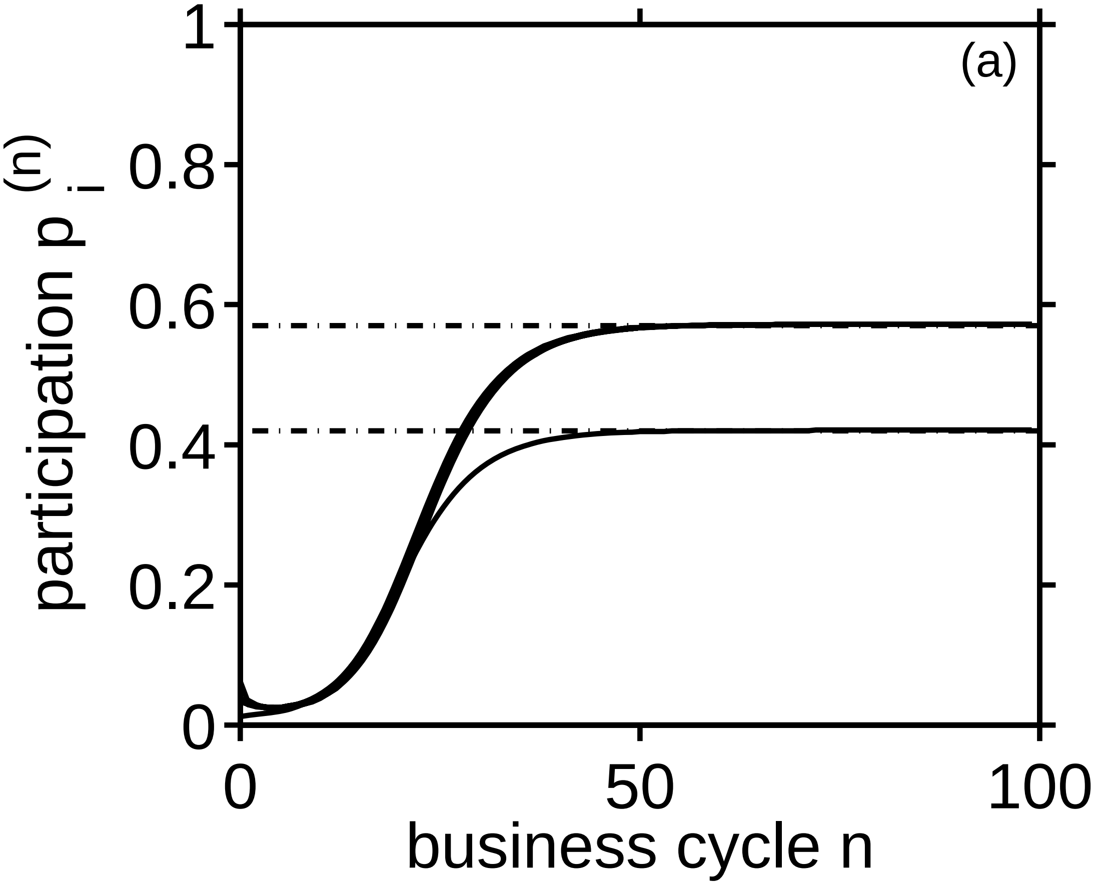

Figure 3a

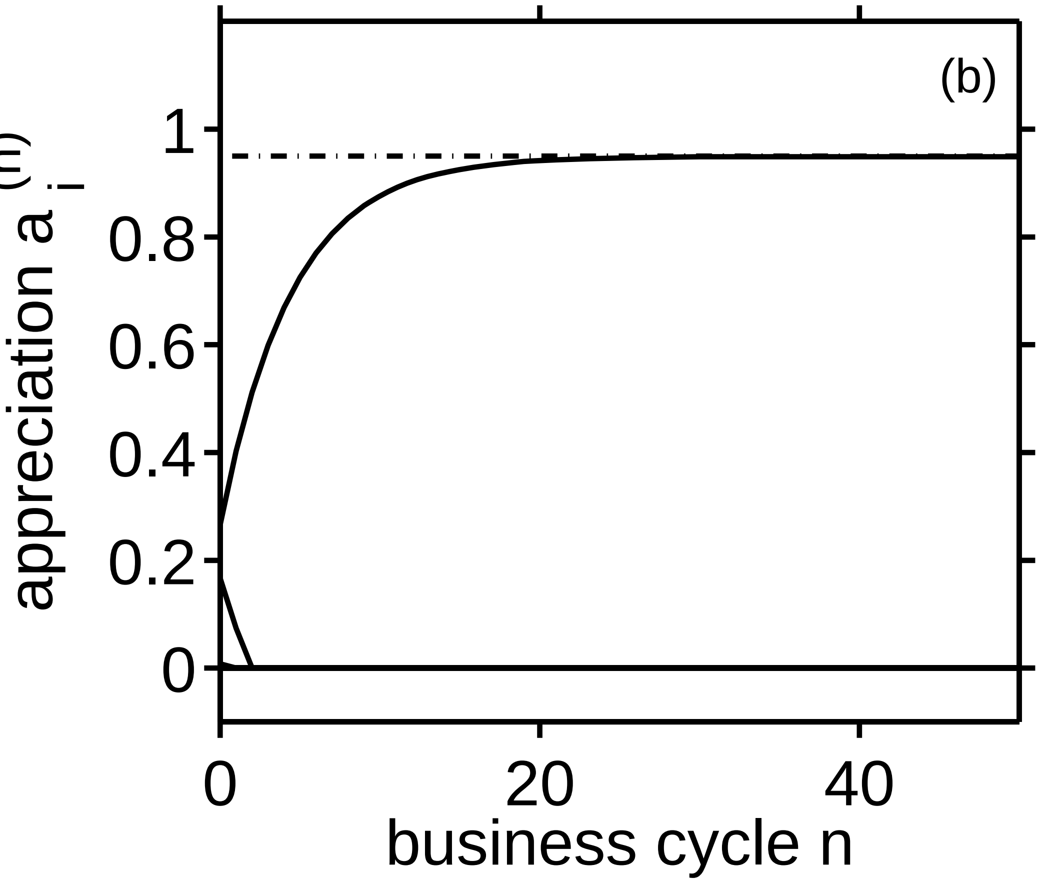

Figure 3b

