Growth Matters: Identifying Best Practices in Growing Civic Collaborations

by

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For my Father and Grandfather

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Table of Contents

List of Figures

List of Tables

List of Appendices

Abstract

The recently introduced Health Children and Families Act represents a potential $15B investment in promoting community health by legislating the implementation of the Nurse-Family Partnerships (NFP) program in all 50 states. Although legislation does not mandate the implementation strategy, civic collaboration has been found to be uniquely successful. To fully leverage the value of civic collaboration, this study aims to identify and formalize one important aspect of collaborative activity—the growth process during the initial stages of collaboration. By comparing field observations from several community health programs, we have identified the features of civic collaborations most associated with favorable program outcomes. Specifically, successful collaborations have started with small initial groups, proceeded to engage in high quality planning processes, and have slowly included new members. Using a coordination game model from experimental economics, we formalize strategic behaviors in civic collaboration as a minimum-effort coordination game with Pareto ranked equilibria. Three best practices (small initial group, planning, and growth) observed from the field are interpreted as interventions in coordination failures within the game. This coordination game framework is incorporated into an agent-based model. A series of experiments in the agent-based model offer an in-depth understanding of the separate and combined effects of the three best practices and how their contributions change over the lifecycle of a civic collaboration program. Findings from this study not only inform the program implementation of Healthy Children and Families Act, but also help stakeholders in other civic collaboration programs to understand and adopt the best practices and achieve optimal outcomes.

Chapter 1

Overview

WASHINGTON, D.C. – United States Senator Ken Salazar (D-CO), along with Senator Arlen Specter (R-PA), ranking member of the Senate Appropriations Subcommittee on Labor, Health and Human Services, Education and Related Agencies, last week introduced the bipartisan Healthy Children and Families Act. The Healthy Children and Families Act would expand access to the highly-successful Nurse-Family Partnership through the State Children's Health Insurance Program (SCHIP) to all 50 states and the District of Columbia, providing at-home nurse visits for up to 570,000 first-time mothers each year.

- from an April 3rd, 2007 Senatorial press release

Introduction

Civic collaborations, also known as collaborative partnerships, are alliances among community stakeholders and organizations from multiple sectors that work together to improve conditions with the aim of promoting and sustaining community health; as a strategy, such civic collaborations are increasing in frequency (Roussos & Fawcett, 2000). Federal and State health agencies routinely support, and often mandate, the formation of collaborative partnerships to design and implement community health initiatives (Hicks, et. al., submitted 2006). The Institute of Medicine defines "mobilizing community partnerships" as an essential public health service, and the National Public Health Performance Standards include the use of collaborative partnership as a key indicator of effective performance (Zahner, 2005).

To fully leverage the value of civic collaborations, this research aims at identifying and formalizing best practices of such collaborations. Specifically, Hicks et. al. (submitted 2006) found a correlation between program outcomes and the process quality of the early phases of civic collaboration development in Colorado. It was during this early phase that the collaborations grew from just a few participants to a function group. By evaluating implementations of the Nurse-Family Partnership, and particularly by understanding the successes and struggles during the growth process when employing civic partnerships used to implement NFP in Colorado, we can derive insights into best practices. The direction of this research is motivated by and builds on previous and current research into civic collaborations as a viable strategy for community health programs (Hicks & Larson, 2003; Johnston & Hicks, 2004; Hicks et. al., submitted 2006).

Nurse-Family Partnership (NFP)

The Nurse-Family Partnership is perhaps the single most effective public health program in the US (Isaacs, 2007). Conceived by Dr. David Olds, the Partnership sends specially trained nurses on weekly or bi-weekly visits to low-income, first-time mothers, beginning as early as possible in the pregnancy—typically between 16 and 28 weeks—
and continuing until the child’s second birthday. The nurses help mothers improve their health and nutrition during pregnancy, learn effective early parenting skills, develop healthy family support systems, and reach program goals like completing school and

finding employment. The Senatorial Press Release sums up the program's value in this way[1]:

> Today, NFP operates 150 programs in 22 states and has served more than 69,000 women and children nationwide. The benefits of the NFP "exceeded costs at a society-wide level," according to a report by the respected non-partisan Brookings Institution released in February, 2007. The report found that NFPs on average generated savings of $2.88 for every $1 invested, and noted, "At age four, children in the Nurse-Family Partnership were living in safer homes and in environments that were rated as more conducive to child development."

Implementation Choices

Under the current instantiation of the NFP, different states employ different implementation strategies. In one strategy, the program is deployed through a top-down process by activating current state resources and services. The State of Oklahoma uses this type of implementation, which is described on the NFP web site[2]:

> After searching for an evidence-based model to reduce child abuse and neglect, the state of Oklahoma decided to implement the Nurse-Family Partnership (NFP) model utilizing the county health department system. Children First, Oklahoma's NFP, was created by state statue in 1996 and funded with state appropriations. In February 1997, four pilot sites with 19 nurses were based in Garfield, Garvin, Muskogee and Tulsa Counties. By October 1998, services were available in all 77 counties. Currently the county health department staff consists of 170 public health nurses providing home visits, and 22 nurse supervisors. Training, quality assurance through site visits and audits, as well as general consultation is provided to the Children First nurses by Children First Program Staff out of the Oklahoma State Department of Health's central office. Central office staff is housed in the Family Support and Prevention Service at OSDH and consists of a director, three nurse consultants, an epidemiologist and other administrative staff.

Conversely, the Colorado implementation of NFP is unique in that it uses civic collaborations as its site development strategy. To date, in Colorado 16 collaborative

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[1] http://salazar.senate.gov/news/releases/070403hlth.htm

[2] http://www.nursefamilypartnership.org/content/index.cfm?fuseaction=showContent&contentID=139&navID=119

partnerships are in place, with over 2,800 families in 50 of Colorado's 64 counties enrolled in the NFP (The Colorado Trust, 2001). These collaborative partnerships are facilitated by Invest in Kids (IIK), a non-profit organization based in Denver, Colorado that partners with communities to implement evidence-based programs targeting children (prenatal to age 5), particularly those from low-income families. The NFP was the first program that IIK advocated in Colorado.

IIK uses a four-part process to facilitate the establishment and work of the 16 collaborative partnerships. As outlined in the official implementation guide for NFP in Colorado, this process begins with the creation of a working group comprised of all interested health professionals. Rather than assuming the program will be effective in the community, stakeholders engage each other to identify community needs and determine how well program services meet these needs. This is a critical aspect of the collaboration. This working group also assesses whether the human services delivery system in the area is capable of delivering the program. This too requires an exploration of the community's capacities, in particular the ways in which programs that offer overlapping services will fare once the NFP is implemented. In Colorado the NFP is adopted and implemented by stakeholders from a variety of sectors, including county health departments, community health agencies, county human services departments, school boards, local head starts, county commissioners, and business and civic leaders (Invest in Kids, 2005).

Early research of the site-development patterns of NFP has shown that the quality of the programming outcomes was not uniform across different sites. To understand why, researchers at the University of Denver conducted over one hundred interviews with key participants of the first stage of program development, including the nurse supervisors from all sixteen sites. They also rated the community processes with a process quality rating scale, applied the "Working Together" index of collaboration, developed a forced-choice instrument to test the differences of experience within the community process, and made a conscious effort to transform their qualitative findings into quantifiable results (Hicks and Larson, 2003). The key finding was that a high quality process during the first part of the collaboration correlated strongly with program outcomes years later (Hicks, et. al., submitted 2006). This strong correlation motivates the present research to focus on best practice interventions during the first part of the civic collaborations.

There are three subsequent parts to the civic collaboration design that are helpful to present, but not the focus of the current research. The second part of the process involves building the long-term community support necessary to secure grant dollars to fund the program. This requires broadening the working group beyond immediate health care providers to include the full range of professionals needed to ensure a robust client load. Moreover, the collaborative partnership must also cultivate a group of citizen advocates who can promote the program throughout the community.

The third part of the process is implementation. The collaborative partnership must initially decide the agency that will house and run the program. Given the costs of the program and the number of agencies collaborating, this is a difficult process and may result in a conflict the partnership will have to mediate. The partnership must also hire and train the nursing supervisor and home visitation staff as well as expand the caseload. Given the acute nursing shortage, especially in rural parts of the state, this too is an extremely difficult and potentially conflict ridden process.

Finally, IIK helps collaboratives evolve into a long-term advisory board. An advisory board is a community-based support system that ensures program fidelity and sustainability, monitors the program's success, coordinates fundraising efforts and advocates the program to state and local decision-makers.

When civic collaborations have been used, on average they have been found to be more successful than the national average on the key measures of program success, see Table 1:

Outcome	***Colorado NFP***	***National NFP Average***
Average visits during (pregnancy – infancy – toddler)	**10.1 - 20.4 – 16.3**	**9.5 – 17.5 – 11.7**
Premature infants	**7.9%**	**9.7%**
Low birthweights	**8.2%**	**8.5%**
Initiated breastfeeding (infant – 6mo – 12mo)	**84% - 39% - 20%**	**69% - 29% - 16%**
Reduction in mother smoking	**25%**	**16%**

Table 1 : Comparison of national averages of NFP outcomes when using civic collaboration[3]

The demonstrated results of the use of civic collaborations with NFP extends previous findings that community program implementions that use civic collaborations have great potential in improving public health and addressing social and economic problems (Coutto, 1998).

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[3] State of Colorado Nurse Family Partnerships - Evaluation Report 6 – June 30, 2006

A significant caveat must be noted regarding the success of civic collaborations. While the use of civic collaboration for the NFP programs has, on average, been more successful than the national average, the use of civic collaboration as an implementation choice does not guarantee success. An examination of the individual communities that used civic collaborations to implement NFP show a wide variety of results even when implementing the same program using the same implementation strategy. Some NFP civic collaborations failed to get off the ground, some struggled to perform for years until a decision was made to end the program, and some performed exceptionally well.

To realize the potential of civic collaboration, we need to understand the practices that are essential to the program success, which I refer to here as "best practices." The objective of this study is to identify, formalize, and gain insights into the best practices of civic collaboration. The research program of this study includes four steps. First, we investigate field observations from the 16 community implementations of NFP in Colorado to identify practices that are associated with favorable program outcomes. Second, we borrow theories from economics, specifically game theory, to formalize the practices. Third, we ground, calibrate, and validate an agent-based model to implement the theoretical framework. Fourth and finally, we conduct experiments in the agent-based model to gain insights into the relative effect of and interactions between the best practices.

Step 1: Identifying best practices from field observation

We investigated field observations from the initial stages of the collaboration in 16 communities that implemented the NFP programs. First we identified an intervention evident in all of the communities observed and unique when compared to other implementations of NFP across the nation, namely:

- A snowball growth process starting with a small initial working group

We then identified two interventions that are associated with more favorable program outcomes when using the snowball growth process. Two interventions we identified in the current research that seemed to distinguish high-performing from low-performing civic partnerships are:

- A deliberative planning process
- The thoughtful inclusion of new people into the working group

These distinguishing factors were identified by analyzing supporting data, including:

- Interviews with the directors of IIK who were involved in the development of all sixteen communities
- Narrative descriptions of each community implementation in Colorado NFP initiatives, provided by the directors of IIK
- The official implementation guide for NFP in Colorado
- Program outcomes (average visits, birth weights, premature infants, attrition of participants, …) from data entered into the Clinical Information System, a system that is used as a foundation for the continuous quality improvement of program operations and outcomes nationwide

Intervention one: Building a small initial working group with snowball growth

The first part of the four part process to facilitate the establishment and work of the 16 collaborative partnerships begins with the creation of a working group comprised of all interested health professionals. Participants come from different sectors of the community and include individuals, government agencies, churches and civic organizations. In the NFP program specifically, the makeup of participants vary, and can include health department doctors, human services department directors, public health nurses, elected officials, existing nurse home visitation programs, other youth agencies, other health providers, city officials, law enforcement officers, judicial officers, and business leaders (Invest in Kids, 2005).

The selection process is unique for each community. From the interviews of the program directors:

> ***Interviewer***: *How did you initially select who was to be part of the collaboration?*
>
> ***Executive director of IIK***: ***The way we initially target the people was different in every community***. *We would typically have one contact that would put us in touch with someone else and they would pull in someone else. In some communities we would cold call the director of the health department and invite them to lunch and tell them about the program. Then* ***we had to defer to the local folks to see who else should be at the table, but we had to push them to see who else needs to come***. *We had to let them pick because we do not know the community. They are the ones who know who are key people in the community. We have targets. We can say we want the Director of Human Services, Head Start, the school people, health department, or elected officials, but it was hit or miss whether we got a judge, a probation officer, or a district attorney. Sometimes we got them, but only if others looped them in.*
>
> ***Interviewer***: *Did you ever object to anyone?*
>
> ***Executive Director of IIK***: *Never*

The working group conducts a community needs assessment to determine how well the program services meet the community's particular needs. This is a critical aspect of the collaboration, and it is not taken for granted that the program fits the community. Some communities never progressed from the planning stage, and the program was not implemented in these communities.

Intervention two: Deliberative planning process

In a study submitted to *Prevention Science* (Hicks, Larson, Nelson, Olds, & Johnston, submitted 2006), we hypothesized that the process quality of building collaborative partnerships would account for a significant proportion of the variance in *attrition* beyond that accounted for by the characteristics of individual participants. The attrition rate of participants is an immediate indicator of program success (Olds, 2003). We were seeking to discover whether certain qualities manifested in community collaboration processes significantly improve the success of the program. The most striking aspect of the results is not simply that the hypothesis is supported but rather the strength of the association between process quality and attrition.

In practical terms the correlation between process quality and program outcomes suggests that collaborative partnerships that devote sufficient upfront time and energy to improving the quality of the process employed, as well as the capacity of individuals to enhance those processes, are likely to be more successful, at least with respect to reducing the attrition among the individuals these programs served. One additional fact makes this finding even more surprising: site level data on process quality were collected approximately four years before the programmatic data on attrition were collected. That is, the process quality data were gathered from the interviews and scaled responses of community stakeholders who were at that time involved in bringing the NFP program to their community and developing a collaborative partnership to achieve this result. Four years later when the program had been implemented, the attrition data were summarized for each of the programs.

One distinguishing feature of more successful collaborative partnerships was the freedom to develop according to their own schedule. A result of developing at a natural pace instead of being driven by external timetables allowed them to engage in a deliberative process, even if that deliberation slowed down the process. At least two community implementations were delayed to make sure that everyone in the working group was coordinated toward the same goals.

According to the Deputy Director, the ability to grow slowly was necessary:

> ***Deputy Director of IIK****: One community in particular was a very political community. You have to navigate it carefully otherwise you will get hosed. So I think* ***that it would not have been possible to go any quicker and result in a successful program.***

The Program Director also compared the process of developing the same program in two different communities, one with a highly deliberative process and another in which a lack of deliberation was observed during the planning process.

> ***Deputy Director of IIK:*** *We had a great group in (community one) who was* ***committed and thoughtful****. It was* ***scarier*** *when you went into a community like (community two) and they were like* ***boom, we are ready, lets go****. And* ***you know that that is not the right thing to do****, but you can't really force them to slow down. And in (community one) it was really a thoughtful approach. It was* ***slow, but it wasn't painful in any way****.*

Some of the communities paid "lip-service" in order to progress to the next stages of the program. These programs did not perform as well in the long term as those observed as having a deliberative planning process. Although placing artificial time limits on each stages of the process might be tempting, such external pressures have limited success, as artificial time constraints negatively influence the rate and quality of later work (Kelly et.al., 1990).

Intervention three: Thoughtful inclusion of new people

Early experience, the degree of interaction, and the ways in which people join existing communities make a difference how well participants performed learning the norms of the community (Lampe & Johnston, 2005). If the early stakeholders in the group devoted their energies to competing for resources, building their back-home agencies, expanding spheres of influence, or pursuing individual agendas, the quality of the process would have suffered and the subsequent lack of confidence in that process would have affected new participants, ultimately decreasing their willingness to commit time and energy to implementing the decisions of this early stakeholder group (Hicks, et al., submitted 2006). Theories of organizational learning suggest that learning how to perform in groups often takes place through legitimate peripheral participation in communities of practice (Lave & Wenger, 1991).

When asked how new people were included in the high-performing compared to low-performing NFP communities, the Executive Director of the program responded:

> **Executive Director of IIK**: There are a lot of stories about **how we have engaged additional people**. We just did an orientation last week and we walked through a history of the program and it was a **really thoughtful orientation**. Other places were like – hi, I am so and so and I am replacing so and so.
>
> **Interviewer:** Did you notice a **difference in performance** between those different styles of including new participants?
>
> **Executive Director of IIK**: **Oh sure** – one of the key things that we have seen was if the implementing agencies continue **successfully** the agency engaged in **substantive discussion**. When it is only information sharing with just updates then **it is hit or miss** if people are choosing to attend. If there is **thoughtful and**

> **productive discussion**, I think that at the end of the day is where there are the ones that are the **most successful**.

The same relationship holds for those communities that were not able to foster a credible and open process. When people are invited to participate in collaborative activities they must make a quick, often intuitive, judgment as to the likelihood that they will be exploited, rejected, or isolated by the others (Tyler & Lind 1992). Even though coordinating toward a common goal might provide significant advantages over self-oriented goals, a judgment that investing in the group goals will lead to a relatively high likelihood of exploitation, rejection, or isolation will lead people to pursue self-oriented lower-risk, lower-reward goals (Tyler & Lind, 2001).

Step 2: Theoretical Development:

For the second step of our research, we borrow theories from economics, specifically game theory, to formalize the best practices we observed in the field.

Game theory

Game theory has a history of being used for theory construction and to provide insight into the dynamics of a system. In game theory, multiple players make individual decisions based on a pre-established payoff structure to achieve the best personal outcome. Game theory and repeated games provide a formal modeling approach for social situations where individuals interact with others. Repeated game play has been used to explore the emergence of complex group behavior by observing the interactions between individuals (Schelling, 1978; Holland, 1998), testing novel configurations in game theoretic experiments (Katz and Shapiro, 1985; Ostam, 2000), rationalizing the potential of organizational structures to self-organize in real world settings (Lansing, 1991; Holland 1995), justifying new structures of information exchange (Axelrod, 2001), and exploring the development of common practices in policy development (Skryms, 1996). We use game theory so we can study the role of interventions during the growth process by naming the participants and available actions, formalizing the problem, and extending the rich experimental economics literature that studies coordination challenges in groups (Van Huyck et al., 1990; Camerer and Knez, 2000; Knez and Camerer, 1994; Cachon and Camerer, 1996; Chaudri et al., 2001; Weber, 2007).

Choosing the appropriate game

To meet our research objectives, we must choose the game that best represents the nature of the collaboration we see in the field, isolate the central conflicts and interactions challenge, and then find the proper theoretical framework to examine the outcomes that develop from the interactions of individual participants. We must then contextualize the three best practice interventions within this framework.

Commonly used group games in the literature vary based on the type of coordination and the features of the game established by the payoff structure. There are three common notions for coordination. The first notion is from the prisoner's dilemma or social goods game in which individuals can either cooperate or defect; if we fail to coordinate, then someone benefits at someone else's expense (Axlerod, 1984). The second notion is pure coordination where if we fail to coordinate everyone loses; this is very different than someone gaining an advantage. For instance, failing to drive on the correct side of the street is in no one's best interest. There is a third notion of cooperation in which a group of people contribute diverse skills, abilities, and information to potentially achieve a super-additive outcome; we will do better than if we were all isolationists. While all three of these aspects of coordination are in play within the working groups of NFP to different extents, this paper focuses on the third because in the communities in Colorado we observed people come together with different resources, skills, and contacts and when they coordinated successfully, the collaborations they created out-performed the national averages.

Three games that test these aspects of coordination are commonly referred to as social goods games[4], pure coordination games, and minimum-effort games and are characterized by the dilemmas individual participants face when playing the game, the presence or absence of a risk-dominated strategy, and the presence or absence of an incentive to deviate, see Table 2.

Game	Social Goods	Pure Coordination	Minimum Effort
Dilemma	Sacrifice personal wealth vs. global welfare	Align strategies with others	Personal Resource security vs. group efficiency
Incentive to deviate	Yes	No	No
Risk-dominated strategy	Yes	No	Yes
Example	Paying Taxes, Leaving feedback on Ebay	Coin Flip, Wearing same color shirt to playoff game	Chain-building game, Stag-hunt

Table 2: Comparison of characteristics of different games

Social goods game

A social goods game, also called a public goods game, is characterized by individuals facing the option to contribute personal resources (time, money, energy) toward a project that will benefit the group more than the direct return will benefit the individual (Katz

[4] A Prisoners dilemma game is a common form of two player social goods game

and Shapiro, 1985; Ostam, 2000). This game is usually played in the lab by giving a group of individuals a personal fund, for instance $5. Individuals then choose to contribute any amount of their personal fund to the general fund. All money that is contributed to the general fund is then doubled and then equally redistributed to all people playing the game. So in a game with four people, for every $1 contributed, you will only receive a personal return of $.50 (=$2.00/4). However, the individual also earns money based on what others contribute to the general fund. So the best group level outcome is if everyone contributes his or her entire $5, for a total of $20, which would then be doubled to $40 and redistributed equally, wherein each person would receive $10. However, there is an incentive to deviate. The best individual outcome would result from donating nothing and having everyone else contribute their entire $5, to total $15. This $15 would then be doubled to $30 and be redistributed equally, so that each person receives $7.50. By not contributing any money, the person who deviated from the group outcome by being selfish would earn $7.50 on top of his or her original $5 for a final total of $12.50. Examples of this best economic outcome in the real world occur when people do not pay their taxes, ignore water restrictions (Schelling, 1978), or fail to contribute feedback to eBay (Gazzale, working paper).

Pure coordination game

The basic form of a coordination game, usually called a pure coordination game, is characterized by complete symmetry between players, between strategies, and between equilibria (Mehta et al., 1994). A classic example of pure coordination game is the game of “Heads and Tails” from Schelling’s seminal work (1960). In this game, multiple players write down either “heads” or “tails.” If they simultaneously write down the same word, each is paid some given amount of money. If they write down different words, they receive nothing. In this pure coordination game, players have the same payoff structure, the same strategies ("heads" or "tails") and the same expected value if either "heads" or "tails" becomes their unanimous choice. In the real world there is no benefit in being the only individual driving on the wrong side of the road, or being the only person not wearing the same color shirt as the rest of the fans at the basketball playoff games.

Minimum-effort game

The pure coordination game has been refined in several ways to represent more complex situations. One family of refined coordination games is referred to as minimum-effort games (Skryms, 1996, 2004; Van Huyck et al., 1990; Camerer and Knez, 2000; Knez and Camerer, 1994; Cachon and Camerer, 1996; and Chaudri et al., 2001). In a minimum-effort game, players have to invest some effort to achieve a potential payoff, but the actual payoff to all players is tied to the effort of the person who contributes the least. Individuals participating in the minimum-effort game are faced with the dilemma of protecting their personal resources or investing their resources toward a group goal that will improve the welfare of everyone involved, while facing the risk that others might not contribute and their investment will be lost.

A simple example of a *chain-building* exercise can help clarify the nature and dilemmas inherent in the minimum-effort game. In the chain-building example a group of people have the task of building a linked chain that will be used to earn money for the group. Each person in the group is responsible for building one link of the chain. To do so, each person can choose to spend either $1 of their own money and build a weak link or $10 of their own money and build a strong link, see Figure 1.

Figure 1: Costs to build a strong or weak link

After each person has independently decided to build a strong or a weak link the links are joined into a chain and the strength of the chain is tested. The chain is only as strong as the weakest link, so that a chain is weak even if only one weak link is present; the exact number of weak links in the chain does not matter. Each member in the group will earn $5 if the chain is weak. If the chain is strong and made of entirely strong links; each member will earn $30. A person choosing to make a weak link will earn $4 regardless of the choices the others make. A person who chooses to makes a strong link might either lose $5 or earn $20 depending on the links the others choose to build. The chain-building example demonstrates the dilemma each individual of a group faces when deciding between personal resource security and group efficiency.

In this example of a minimum-effort game, when the players all coordinate to build the same type of link, the outcome is a game of *pure-strategy Nash equilibrium*. A "pure-strategy Nash equilibrium" exists when no player gains anything by being the only person to make a choice different than the rest of the group. When everyone makes the same type of link, the choice is sustainable as long as no new participants are added. The preference of outcomes between a strong-chain equilibrium and a weak-chain equilibrium are orderable because the game has different payoffs for different strength chains. The *Pareto-optimal* outcome is for everyone to make the strongest links. A “Pareto-optimal” outcome is a combination of choices in which it would not be possible to improve the well being of one participant without making the other participants worse off. However, strategic uncertainty exists because a player is unsure of the strategies others may choose. As the number of players increases the probability of someone building a weak link also increases. As the risk of someone creating a weak link increases, the probability increases that even people who would build a strong link in a lower risk environment might decide to build a weak link instead. With so many sources of risk and uncertainty about what others will choose, and thus which choice is the best choice, the only certain option is to build a weak link. Thus, as the uncertainty of others’ actions increases, the difficulty of making a strong chain also increases.

Collaborative partnerships as minimum-effort games

Compared with more traditional teams, civic collaborations are unique in that when they are successful, the actions of individual actors come together in a decentralized yet coordinated action. In civic collaborations, the participants normally have more choice over which programs to join (Roussos & Fawcett, 2000; Johnston & Hicks, 2004; Malone, 2004). In collaborative partnerships the dilemma of the chain-game occurs when individual participants choose between using their resources to further the goals of the collaborative partnership or to protect their personal resources (Hicks & Larson, 2003). Thus a major obstacle in creating an effective collaborative partnership is coordinating the action of all the participants toward the group goals.

As previously mentioned, when people are invited to participate in collaborative activities they must make a quick, often intuitive, judgment as to the likelihood that they will be exploited, rejected, or isolated by the others (Tyler & Lind 1992). Even though coordinating toward a common goal might provide significant advantages over pursuing self-oriented goals, a judgment that investing in group goals will lead to a relatively high likelihood of exploitation, rejection, or isolation will lead people to pursue self-oriented lower risk, lower reward goals (Tyler & Lind 2001). Directly evident in the successful civic partnerships observed in Colorado was the willingness for stakeholders to risk their own interests while focusing on broader and often more difficult to reach goals. The minimum-effort game captures many of the characteristics that occur when stakeholders have a choice in how to coordinate their efforts in collaborative partnerships.

Step 3: Agent-based Modeling

The unique characteristics and the empirical strength of agent-based modeling make it an appropriate method by which to study interventions in the growth process of civic collaboration. We use observations from the field and a previous laboratory experiment as empirical benchmarks for the development of the agent-based model. Within the agent-based model, computer-simulated agents serve as experimental "subjects" whose behaviors are controlled by specific behavioral rules. Interactions among agents could induce social structures, group level behaviors, and differences in performance outcomes. Individual choices are formalized as strategic behaviors in a game-theoretic minimum-effort game (Skryms 1996, 2004; Van Huyck et al., 1990; Camerer and Knez, 2000; Knez and Camerer, 1994; Cachon and Camerer, 1996; and Chaudri et al., 2001). The model serves as an artificial collaboration environment where we can easily manipulate different parameters, visualize individual and combined effects during the growth process, and eliminate confounding influences that would be unavoidable in the real world. By manipulating the size of the initial group, the growth rate of the simulated civic collaboration program, and the ways in which new members are included into the group, we can infer their respective effect on success of the program.

Understanding the growth process in natural groups is particularly difficult for many reasons. Much of the empirical foundation of group theory comes from studying a specific type of ad hoc group in a laboratory with no history and a very limited future. The membership of the group is normally assigned, and the experimenter controls the simple tasks they perform. Laboratory groups exist independent of context and are not embedded in any larger social units (McGrath, 1991). However, when studying groups in their natural settings, it is difficult to experiment with various conditions, observe enough critical variations to draw conclusions about causality, and avoid influencing the interaction of the groups while observing them. These specific limitations have been reported with the previous research on the NFP civic collaboration in Colorado (Hicks, et al, Submitted).

To address the difficulties with individual research methods we have adopted a variation of the three-part research strategy proposed by Arrow, et al. (2000) that combines a theoretical framework, empirical studies, and agent-based modeling. A multi-method approach is necessary to understand and explore multiple aspects of the problem, see Figure 2.

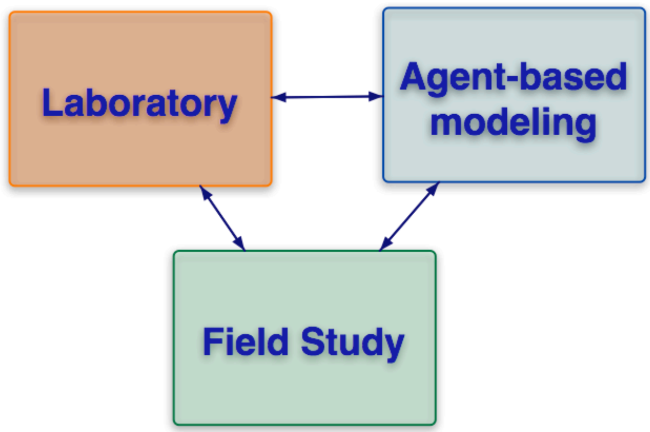

Figure 2: Multi-method research agenda

Agent-based modeling can be used to test separate hypotheses and generate explanations of complex group behavior. Understanding the dynamics, history, and relations between agents in an environment can complement field studies and may be a more satisfying explanation of behavior observed in the environment (Lansing, 1993). Compared with traditional social science paradigms, such as statistical estimating and differential equations, agent-based modeling has five unique characteristics. First, it takes a bottom-up approach. Rather than seeking a centralized control mechanism for orderly behaviors of a system, agent-based modeling explores whether decentralized interactions among autonomous actors can lead to system-level regularities (Holland, 1995; 1998). Second, an agent-based framework assumes adaptive rather than fully rational behaviors of actors (Axelrod, 1997). Actors with limited information and foresight adopt strategies through interacting with others. Third, an agent-based model allows heterogeneity among actors, whereas traditional social scientists often suppress agent heterogeneity in order to make their models tractable (Epstein & Axtell, 1996). Fourth, agent-based modeling focuses on dynamic processes that produce or disrupt equilibria rather than the static nature of equilibria (Epstein & Axtell, 1996). Last, traditional statistical or multi-equation modeling assumes linear, deterministic or predictive relationships among parameters, whereas an agent-based framework explicitly takes account of nonlinear, nondeterministic, or recursive interactions among multiple levels of actors.