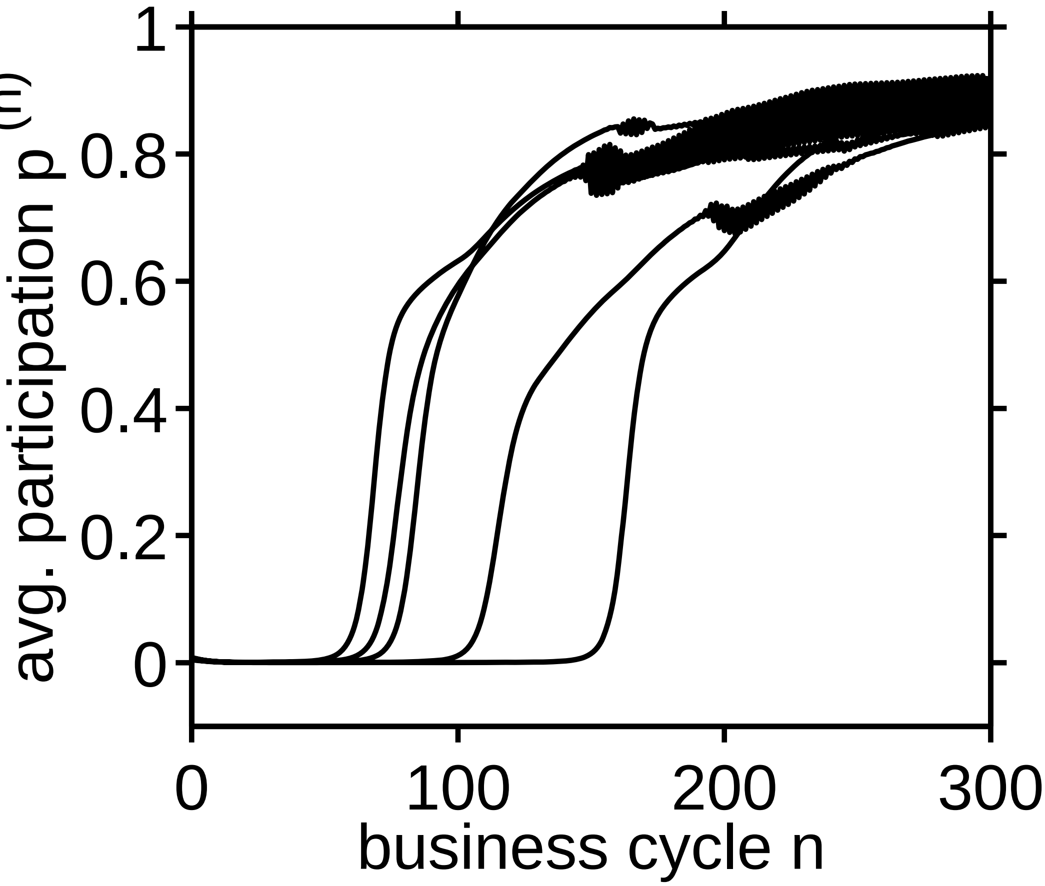
1
0.8
0.6
0.4
0.2
0
avg. participation p (n)
0
100
200
300
business cycle n

Figure 4