Another advantage of agent-based modeling is that the model does not try to explain everything about the phenomenon of interest; simplicity is its strength. The model also avoids attempting to replicate the real world exactly. A model can show that something that has previously been explained in a complex manner might in fact be the result of a simpler explanation (Axelrod, 2003). Instead of looking for correlations between characteristics and outcomes, agent-based models allow for the investigation of an entire process. They can also be used to isolate competing hypothesis because of the ability to control completely the experimental environment difficult to obtain in natural settings (Lansing, 1991; Nan, et al. 2005). Agent-based models gain strength as a research method when they are part of a larger research program (Arrow, 2000). In this case an agent-based model is being grounded by a field study, then calibrated and validated with previous experimental findings.

Overview of remaining work

For the next two chapters of the dissertation, I will use agent-based modeling to test the individual and combined effects of the interventions that we believe are indicative of a high quality civic collaboration.

In chapter two, I begin by creating a baseline model similar to experiments that have studied minimum-effort games in the lab (Van Huyck et al., 1990; Camerer and Knez, 2000; Knez and Camerer, 1994; Cachon and Camerer, 1996; and Chaudri et al., 2001). The model is designed to be as simple as possible, and any variables in the model will be calibrated based on results from the previous seventeen years of laboratory experiments of different size groups playing minimum-effort games. I also created a parallel mathematical model that serves to perform an internal validation check of the fidelity of the model. After the baseline model is calibrated and validated, I test the first intervention that we observed in all of the NFP civic collaborations in Colorado, specifically:

- Snowball growth process starting with a small initial group

This intervention starts with small groups playing the minimum-effort game, and then steadily increasing the number of people playing the game. This intervention will be validated with a similar study that focused on the growth of group size in a laboratory experiment, which found that managing the growth process was one way to increase the success of groups playing a minimum-effort game (Weber, 2006).

In chapter three, I will use agent-based modeling to understand the qualities of the growth process that differentiated the successful from the less successful civic collaborations in the NFP implementations in Colorado. To do so, I will expand on the baseline model by adding two interventions, specifically:

- Deliberative planning process
- Thoughtful inclusion of new people

Both of these interventions can be modeled individually or together in the agent-based model.

For the deliberate planning process, we found that the more successful groups did not rush the initial planning process, took whatever time was necessary to reach a consensus before growing, and took time to allow for the participation of everyone involved. The less successful groups focused more on meeting internal deadlines, progressing through the development stages quickly, and brought too many people into the group too quickly. To model this intervention we vary the rate of adding new participants. In the model, when the rate is lower, the participants play in multiple rounds of the game with the same number of participants before adding any new participants.

For the thoughtful inclusion of new people, we found that in the more successful communities, time was taken not simply to slowly include new members, but to gradually involve them into the activities of the group. In the less successful groups, new members were frequently thrust into participating in the group without knowing the history of the group. To model this intervention we have new members playing the game by interacting with only a subset of the existing population. As they continue to form part of the group, the number of participants they play with gradually increases.

The two growth interventions (deliberative planning, and gradual inclusion into the game) are analyzed in isolation and also in combination with the other interventions during growth, in order to isolate the individual and combined effects of each, see Table 3.

Intervention	In field	In Model
Growth starting with a small initial group	Snowball inclusion of new participants during the growth of the working group	Start with 2 players, play round, add player, play round, repeat.
Deliberative planning	Time taken to deliberate resulting in slower progression through first phase of collaboration	Repeated play at the same size group
Gradual inclusion of new participants	Thoughtful inclusion of new people by sharing history and slowly	When a new player joins the game, they play with only one other player. For

	increasing their role of participation	each round, they play with an additional player

Table 3: Modeling the three interventions

Chapter 2

Baseline Agent-based Model

...models that aim to explore fundamental processes should be judged by their fruitfulness, not by their accuracy. For this purpose, realistic representation of many details is unnecessary and even counterproductive.

-Robert Axelrod, the Complexity of Cooperation (p.6)

Introduction

This chapter has four goals:

1. Introduce a baseline agent-based model of agents playing a minimum-effort chain building game.
2. Given the existing literature from previous laboratory experiments of different size groups playing minimum-effort games, calibrate the model based at the parameter and process level.
3. Add the growth intervention to the model and test whether growth enables coordination in larger groups than a no-growth condition.
4. Verify the growth intervention with a laboratory finding that used a similar intervention (Weber, 2006).

The agent-based model is used to recreate the dynamics of a controlled experimental environment. Agent-based models can be described by defining their agents, environment, rules and interactions, and measurements. For the remainder of this dissertation there will be four versions of the model:

1. Baseline model
2. Intervention 1: Growth
3. Intervention 2: Deliberate planning / Slow Growth (in Chapter 3)
4. Intervention 3: Gradual inclusion / Small Chains (in Chapter 3)

Each subsequent version will extend the previous model by adding characteristics or features to the agents, environment, rules and interactions, and/or measurements.

Baseline model

The following description explains the baseline model created using NetLogo (Wilensky, 1999). In all versions of the model, the agents will play multiple rounds of the chain building game with other agents. In each round, each agent will independently choose to build either a strong or weak link. After each of the agents has chosen whether to build a strong or weak link, they will receive a payoff based upon their choices and the collective actions others chose, see Table 4.

		The collective choices of other players	
		All strong links	One or more weak links
Individual player's choice	Strong link	*Strong-chain-payoff*	*Sucker-payoff*
	Weak link	*Weak-chain-payoff*	*Weak-chain-payoff*

Table 4: Payoff table of minimum-effort chain game

Agents

There are two types of agents in the model, players and links.

Players

Players are created with one attribute, their *generic attitude* toward other players (see Figure 3).

Figure 3: A typical player

This level is a value from 0 – 1. *Generic-attitude* * 100 represents the percent likelihood they think a player they have no other information about would build a strong link. The *generic-attitude* for each agent is randomly drawn from a normal distribution with a mean determined by the environmental variable *average-attitudes* and a standard deviation of .2. If the result of the random draw is greater than 1 or less than 0, then generic-attitude is set to 1 or 0 respectively for that player.

Two observations justify the use of a *generic-attitude* variable to estimate others behaviors. First, according to the economics literature on coordination games, the main issue in coordination results from a player's uncertainty over what others will do

(Crawford, 1995; Weber, 2005). The *generic-attitude* variable reflects this uncertainty. Second, based on field observation, the level of participations of stakeholders in the NFP collaborations in Colorado was based in part on the attitudes they had towards others and toward the overall process (Hicks, et al., submitted 2006).

Links

The second type of agent in the model, links, represents and maintains the attitude one player currently has toward another player. Each player maintains a relation to each of the other players in the model by individual directed links. The links are initialized based on the *generic-attitude* of the player from which they emanate. Figure 4 shows links emanating from player 0 toward both players 1 and 2. Not shown in the figure are the links that players one and two have toward each other and toward player 0.

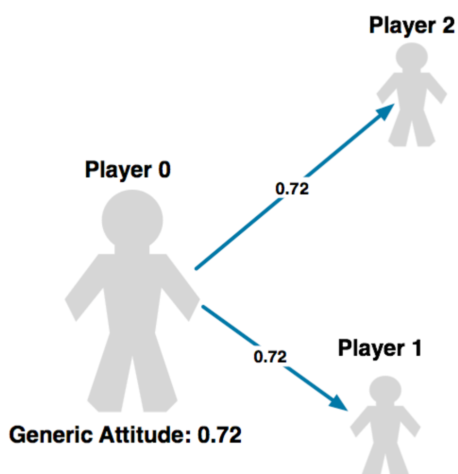

Figure 4: A player and the attitudes held toward other players stored in links

As the game is played, the attitude held in each link is updated.

Environment

The environment for the baseline model consists of six variables: *group-size*, *average-attitudes*, *participation-update, strong-chain-payoff, weak-chain-payoff, and sucker-payoff*.

Group-size

The *group-size* variable is the independent variable in the baseline model experiment. *Group-size* is set between 2-12 to represent how many players are participating in the experiment.

Average-attitudes

The *average-attitudes* variable is the mean of the normal distribution that a player's *generic-attitude* is drawn from. The *average-attitudes* value can be set from 0 to 1. Higher levels of this value represent a population that, on average, will believe that other players are more likely to build strong chains. For the baseline model, this value was calibrated at 0.75[5].

Participation-update

The *participation-update* variable is a model setting and it is applied to all links to calculate to what degree a players will change their attitudes of other players' next actions based on the outcome of the current round. This variable can be set from 0 to 1. A value of 0 represents that no change in attitude will be made. A value of 1 will change a links attitude to either 0 or 1 based on the outcome of round.

Payoffs

[5] Other values for *average-attitudes* tested were 0.50, 0.90, & 0.95. The use of a value of 0.75 is justified in the model calibration section.

The payoffs for the minimum-effort game follow the form that the strong-chain payoff is higher than the weak-chain-payoff, which in turn is higher than the sucker payoff (Skryms, 2004). The specific values of each payoff were set according to the payoffs used in the minimum-effort game in agent-based model used in Johnston (2006), see Table 5.

		The collective choices of other players	
		All strong links	One or more weak links
Individual player's choice	Strong link	*Strong-chain-payoff (8)*	*Sucker-payoff (0)*
	Weak link	*Weak-chain-payoff (3)*	*Weak-chain-payoff (3)*

Table 5: Agent-based model payoff table

Interactions / rules

This section details how the model represents the experiment, from the setup through the steps of each round.

Setup

The model creates a group of agents equal to the group-size variable. For example, Figure 5 shows a sample initial set up an experiment with a *group-size* of 3 and *average-attitudes* 0.75.

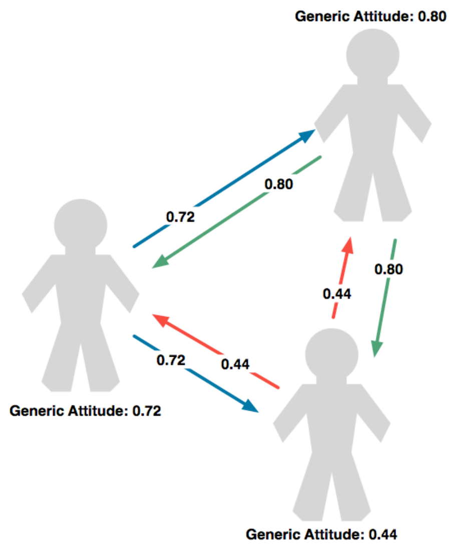

Figure 5: A generic setup of *group-size* 3

Each agent has a *generic-attitude* drawn from a normal distribution based on the *average-attitudes* variable. The player's individual attitudes toward other players are stored in the links emanating from them.

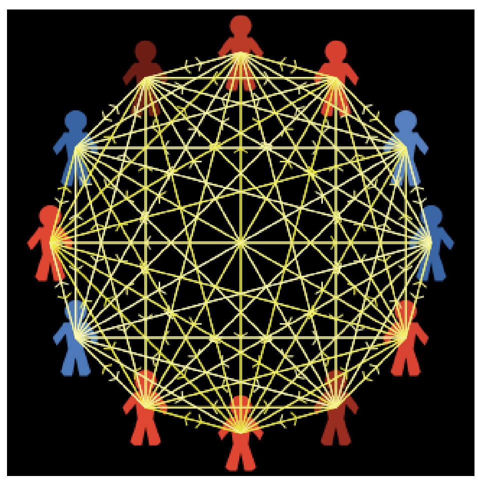

Figure 6: Screen-capture after setup with group-size 12

See Figure 6 for a screenshot of the setup of the baseline model with *group-size* 12.

Playing a round

A round consists of each player making a choice to build a strong or weak link, receiving a payoff based on their choices and the group outcome, and then updating their attitudes of the other players based upon the group outcome.

The first step of each round has every player choose to build a strong link or a weak link. To make this choice each player independently calculates the expected value of choosing to build a strong link based upon their current estimate of attitudes of the other players in the room. Specifically, they use the following calculation:

*Expected value of a strong-link choice = my-attitude-toward-player 1 * my-attitude-toward-player 2 * ... my-attitude-toward-player-n * strong-chain-payoff*

A player will choose a strategy based upon the highest expected value of all available strategies (Winter & Szulanski, 2001). If the calculated expected value of a strong-link choice is greater than the weak-chain-payoff, then the player will choose to build a strong link. If the calculated expected value of a strong-link payoff is less than the weak-chain-payoff, then the player will choose to build a weak link. There is no need to calculate an expected value for a weak-link choice because the payoff of choosing to build a weak link is always the weak-chain payoff, regardless of what others choose. In the model, agents who build a strong link are shown in blue, and those who build a weak link are shown in red, see Figure 7.

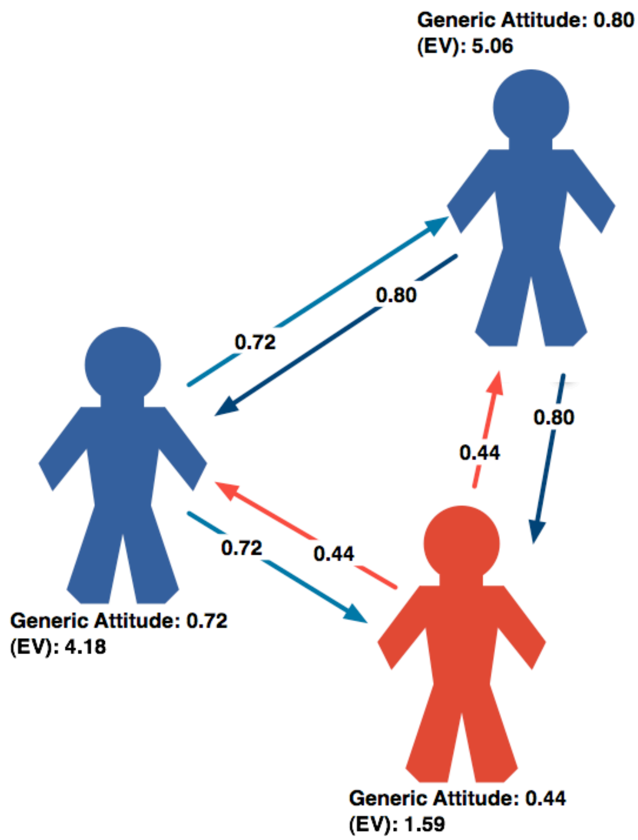

Figure 7: First round choices based on a comparison of the expected value of a strong link choice and the weak-chain payoff of three

The final step of each round is for each of the players to update their attitudes toward the other players based upon the group outcome. The group outcome is used to simulate the same information present in the laboratory experiments, wherein at the end of each round the experimenter would announce only the minimum choice of the participants without revealing players' individual choices[6]. If the group-outcome was a weak chain, each attitude would be updated using the *participation-update* variable according to the following calculation:

[6] While in small-size games it might be possible to deduce the specific actions of the other players, that dynamic was not replicated in the model.

*updated-attitude = current-attitude – (current-attitude * participation-update)*

If the group-outcome was a strong chain, each attitude would be updated using the *participation-update* variable according to the following calculation:

*updated-attitude = current-attitude + ((1 – current-attitude) * participation-update)*

For example, if the three agents in the figure played one round, then two players would choose to build a strong link and one player would choose to build a weak link. The outcome would be a weak chain, due to the presences of one or more weak links; the weak link player would receive the weak-chain payoff, and the strong link players would both receive the sucker payoff. Afterward, they would update their attitudes using the first equation with a participation-update variable of 0.75. Figure 8 shows the updated attitudes, and the expected values and choices for round 2.

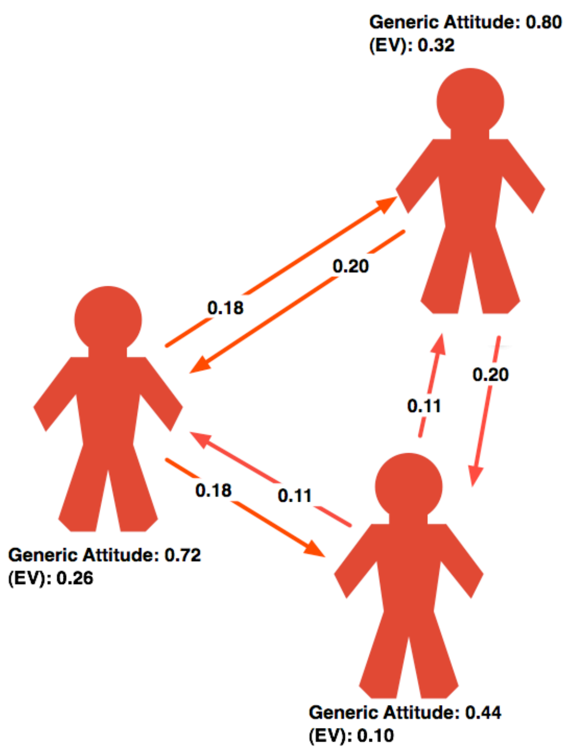

Figure 8: Round 2 choices, attitudes, and expected value for strong-link choice. All expected values are less than the weak-chain payoff of three, so all players choose to build a weak link (red players).

The model then runs another round in which the agents each make a choice, receive a payoff, and update their attitudes of other players. In the baseline model, each experiment is run for 12 rounds.

Measurements

The dependent variable in the baseline model is the group outcome of the final round of the experiment. The example shown in figures 3, 4, 5, 7, and 8 would be a weak-chain outcome.

Model Validation

There are significant limitations to using agent-based models as a research tool. While such models may be closely controlled, results derived in artificial situations do not always extend well to more naturalistic settings. One common complaint is that simplifying the model significantly decreases the credibility and applicability of the resulting findings. Agent-based models also normally face greater challenges of validation than more mature methods of scientific research (Axelrod, 2003). However, these challenges can be overcome by creating a deliberate plan for validation at the onset of the modeling project. Validation is neither a simple nor clearly defined topic (Johnston, 2005). To validate our agent-based model we employ three validation processes proposed by Carley (1996): grounding, calibrating, and verifying.

Grounding

Grounding establishes the reasonableness of the model, showing that simplifications made from the real world do not trivialize the model and that other researches have successfully made similar assumptions to capture the key elements of the theory. The grounding of the model was largely addressed in chapter one in the discussion of game theory and why, in particular, the minimum-effort coordination game most closely represents the collaborative partnerships in Colorado.

Calibrating

Calibrating the model is an iterative process of modifying its variables to fit the real data that is available. In this dissertation we calibrate the *average-attitudes* and *update-participation* variables of the baseline model by the comparing model outcomes of different size groups which have different variable settings to the experiments of different size groups playing the minimum-effort game (Van Huyck et al., 1990; Camerer and Knez, 2000; Knez and Camerer, 1994; Cachon and Camerer, 1996; and Chaudri et al., 2001; Weber, 2006).

Verifying

Verifying the model is the process of demonstrating that it matches the real world in some capacity. During verification, unlike the calibration phase, the variables in the model are not altered. In this dissertation we verify that the growth intervention of the model matches the recent findings from Weber (2006), where both his experimental findings and the model in this dissertation show that the mechanism of growing a group from a small to a large group size can result in the coordination of groups of size twelve.

Model Calibration

Calibration occurs at both the process and parameter levels. For the process calibration, the overall design of the experiment in the model, up to twelve people playing a repeated minimum-effort game, was motivated by the design of laboratory studies (Van Huyck et al., 1990; Camerer and Knez, 2000; Knez and Camerer, 1994; Cachon and Camerer, 1996; and Chaudri et al., 2001; Weber, 2006).

For parameter level validation, the design of the model requires setting the *average-attitudes* and *participation-update* variables to specific values for the experiment. Although different settings of these variables do have an effect on the model outcome, this dissertation does not study how different baseline attitudes or different reaction rates to behaviors effect program outcomes. To test the interventions of interest (growth from a small group, slow growth, and small-chains), the variables *average-attitudes* and *participation-update* need to be calibrated to settings that produce a set of expect results in the baseline model and to be left at that level for the remainder of the model development.

To calibrate reasonable values for *average-attitudes* and *participation-update* variables, the model was run 1000 times for each of the 16 different combinations of four different *average-attitudes* values [0.5, 0.75, 0.9, 0.95] and four different values of *participation-update* values [0.2, 0.5, 0.75, 0.9] over different group-sizes [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12] for a total of 176,000 runs. The results were then compared to findings taken from the last seventeen years of experimental research into coordination within different size groups in minimum-effort games.

Studies of group coordination problems in the lab show that as the size of the group increases its ability to coordinate the actions of those individuals involved sharply decreases (Van Huyck et al., 1990; Camerer and Knex, 2000; Weber 2006). The experimental difficulty of making "strong chains" has been the focus of research for some time[7]. In a series of laboratory studies from 1990 to 2006, coordinating any group larger than 6 members within the lab was nearly impossible (Van Huyck et al., 1990; Camerer and Knez, 2000; Knez and Camerer, 1994; Cachon and Camerer, 1996; Chaudri et al., 2001; Weber, 2006). These findings are summarized in Figure 9.

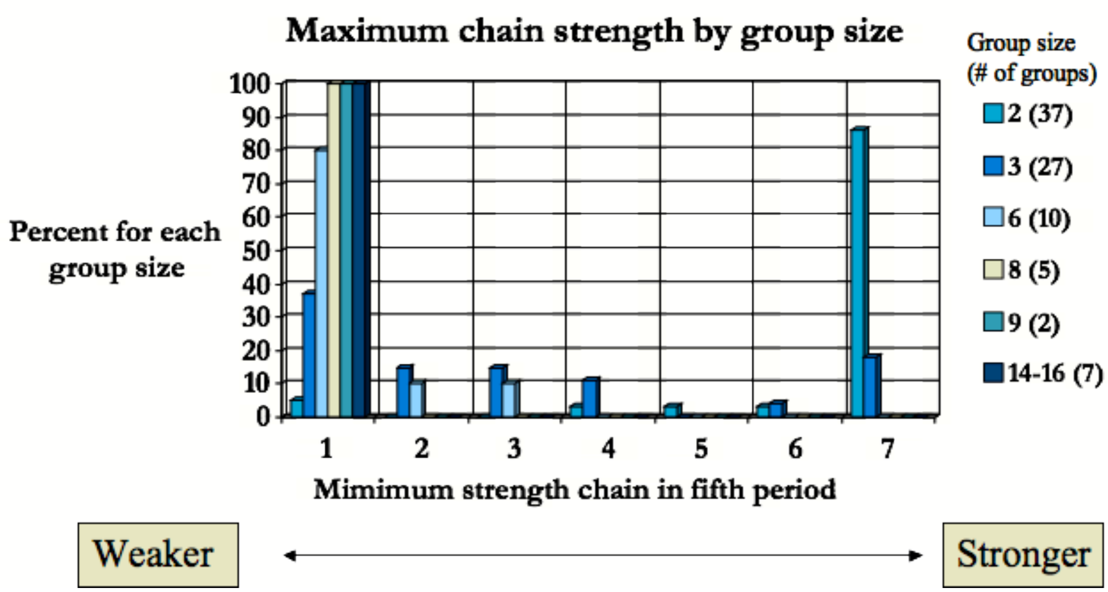

Figure 9: Maximum strength chain based on group size

In these studies the subjects participated in a 7-action minimum-effort game. To compare it with the chain-building example, the players build a chain by choosing between seven different strengths of chain links, and the payoff to the group is based on

[7] While the experiments do not use the chain-building analogy, the structure of the minimum-effort game that was used is identical to that of building chains with different strengths. For the sake of consistency, throughout this dissertation I will describe the experiment as if the experiment is a chain-building game.

the weakest link. Also demonstrated in Figure 9, when a group is comprised of only two members, *eighty-six* percent of the time both participants coordinated to the strongest-chain equilibrium. Even the addition of one extra person drops the ability to coordinate in the strongest-chain equilibrium to *eighteen* percent. Six people were unable to coordinate any higher than the third worst outcome, and that was only *ten* percent of the time. Finally, groups of eight or more always coordinated on the *risk dominated equilibrium*. A "risk-dominated equilibrium" is a strategy in which the participants choose to maximize their outcome regardless of what choices the others make. In this case the risk-dominated strategy is to build the weakest link.

In the laboratory studies, the minimum-effort game was played with seven different possible choices. To account for difference in the baseline model with only two choices, I perform the data transformation of treating any non-risk dominated outcome as a weak-chain outcome. To calibrate the model I compared the results in the literature with the results of the 16 possible configurations of variables on the basis of three criteria: value validation, point validation, and pattern validation (Carley, 1996).

1. Percent of non-risk-dominated outcomes of two player games (value validation)
2. Size above which participants could not coordinate and reach a non-risk dominated outcome (point validation)
3. Same general pattern of results as size increases (pattern validation)

Based on these criteria, of the 16 possible configurations of variables, the setting the average-attitude variable to 0.75 and the *participation-update* to 0.75 produced the best fit, see Figure 10.

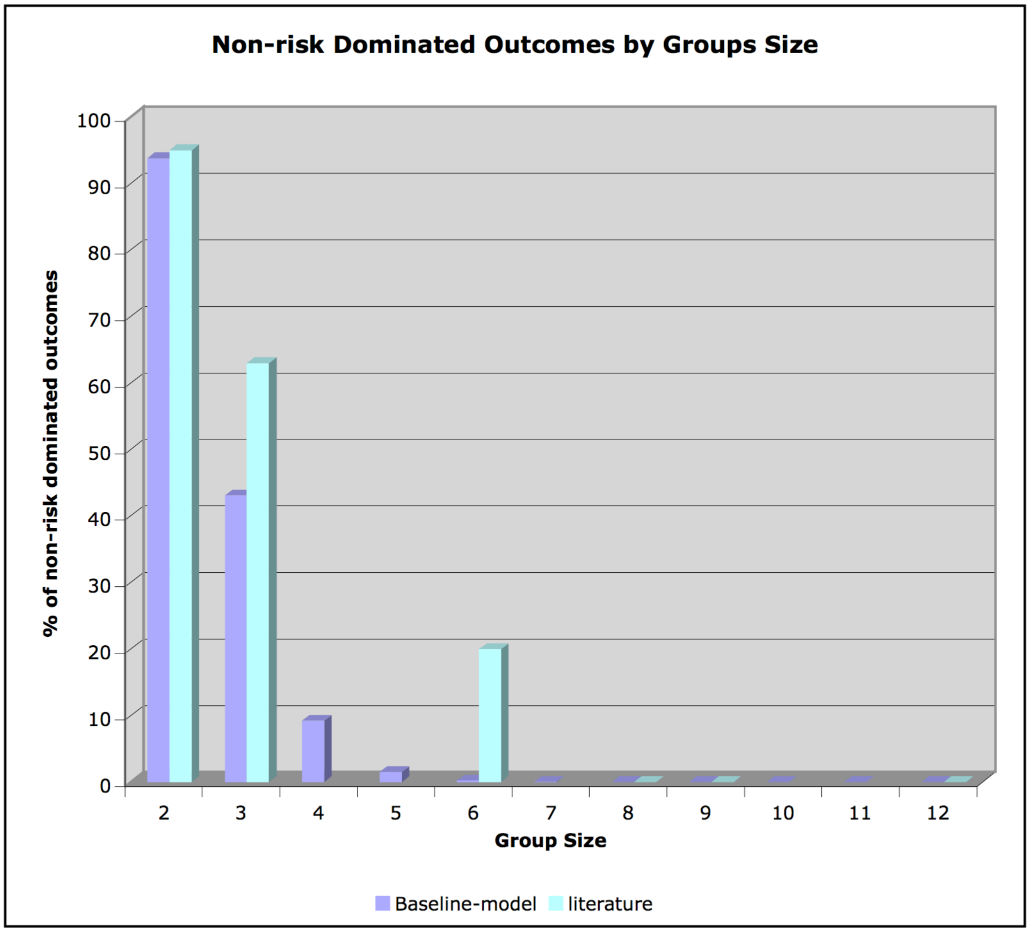

Figure 10: Comparison of literature results and model results with settings (*average-attitudes* - 0.75) and (*participation-update* - 0.75)[8]

Applying the three criteria, we claim value validation because at group size 2, the 93.8% of model outcomes were not the risk-dominated outcome, and in the laboratory, across six studies and 37 groups of size 2, 95% of outcomes were not the risk-dominated outcome. We claim point validation, because in both the laboratory experiments and the model, some trials were able to coordinate to a non-risk-dominated outcome with a group-size of six, but not at group sizes larger than 6. And finally, we claim pattern validation because for a group size of two, there was a high likelihood of coordinating to

[8] The laboratory experiments used for comparison did not test groups of sizes 4, 5, 7, 10, or 11.

a non-risk-dominated outcome; however, the addition of even one extra person drastically reduces the ability to coordinate, and increasing group size additionally continued this pattern, both in the laboratory and in the agent-based model. A linear regression run on the model data found that the group size had a statistically significant relationship to the coordination outcomes ($p < .001$).

Intervention One: Growth

The baseline model is extended to test whether using a growth mechanism during the minimum-effort game will increase the likelihood of coordination in larger outcomes. In a run with a final *group-size* of 12, the game will start with two people playing the minimum-effort game while a third person watches. In the next round the person who was watching will join in the game play and a fourth person will be added to observe the game. This pattern continues until there are 12 players in the room all playing the game. Having a player observe one round before participating is motivated by an experiment (described in greater detail later in this chapter) that also uses growth in coordination games (Weber, 2006).

Agents

Both players and links have the same characteristics as players and links in the baseline model. Players agents are extended to have a binomial variable *active?*. If *active?* is set to true then a player is actively playing in a particular round. If *active?* is set to false than they are observing the outcome of the round, but they are not participating in the game or influencing the outcome of the game. Observing agents in the model are represented by the color gray.

Environment

The group-size variable represents the final size for the group. All groups start with only two active players and add one player each round until the final group size is reached. One new variable in the growth model is the *observation-update* variable. Similar to the *participation-update* variable, this variable is used to update the attitude, based on the round-outcome, that an active player has toward a participant observing, but not participating in the game play. Knowing someone observed an outcome is a way of knowing that the two players have both observed the same events in the model's history, though it does not provide the same degree of information as actually having played with another person. For this reason, the observation-update variable is set between 0 – 1 and is less than the participation-update variable. In the model, the observation-update variable is set to 0.5.

Interactions / rules

The baseline model will be run adding one player to the game each round until the simulation reaches the final group-size.

Setup

In group-sizes of 3 or higher, during the setup of the model, three players and their associated links to other players are created. Two players have *active?* set to true and the third player has *active?* set to false, see Figure 11.

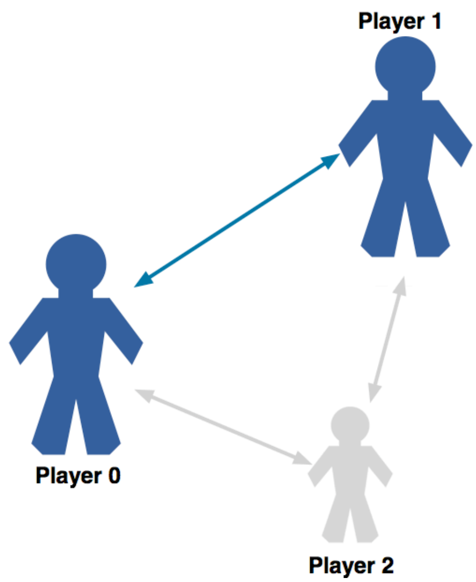

Figure 11: Setup in growth condition of group sizes 3-12. Blue players are active and making a strong-chain choice; the gray player is observing the play of the others

Play round

Playing a round is similar to the baseline model, where players make a strong or weak link choice, receive payoffs, and update their attitudes toward others. However, in the growth game, only players with *active?* set to true make a strong or weak link choice, and that choice is based on an evaluation of their attitudes toward only other players with *active?* set to true.

Updating attitudes

The final step of each round is to update the attitudes of players toward all other players, based upon the group outcome. Both active players and observers update their attitudes toward all other players based on the group outcome in each round. If the group-outcome was a weak chain, each attitude toward people who participated would be updated using the *participation-update* variable according to the following calculation:

*updated-attitude = current-attitude – (current-attitude * participation-update)*

If the outcome was a strong chain:

*updated-attitude = current-attitude + ((1 – current-attitude) * participation-update)*

If the group-outcome was a weak chain, the attitude of all links directed at people who observed would be updated using the *observation-update* variable according to the following calculation:

*updated-attitude = current-attitude – (current-attitude * observation-update)*

If a the outcome was a strong chain:

*updated-attitude = current-attitude + ((1 – current-attitude) * observation-update)*

At this point all existing attitudes have been updated based on the group outcome and activity status of the players.

Next round

At the beginning of the next round, and all rounds until the final round, the following sequence of events occurs. First, the player that observed in the previous round is made active and will participate in the current round. Next a new player is added to the room to observe, see Figure 12.

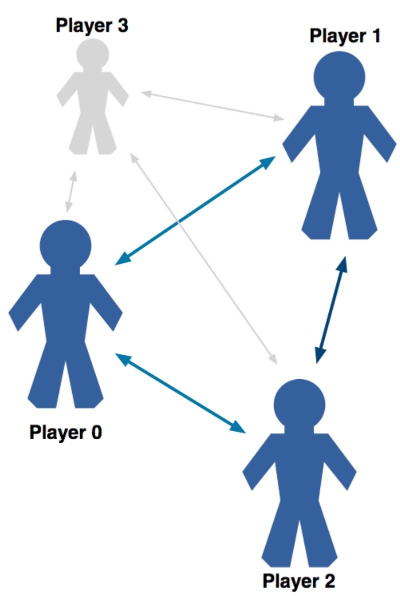

Figure 12: Growth round 2, now three active players and one new observer

When the new player is added to the room, new links are created from each current player to the new player based on each individual's *generic-attitude*. For the new player, they form links to all existing players based upon their own *generic-attitude*. The new player is not active and does not participate in the next round of the game.

Final round

In the final round of the growth model the new participant that was added in the previous round is made active, and no new participants are added. All players play one final round of the chain-building game.

Measurements

There are two possible outcomes of the model. Figure 13 shows a screen-shot from the Netlogo growth model of a weak-chain outcome, and Figure 14 shows a screen-shot of a weak-chain outcome.

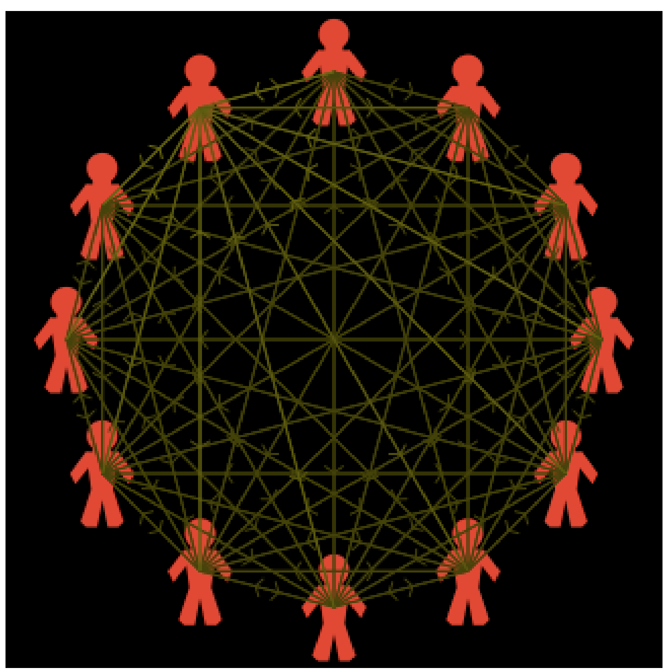

Figure 13: Weak-chain outcome

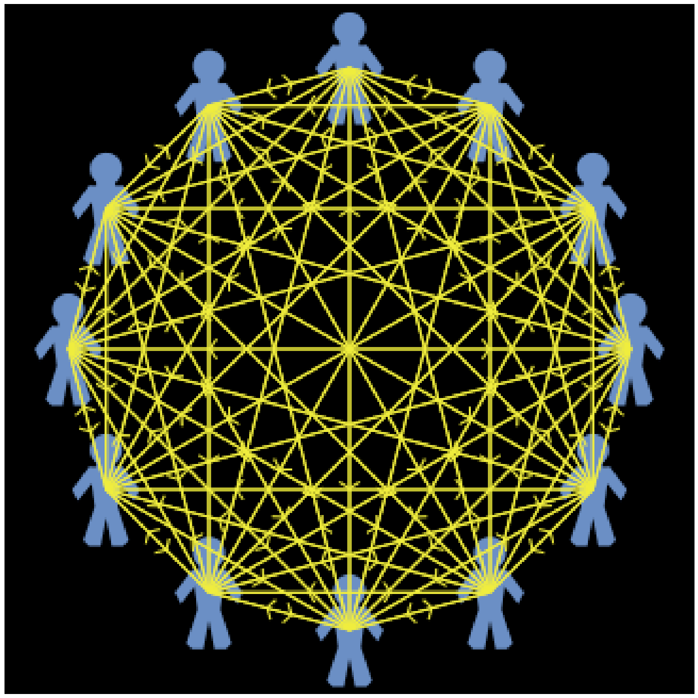

Figure 14: Strong-chain outcome

The brightness of the links represents the attitude of one player to another. Brighter links indicate an attitude that someone is more likely to build a strong link. A faded link indicates an attitude that someone is less likely to build a strong link. The brightness of the players also represents the certainty with which they made their choice to build a link. Faded players are close to the threshold between choices.

Results

Growth matters. A one-way ANOVA comparison of the final outcomes of the growth and no-growth conditions for 11 different group-sizes (2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12) showed significant overall differences, ($F (1, 4281)= 3.4$, $p < .001$.), see Figure 15 for a results comparison of the no-growth condition of the model, the no-growth laboratory findings from the literature, and the growth model.

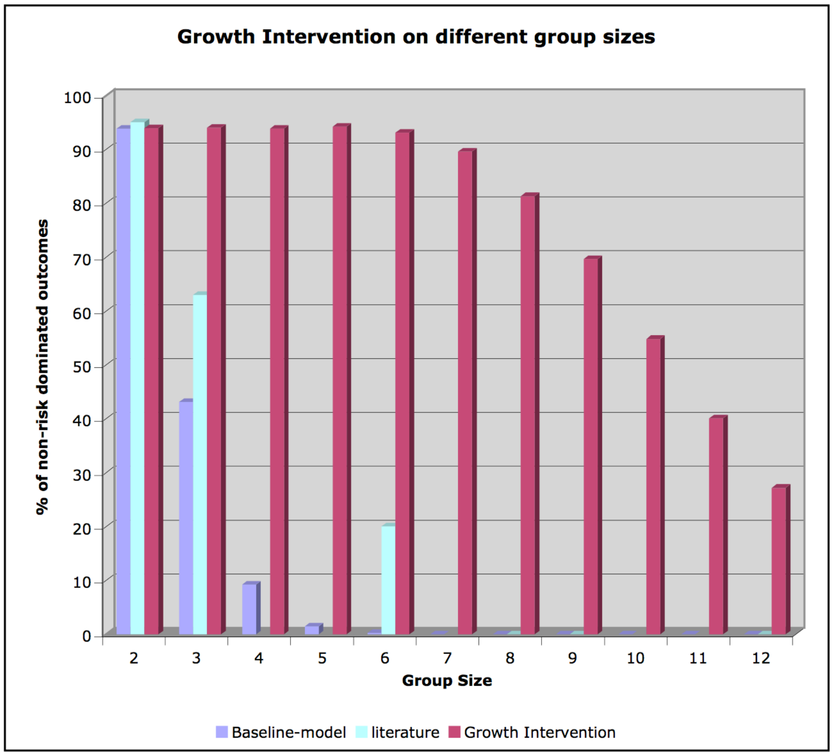

Figure 15: Percent of non-risk dominated outcomes with different group sizes in the literature, baseline model, and growth model

Model Verification

The growth intervention of the model is verified by comparing the results with the recent findings from a laboratory experiment that also used growth as an intervention to increase the likelihood of coordination in large groups (Weber, 2006).

Verification based on experimental studies

In Weber's laboratory study, 12 people played a minimum-effort game similar to those previously described with seven different chain strengths. The experiment was designed to test steady growth and whether new entrants observing the previous performance of the smaller group could produce groups coordinated to stronger-chain equilibriums than control groups that started out large and did not change size. The two conditions of the experiment were:

1. ***Control group:*** Twelve subjects played the game for twelve rounds
2. ***Growth group***: New entrants observe the group's history of previous choices

In each round each player chose a number 1-7 to correspond to the strength of chain link they wanted to build and gave their choice to the experimenter. The experimenter calculated the strength of the chain based on the minimum value given and then wrote the chain strength on a board for the group to observe. Before the next round the board was erased and the next round started. In the growth condition, at commonly known times, other participants joined the group of those actively playing in the game. The growth conditions ran for 22 rounds, compared to the 12 in the control group. Extra rounds were added so that in the growth condition the first two participants could repeatedly play the game before new participants joined. When playing in a group of two, repeated interactions increased, but did not guarantee the likelihood that the two would coordinate to a highly efficient equilibrium. In the history condition both people actively playing and those that were added later were present in the room. In both conditions all twelve people played in the last few rounds.

Weber's Laboratory Results

The control group with no growth that started out at a large size mimicked the results of previous experiments in which no groups were able to coordinate above the risk-dominated, weak-link strategy. In the history condition, when the group was of size two they were able to coordinate to a Pareto-efficient, strong-chain outcome. Groups that grew when new members observed previous behavior were able to coordinate at higher levels of efficiency, including the strong-chain outcome. However, growth did not guarantee the strong-chain outcome. In some cases these groups reverted to the risk-dominated strategy. Subjects in the growth condition were able to coordinate on the strong-chain outcome 22% of the time, on the risk-dominated, weak-chain outcome 44% of the time, and somewhere in between (medium strength chain) 33% of the time. If the initial stages of the game produced the risk-dominated outcome, then the end result was also a risk-dominated outcome. Every time that a strong chain was the final outcome, the initial interactions also resulted in a strong-chain outcome. This experiment shows that the use of growth is a potential mechanism for achieving coordination in large groups with real people, something that had previously not been obtainable in a laboratory setting.

Comparison of laboratory with model

In both the model and the laboratory experiment the growth intervention enabled, but did not guarantee, the strong-chain outcome of groups of size 12. A close examination of the model outcome also finds that the pattern of individual results follows the qualitative results of the Weber (2006) experiment. Both methods found groups that were not able to coordinate above the risk-dominated outcome in the first round, groups that coordinated for a few rounds and then transitioned to the risk-dominated outcome before reaching the full group size, and groups that coordinated the entire time. The general proportion of groups that were able to coordinate the entire time was also similar: 27% for the agent-based model and 22% for the laboratory experiment using the calibration settings from the baseline model. Finally, in either the lab or the model, there were no groups that started out within the risk-dominated outcome and then transitioned to the strong-chain outcome[9].

Discussion

To revisit the four goals of the chapter: a baseline agent-based model of agents playing a minimum-effort chain building game was introduced (1). The model was calibrated at the process level my mimicking the design of previous experiments that used the minimum-effort game. The model was calibrated at the parameter level by adjusting the average-attitudes and performance-update variables to reasonably simulate previous laboratory experiments of different size groups playing minimum-effort games (2).

After this calibration process, the model was extended through the addition of the growth intervention (3). This intervention was motivated by the Colorado collaborative partnerships that used a similar growth process starting with a small initial group when developing their working group. The model indicated that growth enables more coordination in larger groups than a large to begin with condition and then verified the growth intervention with a laboratory finding that used a similar intervention (4) (Weber, 2006).

Like all good models, the baseline and growth models provide some insight into the larger phenomenon of interest and also raise additional questions.

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[9] Weber's experiment also tested another condition in which growth occurred, but new entrants joined the group with no knowledge of the group's history. Without knowledge of previous group behavior, these groups preformed similar to the no-growth, control condition, failing to coordinate to the strong-chain outcome. The agent-based model also tested a similar condition, growth without observation, and the results were similar to the laboratory no-history condition. In 1,000 rounds, no groups of size 12 achieved a strong-chain outcome.

Both the model and the laboratory study show that early interactions are very important. This is consistent with previous findings. Gersick (1988) studied the entire life cycle of eight naturally occurring teams and found that people's first interactions with each other set lasting precedents that affect the ways in which members of the team will relate to each other and perform for the remainder of the project. In the model, groups that started as weak-chain builders were never able to switch and become strong chain builders. In the lab, groups that did not have early strong-chain interactions also never transitioned to strong-chain builders later in the experiment. A similar quality was reported during the interviews with the directors of IIK:

> ***Deputy Director of IIK:*** *I have see communities go from adequately performing to low and high-performing to low, but not the other direction.*

This is consistent with correlation found in the Colorado NFP collaboration that groups with a low-quality planning process will likely be low-performing for the lifecycle of the program (Hicks, et. al. submitted 2006).

Additionally, by observing the model in progress, rather than simply recording the final outcome, it was apparent that in the growth cases that started out with early coordination but then failed, it was the addition of new participants and the choices they made that caused the group to fail. Until recently, the growth process, and the challenges associated with when and how people join a collaborative partnership, have been largely overlooked. In the majority of group research, as with Gersik's work, the established group has been the central unit of investigation (Kelly, 1990; McGrath, 1991; Wrochel, 1994; Arrow et. al, 2000). The challenge of transferring to program outcomes the benefits of including a growth process in the initial planning stage raises the question, what is it about the growth process that matters?

Chapter 3

Exploratory Agent-based Model

All models are wrong, some are useful.

- George Box

Introduction

If growth in and of itself only allows for the existence of strong chains in 22% of the laboratory cases and 27% of the model cases, what differences in the growth process cause some groups to form strong chains and other groups to form weak chains? The previous chapter suggests that early interactions set the path of the group, and that strong-performing groups can be destabilized by the inclusion of new participants who choose to build weak-links. The observations of the Colorado NFP programs suggest at least two distinguishing characteristics, either of which could account for high-performing groups:

- A high-quality deliberative planning process
- The gradual inclusion of new participants

The goal of this chapter is to use agent-based modeling, a technique that allows us to test each intervention, first in isolation and then combined. Comparing results from the growth model in chapter two to a model including each intervention, we can isolate the competing effects of each characteristic of high-quality collaborations. The comparison of these results will be discussed in relation to previous findings and will be verified with observations from the NFP communities in Colorado.

Intervention Two: Deliberative Planning / Slow Growth

One characteristic of more successful collaborative partnerships was the ability to develop according to their own schedule. A result of developing at a natural pace instead of being driven by external timetables was the ability to engage in a deliberative process, even if that deliberation slowed down the process. At least two community implementations were delayed to make sure that everyone in the working group was on-board.

To test a deliberative planning process we identify characteristics that might articulate a deliberative planning process and focus on the rate of growth. At the conclusion of his laboratory study of managing growth, Weber (2006) also indicated but did not prove that the rate of growth, and the ability to take advantage of growth, might play an important role as an intervention. He allowed managers to determine when to add new people to a group, and initially they all added people too quickly, resulting in low-performing groups. However, when given another chance, the managers slowed down the rate of growth and half of them were able to successfully manage the growth of their groups to the equivalent of a strong-chain equilibrium.

Agents

Both players and links have all of the characteristics of the players and links in the previous growth model.

Environment

The growth-rate variable represents the pace that the group grows. With a *growth-rate* value of 1 a new player will be added to the group each round. With this variable setting, this model is functionally equivalent to the growth model. With a *growth-rate* value of 2, a new player will be added every other round, with a *growth-rate* value of 3, a new player will be added every third round, and so on. *Growth-rate* values of 1, 2, and 3 were tested in this model.

Interactions / rules

The final *group-size* is 12 in all versions of this model. One consequence of changing the growth rate is that for growth rates greater than 1, the length of the game also had to be increased to allow for the group to grow to size 12.

Setup

During the setup of the model, three players and their associated links to other players are established. Two players will be active and one player will observe.

Play round

For each round, all active players will play the minimum-effort game following the same sequence of events as the growth model. First, active players will choose to build a weak or strong link based on their attitudes about the choices they expect other active players' to make. Then the links are combined, and the group outcome is calculated. Finally, all agents update their attitudes according to the same formulae from the growth model.

Next round

At the beginning of the next round the current round number is *modded* by the growth-rate. If the value is 0, then a new player is added. Put more clearly: with a growth rate of 1, one player is added in rounds [2,3,4,5,6,7,8,9, and 10], with a growth rate of 2, one player is added in rounds [2, 4, 6, 8, 10, 12, 14, 16, and 18], and with a growth rate of 3, one player is added in rounds [3, 6, 9, 12, 15, 18, 21, 24, and 27]. When a new player is added, he or she is added as an observer and the observer in the previous round is made active. So there is always one person observing until the final round, whereupon the last observer will become active in rounds 11, 20, and 30.

Measurements

There are two possible outcomes of the model: a strong-chain outcome and a weak-chain outcome.

Results

The model was run 1,000 times at growth rates 1, 2, and 3.

Slow growth

Slow growth matters. In the model with a growth-rate of 1 (a model equivalent to the growth model from chapter 2) and a group size of 12, there were 254 strong-chain outcomes over 1,000 rounds. When the growth-rate was changed to 2, there were 943 strong-chain outcomes over 1,000 rounds. Comparing the percentage of strong-chain outcomes at a growth-rate of 1 and a growth-rate of 2, a one-way ANOVA of outcomes over 1,000 rounds found a statistically significant difference ($F(1) = 1056$, $p < .001$). See Figure 16 for a comparison of the outcomes at the two growth rates.

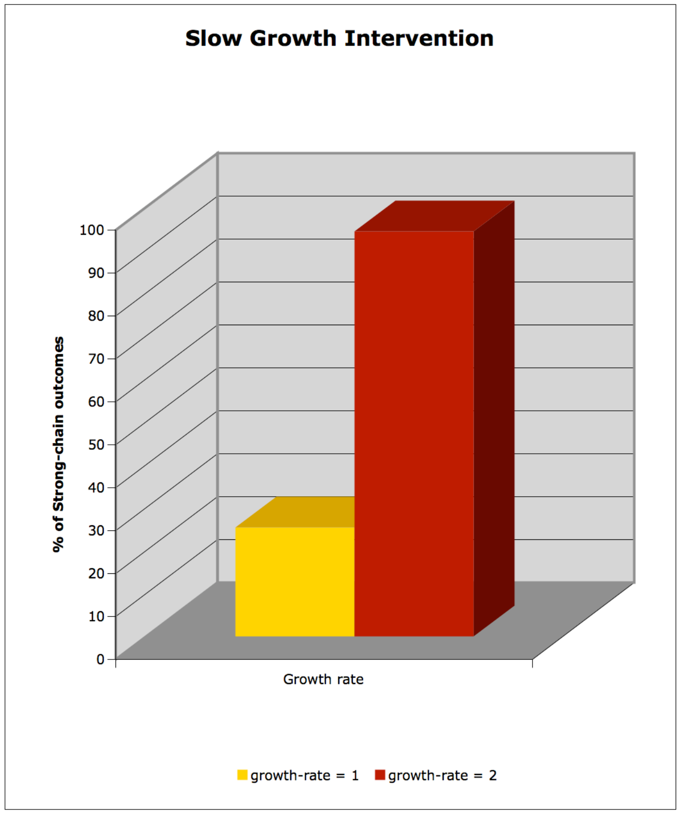

Figure 16: Comparison of growth model with *growth-rate* set to 1 and 2

<u>Extra time</u>

One interesting result showed that although there was a significant improvement in performance when changing the growth rate from 1 to 2, there was no additional benefit from changing the growth rate from 2 to 3. When the growth rate was changed to 3, over 1,000 runs, there were 939 strong-chain outcomes, slightly lower than a growth rate of 2 and accountable by the normal variation of the model over that many runs. See Figure 17 for a comparison of the outcomes at the three growth rates.

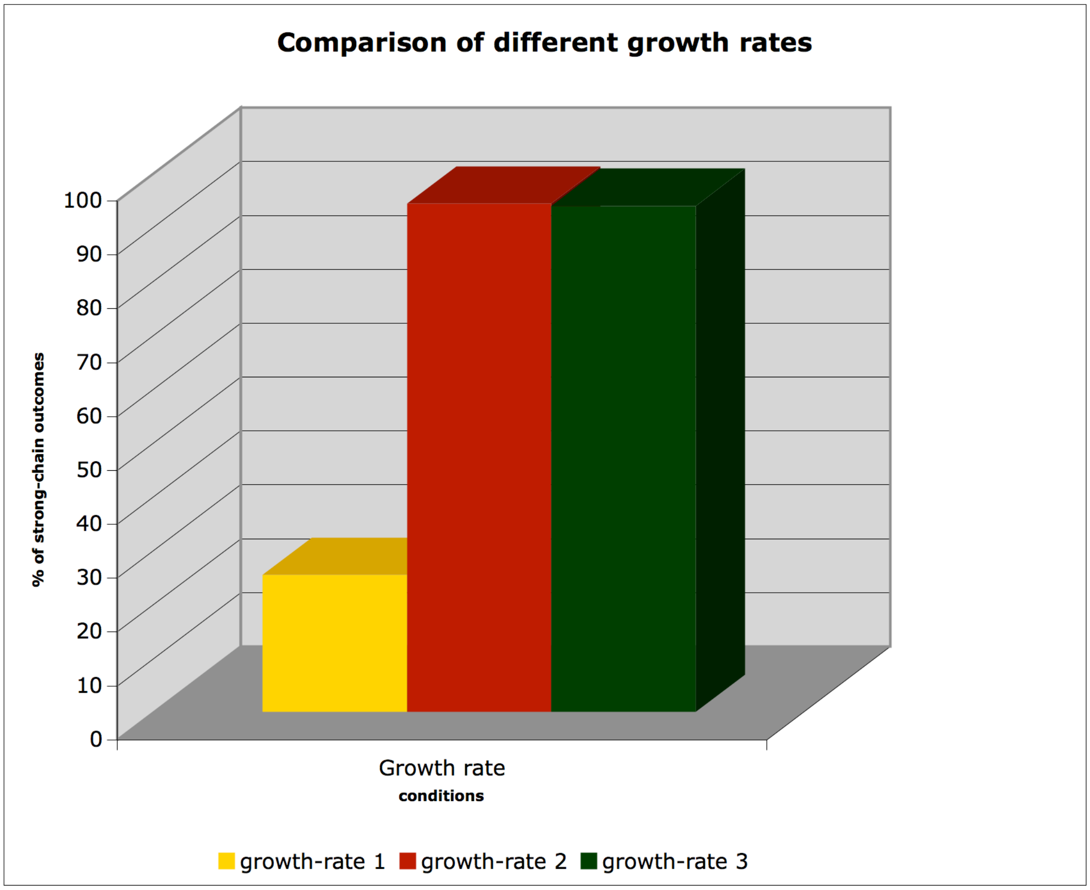

Figure 17: Comparison of growth model with *growth-rate* set to 1, 2, and 3

Intervention three: Gradual inclusion / small chains

Another characteristic of more successful collaborative partnerships was the way in which new members were added to the collaborative partnerships. Theories of organizational learning suggest that learning how to perform in groups often takes place through legitimate peripheral participation in communities of practice (Lave & Wenger, 1991). Accordingly, individuals first observe or play minor roles in the activities of a community before gradually participating more actively. In the high-performing communities in the NFP in Colorado, the community made an extra effort to thoughtfully include new members and share with them the history of the group. To extend the growth model from chapter 2, active new participants will evaluate their possible choices based on the interaction with a limited number of group members. As they continue to play, they will base their decisions on interactions with an increasing number of other players until they are fully integrated into the group.

Agents

Player agents have the same characteristics as the growth model. Link agents have all the same characteristics as the growth model as well as a new variable, *playing?.* This binomial variable still maintains the attitude that one player has toward another, but now also monitors who the player is interacting with, regarding which choice to make. In the growth model, players based their decision on their attitudes of all active players. In the small-chain model, players might base their decisions on a subset of active players. The *playing?* variable in the links keeps track of which other players are in that subset.

Environment

The only new environmental variable is *small-chains?,* a binomial variable that, when set to false, the model will behave identically to the growth model, and when set to true, will gradually include new players. All other environmental variables are the same as the growth condition.

Interactions / rules

The model is tested with a final group size of 12 in all versions of this model. One consequence of slowly adding new participants is that, to allow for full integration, extra rounds must be played after everyone has become active.

Setup

The setup in the small chains model is the same as the growth model.

Play round

Playing a round is similar to the growth model where players make a strong or weak-link choice, receive payoffs, and update their attitudes of others. However, an active player might not use all other players to evaluate its choice, but only the other players at the end of active links. In Figure 18, the blue and red players are making their determination based only on the players at the other end of the purple, active, links. The black links represent the attitudes of others not actively interacting with the player. For instance, at the bottom left, the gray player is observing this round is not active. The red player on the left has chosen to build a weak link based on its assessment of the person on the right and the person at the bottom right. The red player's attitude of the player at the top did not influence its choice.

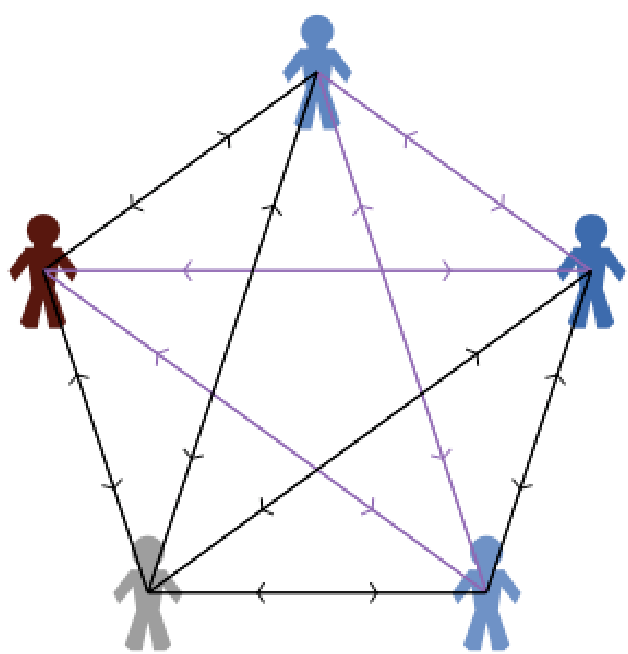

Figure 18: NetLogo model of the small chain intervention

If a player has an active link to another player, that player also has an active link to the original player.

Updating attitudes

Updating attitudes is the same as in the growth model.

Next round

At the beginning of the next round, players with *non-playing* links will randomly switch one of these *non-playing* links to *playing*. They will also have the player at the other end of the link switch their link with the original player, from *non-playing* to *playing*. An agent can only have one link switch to *playing* each round.

Final round

In the final round of the small-chain model all links will be active and the group will play the game as if players were in the final round of the growth model.

Measurements

There are two possible outcomes of the model, the weak-chain outcome and the strong-chain outcome.

Results

The thoughtful inclusion of new participants, articulated through small chains in the model, matters. The model was run 1,000 times without small chains and 1,000 times with small chains. In the model without small chains (a model equivalent to the growth model from chapter 2) and a group size of 12, there were 254 strong-chain outcomes over 1,000 rounds. When the small-chain intervention was turned on, over 1,000 runs, there were 943 strong-chain outcomes[10]. A one-way ANOVA of outcome on 1,000 rounds comparing the percentage of strong-chain outcomes at a growth-rate of 1 and a growth-rate of 2 found a statistically significant difference ($F(1) = 1096$, $p < .001$). See Figure 19 for a comparison of the outcomes with and without the small-chain intervention.

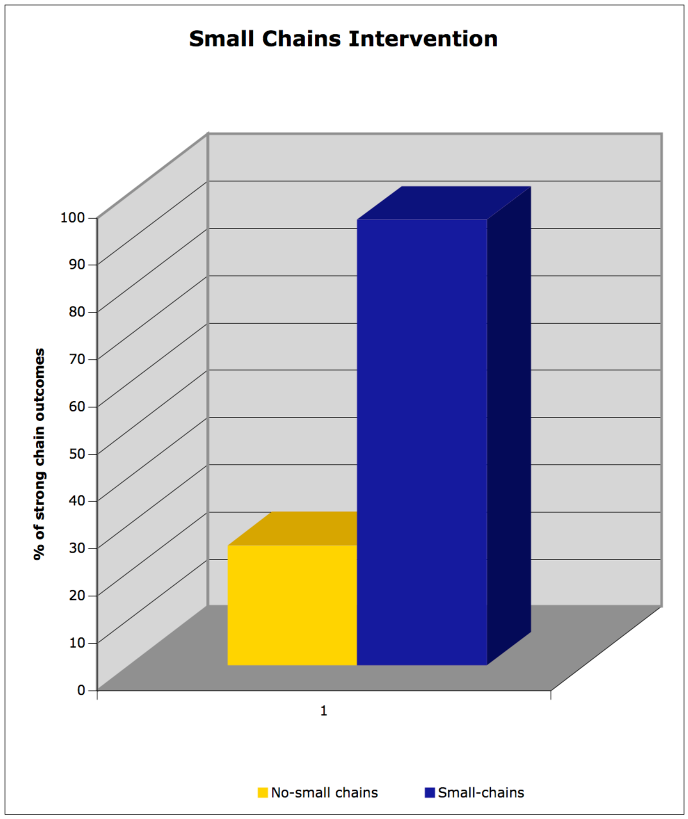

Figure 19: Results from 1000 rounds of different group sizes

Combining the Slow-growth and Small-chain Interventions

We want to test to see whether there are additive effects of a model that uses both interventions. To test this we combine the previous two interventions. Specifically, in

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[10] The no-small chain and no-growth conditions in both comparisons were the same set of 1,000 trials and that accounts for them having the same outcome (254). However, it was purely by chance that both the small-chain and slow growth interventions resulted in the same outcome (943). Running the same model another 1,000 runs, the small-chain intervention produced 934 strong-chain outcomes and the slow growth intervention produced 928.

every round of the model players increase the active links they use to make decisions, not only when there is a growth. The individual and combined effects are reported in Figure 20.

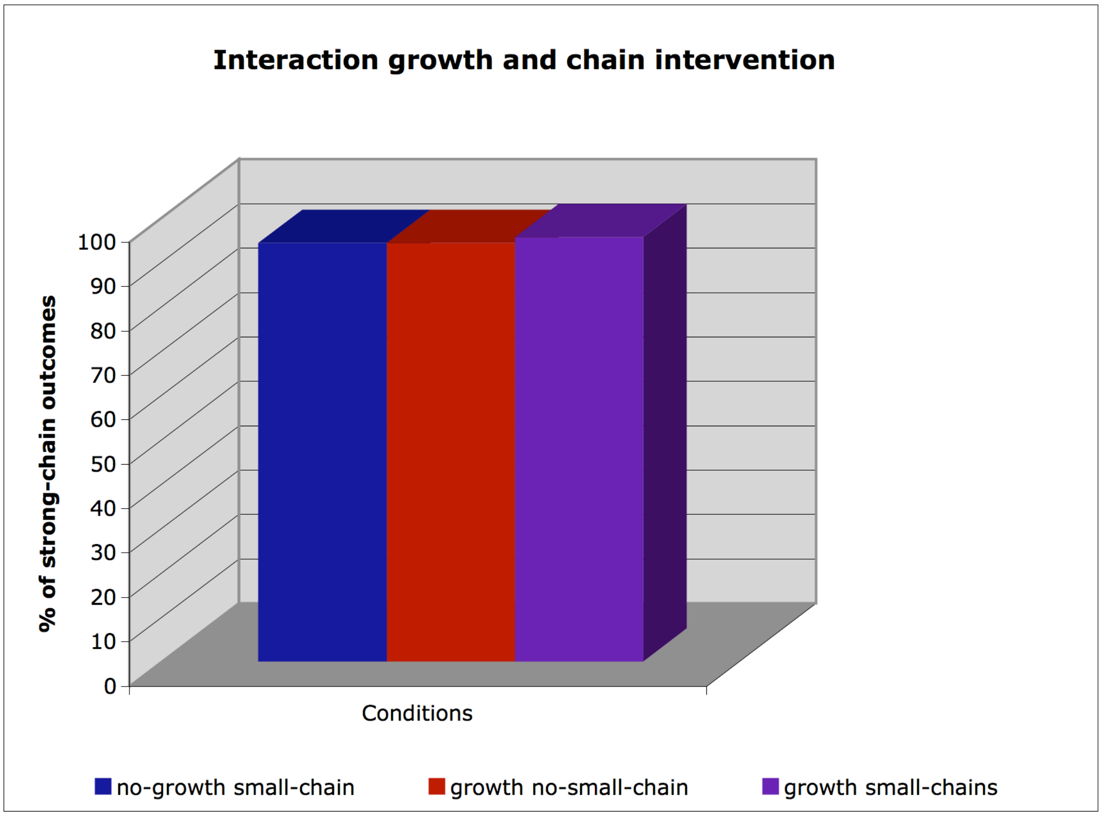

Figure 20: Individual and combined effects of interventions

Both interventions produced 943 strong-chain outcomes, but when a model used both interventions, there was only a slight increase to 956 strong-chain outcomes. This difference was not statistically significant ($p > .05$).

Discussion

The key observation from this chapter is that both the slow-growth and small-chain interventions were successful at increasing the likelihood of successful coordination in the minimum-effort game. Before unpacking the individual and combined effects of each intervention, I want to focus on the importance of this observation. Regardless of the research method used--the growth model in chapter two, Weber's (2006) laboratory findings, or the field study of communities in NFP, we found the same patterns of results; groups fell into one of these three categories.

1. Groups failing to coordinate from the beginning (weak-chain)
2. Groups starting to coordinate and then failing as they grew (weak-chain)
3. Groups initially coordinating and able to continue coordination (strong-chain)

The findings suggest that collaborative partnerships have a higher variance of outcomes than programs that use a traditional top-down implementation style. In the observations of the NFP communities in Colorado, even when all three of these outcomes occurred, the performance of the Colorado collaborative partnerships, on average, was still higher than the national average. If this research leads to a design of best practices that increases, even slightly, the likelihood of even a few collaborative partnerships building strong chains, the potential for overall program improvement is enormous. An even more desirable result would see improvements in the field match the improvement in the agent-based model, in which groups were more often able to achieve strong-chain outcomes (a 371% improvement).

Insights from the Model

The models in this chapter provided some guidance into interventions that could help increase the likelihood that groups will coordinate successfully. What the model found was that both the small-chain and slow-growth interventions were effective approaches for addressing the problem of groups that coordinated initially, but where new members destabilized existing players who were previously coordinating. When either intervention was being used, coordination rarely started with early strong-chain interactions and ended in weak-chain outcomes, but within the initial group playing the game, coordination never materialized. Therefore, both interventions of the model address the challenge of adding new players, but have yet to satisfy the need for interventions that focus on improving the likelihood that early interactions will lead to coordination. One weakness of the current experiments within the model is that the experiments do not indicate which intervention is more effective at minimizing the challenge of new participants joining an existing group. The model does provide insight into some of the characteristics of each intervention.

Unique qualities of small-chain intervention

During the course of building and testing the model, I observed four qualities that were unique to the small-chain intervention. First, multiple players can be added to a small group so that they increase their participation along an overlapping timeline. Second, though the intervention occurs on the individual level, it had a group level result, significantly increasing the likelihood of coordination. The intervention is considered individual because the existing players in the model do not treat new participants differently. Third, the gradual inclusion of new participants decreased the failures of new participants but did not eliminate them. I observed some instances where coordination was successful in the early rounds, but broke down as the game continued. There was still a risk of new players choosing not to build a strong link even after one round of observation and having played with only one person. Finally, while the overall results of improving the likelihood of strong-chain outcomes were similar to the slow-growth outcome, the final coordinated outcome was achieved in fewer rounds. If there is a high actual or opportunity cost to each round, and a program implemented can only choose to utilize one intervention, this is the preferred method by which to increase the likelihood of successful coordination within a group.

Unique qualities of slow growth intervention

The model also provided three insights into some surprising characteristics of the slow-growth intervention. First, slowing down the rate of growth helps in environments where there is difficulty including members, but the relationship of the growth rate to the likelihood of program outcomes is not continuous. There seems to be a threshold at which a certain amount of extra time would benefit outcomes. However, once that threshold is reached, the additional slowing of growth does not help and could in fact be counterproductive, particularly if you factor in the actual or opportunity costs of the delay, the momentum of programs, and the patience of willing participants. Second, slowing the growth at this phase of the program is a group level intervention and everyone was affected because the group took additional time. Third this intervention eliminated the risk of new participants making a risk-dominated choice because it took advantage of some of the characteristics inherent in the structure of the minimum-effort game. Particularly, both strong links and weak links are rational choices; repeatedly playing games with the same group of people reduced the uncertainty over what the rest of the group might choose to do and reinforced the players' attitudes that others were going to build a strong link.

The concept of returning to equilibrium despite minor destabilizing acts is known as a *basin of attraction* (Skryms, 2004). The destabilizing act in the model is the introduction of a new player to the group. Robust equilibrium is one of the key dynamics that distinguish the minimum-effort game from a repeated prisoner's dilemma (Axelrod, 1984). With the minimum-effort game, the members of the population will self-regulate isolated deviations from the equilibrium, regardless of whether the equilibrium is weak or strong chain building. In the NFP communities that we studied, basin of attraction is one explanation for why high-performing groups continued to perform at a high level, and low-performing groups performed at a low level despite a high turnover of the people who were directly involved. The basin of attraction is a self-regulating force present in minimum-effort games; but this force has limits. Given time, the basin of attraction can mitigate the risk that new participants might destabilize the strong-chain environment. However, if a program grows too quickly, sometimes as a result of focusing on growth rather than on a high-quality process, it could be possible introduce more risk into the environment than the basin of attraction can mitigate. As a result, a group that had been coordinating towards a strong chain could suddenly fall apart. A potential feature of a highly deliberative planning process is the ability to accurately identify when a community is ready to grow and when a community should "play a few extra rounds" to reinforce the current attitudes. By allowing the basin of attraction to reinforce strong-link beliefs, the community as a whole is more robust to the inclusion of new participants.

Unique qualities of combining small chains and slow growth

When the two interventions are combined, their individual contributions are not obvious. Those advantages that increased the likelihood of achieving a strong-chain outcome realized by the small-chain intervention were also achieved by the slow growth intervention. However, in the slow-growth intervention, there were no instances of new members breaking-up existing strong-chain groups, whereas this did occur in the small chains intervention, albeit rarely[11]. While there was not a significant benefit of using both methods in the model, in the field, the mechanism might work as a redundant or fail-safe contribution, one backing up the other if either should fail for some reason. Also, in the model, these interventions are either present or absent. In the field both are present to some degree and designing collaborative partnerships with both in mind could have an additive effect.

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[11] The model was not designed to count how many groups that ended in a weak-chain outcome formed strong-chains in the early rounds. One monitor added to the model did record the round when strong chains switched to weak chains. That this monitor was greater than 1 in some small-chain intervention runs indicates that in some runs, the group was a strong chain in round one yet resulted in a weak-chain outcome.

Chapter 4

Conclusion

All truths are easy to understand once they are discovered; the point is to discover them.

-- Galieleo Galilei

Introduction

This chapter has four goals. First, I analyze how the findings from the previous chapters contribute to the literature and to our understanding of the growth process in civic collaborations. Second, based on the findings of this research, I make policy recommendations for both the implementers of the NFP programs in Colorado as well as states that might soon implement NFP because of the current proposed legislation. Third, I explore the limitations of the current research. Finally, I will propose a research agenda that expands the current agent-based model, extends the field study to new locations and programs, outlines laboratory studies that test new growth interventions, and also tests how people can use the agent-based model to make policy decisions.

Contributions

Civic collaborations have been shown to be effective implementation strategies for the NFP program. In practice, using a bottom-up growth strategy has, on average, produced results better than the national average on several key measures of program success. However, performance across the Colorado communities that have used this strategy is not consistent. We used a collection of interviews, community narratives, questionnaires, and program outcomes to identify characteristics that distinguish Colorado from other NFP implementations (the growth process) and characteristics that distinguish high-performing from low-performing communities in Colorado (a deliberative planning process and the thoughtful inclusion of new participants). We chose to use game theory to create a formal approach by which to analyze the interaction between individuals in Colorado and rationalize how potential interventions might influence program outcomes. We identified the minimum-effort game, illustrated by the chain-building analogy, as the most appropriate game theoretic situation for representing the NFP collaborative partnerships in Colorado. The decision to use the minimum-effort game was motivated by three main factors. First, there was no individual incentive to deviate from the rest of the group. Second, in situations where individuals felt a perceived risk in contributing they can choose a risk-dominated strategy. And third, the deviation of key people can jeopardize group outcomes.

In chapter two we introduced a baseline agent-based model of agents playing a minimum-effort chain-building game. The variables of the baseline model were calibrated by comparing model outcomes of different size groups with different variable settings to a collection of laboratory experiments of different size groups playing the minimum-effort game. The model was then expanded to include a growth intervention. Findings from the model showed that growth was an effective mechanism to increase the likelihood of successful coordination within groups. Although there was an improvement in the overall performance outcomes, the largest groups were still only able to coordinate to the strong chain outcome only 27% of the time. Within the model, coordination failures occurred either because the initial participants failed to coordinate to a strong-chain outcome or a strongly performing group added a new member that disrupted the group's coordination, resulting in a weak-chain outcome. The growth model was then verified by comparing its pattern of results to the pattern of results produced in a recent laboratory experiment that used a similar intervention (Weber, 2006).

In chapter three the model was expanded to investigate which characteristics of the growth process increase its chances of success. Two interventions motivated by the field were tested. A deliberative planning process was articulated in the model as "slow growth" to represent the time taken to focus on the problem and better understand the issues and concerns of all involved. The thoughtful inclusion of new participants was articulated in the model as "new participants making a decision to build a strong or weak link based on limited interactions." The model showed that both interventions were successful at reducing the risk that the addition of new participants would destabilize a strong-chain group. While the small-chain intervention was able to increase the likelihood of strong chains in less time, the slow-growth intervention eliminated the chance that new participants would disrupt a strong-chain group entirely. The slow-growth intervention also showed a significant improvement when the growth rate was slowed down; however, slowing the growth rate further yielded no additional benefit. There was also no observable benefit from introducing the two interventions simultaneously.

Recommendations

Current legislation proposes a bill to invest $15B in mandating the availability of the NFP program in all fifty states. Policy makers of the current NFP program in Colorado, and those of other states implementing new NFP programs, will hopefully benefit from the findings of the current research by increasing the effectiveness of civic collaborations and, in turn, the likelihood of positive collaboration outcomes.

Current Nurse Family Partnership in Colorado

Motivated by insights from the agent-based models discussed previously, this dissertation proposes four immediate policy recommendations to avert potential breakdowns in the process of building collaborative partnerships. First, program managers should require a consensus to implement a program before progressing from the planning stage. If the group is conflicted or not fully coordinated on the appropriate method of implementing the program, then early failures could lead to long-term problems. This recommendation is to a large extent already in place in Colorado. Second, program managers should allow poorly performing groups to die with dignity. One of the dynamics of the model is that strong chains can transition to weak chains, but there were no instances of a weak chain becoming strong. Instead of repeatedly investing in low-performing groups, hoping they might gradually improve, a more efficient strategy would be cut the losses and refocus energy and resources on new projects that could start out fresh or reinvest current resources into increasing the scope of high-performing programs. The third recommendation is to allow group members to vote out existing participants that are not "strong-link builders." Currently the programs in Colorado never ask people to leave. However, this exposes them to the poison pill or rotten apple situation, in which the counter-productive efforts of a single individual can ruin an entire collaboration. A recent experiment of people playing the minimum effort game allowed participants to vote people into or out of their groups, with the result that it was possible to coordinate at the Pareto-efficient outcome (Charness & Yang, 2006). A final policy recommendation is to evaluate programs on the quality of the planning process and not the rate at which they progress through artificial deadlines or milestones. A natural progression through the program stages allows for the development of a deliberative planning process.

National Nurse Family Partnership initiative

If the Senate initiative is passed and NFP is mandated across all 50 states, direct consequences will likely follow, affecting the outcomes of individual program implementations. First, most programs will probably be implemented in a top-down non-collaborative partnership system. One expected benefit of this approach is greater consistency and fidelity across different program implementations. This approach would also result in greater access to the program and the assurance that all communities would implement it. However, a mandated, top-down approach might not be able to replicate some of the performance outcomes observed when using collaborative partnerships in Colorado.

Based on the model findings, I would recommend the following four modifications to the current legislation. First, instead of mandating the implementation of the program in all states, what should instead be mandated is the availability of governmental resources for communities that choose to implement the program. However, to receive these resources, communities would have to meet specific guidelines. To evaluate whether communities meet the requirements, two types of specialist, facilitators and evaluators, would be trained. Facilitators would help bring key members of the community together, fulfilling a role similar to that of IIK in Colorado. Facilitators would also have access to seed funding that could help offset initial planning costs. In addition, they would work with the communities and focus on the process of including new people from the planning phase through the implementation of the program. Evaluators would be trained to assess the quality of the planning process, based on the specific indicators of a deliberative planning process, namely, whether the process authentic, inclusive, and focused on the problem (Hicks & Larson, 2003). If the evaluators were to determine there was a deliberative planning process, then the community would receive government funds to implement the program. Finally, I recommend that part of the $15B be spent on grants to the Incentive Centered Design group at the University of Michigan and the new Center for Policy Informatics at Arizona State University to continue to study how these programs might be better implemented.

Limitations

There are several caveats in generalizing the results from this study — some that arise from observations in the field and some suggested by the modeling process. In the field, the exploration into the growth process occurred retroactively, after the NFP programs had already been in place for years. While researchers were involved in the early phases of program development, there were no specific measurements in place to measure the qualities of the growth process or qualify how well new people were included into the program. Observations in this study occurred through interviews with program directors years after the initial planning stages. Another limitation of many field studies is that it is nearly impossible to find statistically significant results from a small number of observations, in our case 16 communities.

To create a model where the outcomes are tractable to specific interventions, we had to make several assumptions. Each assumption can potentially reduce the fidelity of the model to the interaction in the field and the laboratory. First, in the model, the players have only two choices (to build a strong link or a weak link), whereas in laboratory they were given seven different choices. Furthermore, in the field, stakeholders were never given a binary, "are you in or are you out" ultimatum. The levels and types of contribution were far more nuanced than a weak- or strong-link decision. Another limitation is that in the model and the laboratory, all participants make the same choice, have the same influence, and can receive the same reward for their actions. The contributions of stakeholders in the field were not equivalent between participants in terms of degree or type. Also, in the field, there are complicated political histories, power differences, and a wide variety of other factors that cannot easily be accounted for or discounted within the model. By contrast, the game in the model and the laboratory is played in a vacuum. The groups in the field are pulled from the context of greater environmental variables like: current economic conditions, the existence of other similar programs, or the political climate within the state. However, even given these limitations, insight from this research should be useful in recommending new policy interventions.

Future Work

One of the benefits of a multi-method research agenda is that conducting work on each of many different fronts can advance the research. I propose: 1) an ongoing research agenda to improve the current growth model, 2) advancing field research with respect to the proposed legislation, and 3) laboratory experiments that target specific questions that would be valuable to explore with human subjects.

Developing the Growth Model

Four immediate ways to develop the current model are: improving calibration, testing new interventions, developing new measurements, or redesigning the model for a new audience.

Calibration

The current model calibrates the *average-attitudes* variable by assessing how differences in the variables translate into changes in performance outcomes and then by comparing those outcomes to previous studies. The distribution in the *average-attitudes* variable is taken to be a normal distribution with an assumed mean. Instead of using these assumptions, it is possible to use characteristics collected directly from the individuals participating in the collaborations through interviews and surveys. Some of this information is already available. Using the Working Together Instrument (Appendix 1) and the Process Quality Instrument (Appendix 2), communities could be characterized by their average attitudes and the amount of variation within the community. Though not analyzed in the current research, variations in these two qualities might suggest significant differences in program outcomes and thus might lead to a valuable and adaptable tool with which policy makers could design interventions for groups based on the heterogeneity and distributions of attitudes.

Interventions

While growth, a deliberative planning process, and the thoughtful inclusion of new participants were the most readily apparent qualities that distinguished the high-performing NFP communities in Colorado, other interventions, suggested by the interviews and community narratives, could also increase the likelihood of achieving high quality collaborative partnerships. I will propose and very briefly describe some other possible interventions to test either alone or in combination with other interventions.

The first intervention is to model the contribution of facilitators in collaborative partnerships. What is the role of the facilitation provided by IIK in helping to build these collaborations? We identify three potential influences of facilitators. First the presence of such a facilitator might reduce the risk of players building weak links. Second, a strong facilitator might be able to force the choice of individual players. Third, a facilitator could allow faster updating of attitudes, decreasing the time the needed to move from planning to execution. But when should facilitators be involved in the program? One observation from our interviews suggested that facilitation is necessary at the start of the collaboration:

> ***Executive Director of IIK****: When you were* ***starting fresh*** *you could engage judges and leaders because it was an* ***exciting opportunity****.* ***However****, but once the program was there, you had a different group that you were dealing with. On the whole* ***retroactive collaborations were fairly ineffective*** *at getting people passionate and involved.*

A second intervention to test is how robust the growth findings are in different games, different payoff structures, or combinations of multiple games in the same environment. While the minimum-effort game is vulnerable to noise or poison pills, if NFP had the ability to vote dissenters out, how would the dynamics change when the game is switched to a median-effort game, in which players' payoffs are tied the effort of the median player in a group? Similarly, how would the dynamics of the game change if the minimum player was ignored each round? How would growth be different if the challenge was a pure coordination game and the individual dilemma, instead of whether or not to participate in one program, was the need to coordinate on one of many programs that were otherwise equal?

Let me briefly suggest four other possible interventions. First, in the current model everyone participating observes a common group outcome. Could the performance of the group perhaps be improved by controlling access to information and distinguishing local and global information? Second, might large groups build strong chains by developing a series of small strong-chain groups in parallel and then merging them together? Third, can the same benefits of growth be realized even when starting with large initial groups by using variations on the small chain intervention? One idea would be to allow everyone to play multiple minimum-effort games with a limited number of participants and then slowly increase the number of players they are participating with, while maintaining the overall number of players. Finally, can the addition of new people to a group be based on assessments of the group's state and by calculating the size and speed of additions the group can manage with a given probability or risk?

Measurements

The model described in the dissertation only recorded whether the outcome of the group was a strong chain or a weak chain. The addition of new measurements to the model can help tease apart individual intervention contributions. I recommend three improvements. First, it would be valuable to record the average attitudes of the participants in the round. This measure is like taking the temperature of the attitudes in the round and could be used to determine whether there would be any benefit in delaying the addition of a new group member and to realize the benefits of basins of attraction only when necessary. Second, it would be valuable to record in which round the group first built a weak chain and to count how many groups start with a strong chain and then switch to a weak chain. This measure would allow for insights into which phase of the growth process coordination was failing and would improve the understating of the effectiveness of interventions that target specific parts of the process. Third, the model would benefit from monitoring individuals' attitudes, creating profiles of these attitudes in those cases when a player was the first player to build a weak link. By recording the source of the breakdown, it might be possible to identify environmental conditions, or other characteristics about the group, that could be targeted with future interventions.

Audience

Another potential direction for the development of the model is to design it for a new audience, practitioners. The model could be used as a tool kit for program managers and facilitators to visualize, design and test policy choices; test potential design choices; diagnose problems in current collaborations; and develop remedies to existing problems.

Developing the field research

The field research can be developed in many directions. I will briefly examine other implementations of NFP, the case studies of other collaborative partnerships, and collaborative partnerships in other contexts, specifically in business and academics.

Field experiments with other NFP implementations

This is an exciting time to studying the NFP program. In April of 2007, a bill was proposed to the Senate recommending the nationwide implementation of the program. If passed, there will be an opportunity to research the implementation of the program from the initial stages of development, instead of retrospectively. One way to capitalize on this opportunity would be to create large-scale, controlled field experiments that test specific interventions in different states or across different communities within a state. One idea regarding interventions would be to provide all the necessary resources, but to make the program elective for the communities that decide to participate. Another option would be to allow states to choose between a top-down approach and an approach in which individual communities used collaborative partnerships to implement the program. Program outcomes would be measured using the current Clinical Information System and then tested to see whether the style of implementation had a significant effect on program outcomes.

Other collaborative partnership case studies

Invest in Kids is involved in other programs in Colorado that use a civic collaboration implementation strategy. Two such programs are Incredible Years (IY) and the Colorado Healthy Communities Initiative (CHCI), programs that were implemented with growth strategies with different characteristics than that employed by NFP. Exploring the unique characteristics of these strategies can provide additional insight into other aspects of the growth process. IY is a supplemental school curriculum in 12 communities designed to promote social competence. Learning from its success with previous collaborative partnerships, IIK spread the IY program using a similar strategy. However, IY did not share the same level of success as NFP. Unique to IY was the focus on rolling out the program in many communities quickly, and in fact rapid implementation in as many communities as possible was initially used as a measure of success. In many of the communities in which IY was developed, it also had the unique challenge of competing with many other school programs. Exploring the IY programs might provide insight into characteristics surrounding the rate of growth, as well as the challenges involved in distinguishing a program from other competing programs.

CHCI is a program that provided 29 communities in Colorado with seed grants for collaborative partnerships to improve the overall health of the community. Unique to the CHCI program was a forced long, mandatory planning process. The overall program was very effective by nearly any measure. Exploring the role of the long planning process might provide insight into one of the unanswered questions of this research: What interventions are possible to avert breakdowns in the initial stages of collaborations?

Other contexts using collaborative partnerships

This research on the growth process in collaborative partnerships could also extend beyond civic collaborations to the development of business teams, academic collaborations, and a wide variety of other collaborations that are becoming increasingly common. In *The Future of Work* Tom Malone claims that work is naturally evolving toward the project as the central unit of interest instead of the university, corporation, or organization (Malone, 2004). He asserts that projects traditionally handled by strict controlling hierarchies are now being taken on by collaborative partnerships, by which tasks are accomplished as if by "citizen participation" rather than by "hierarchically managed worker-bees." Collaborative partnerships are also increasing in frequency within many business settings because of an increased complexity of problems, as noted by LaFasto and Larson (2001):

> *A steady increase in collaborative teams was reported in the adoption of collaborative strategies in the auto, steel, and textile industries. A similar pattern was noted in science and technology. Collaborative problem solving processes are embraced by the health care industry, as well as by institutions and agencies that fund social programs and initiatives. (xvii)*

Malone (2004) attributes the increase in collaborative partnerships to a change in the very nature of work, a change made possible because of the decreased cost of communication and increased availability of information. These trends give people the choice to participate on projects that are personally rewarding. This is substantially different from choosing to work for an organization and then being assigned to a project of the organization's choice.

Collaborations in academics also face significant barriers to achieving success and rarely perform as intended (Kiesler, 2003). In fact, the number of institutions participating in the collaboration is inversely related to their success (Cummings and Kiesler, 2005, Olson, et. al, 2005). A study of 62 NSF-sponsored projects found that, as the number of institutions involved in a collaboration increased, the level of success decreased (Cummings and Kiesler, 2005). Studying the growth process during the early stages in collaborative partnerships in these contexts could increase the possibility for successful outcomes.

Laboratory experiments

Two categories of laboratory experiments that could be fruitful are those experiments that specifically test interventions in the growth process, and those that test how people might use models and simulations to make better policy decisions.

Growth experiments

Many of the interventions proposed in the model development section could also be translated into laboratory experiments. Interesting insights into the dynamics of the growth process might result from testing different rates of growth, conducting small groups before merging the groups together, and evaluating the influence of facilitators with different attributes. Another interesting series of tests could determine the robustness of strong-chain groups in the face of different destabilizing events such as the replacement of participants, the addition of multiple participants, or the addition of noise to the environment.

Agent-based model experiments

One potentially interesting series of experiments could test how accurately people can make policy decisions on the basis of using the agent-based models in this research. An agent-based model can be designed to include a series of interventions (slow growth, small chains, facilitators, etc.) that can be used to navigate an environment with different characteristics (low average-attitudes, deadlines, limited resources, etc.). In order to get an indication of performance, for every environment there would be a theoretically optimal set of interventions that could be compared to the subject's choices. Subjects could be tested to see whether they could learn to use the model to make better decisions over time, to try and identify the type of information that leads to better decisions, and to gain insights on the ways in which top-down decisions go awry when made in an environment that is dependent on bottom-up processes.

Conclusion

The use of collaborative partnerships to implement the Nurse Family Partnership in Colorado enables new forms of program implementations with intriguing potential benefits. What if successful collaborative partnerships are not just slightly better but radically better than other implementation strategies? What if the difference between a successful and not successful collaboration is largely determined by the controllable factors during the planning process? If variations in performance are largely based on early, measurable, interactions, can we catch low performing groups, dissolve them before committing too many resources, and then start fresh? Could targeted interventions help steer these collaborations down the right path and protect them from threats to sustainability? The current research suggests that the growth process indeed matters and when managed appropriately the thoughtful inclusion of new participants and a deliberative planning process can help realize the potential of collaborative partnerships. Hopefully, the use of collaborative partnerships will be seen as a viable implementation option for what soon could become a nation-wide, $15B Nurse Family Partnership program.

Appendix 1: Working Together Instrument

True	More True Than False	More False Than True	False	The Context of the Collaboration
				1. Our collaborative effort was started because we wanted to do something about an important problem.
				2. Our group's top priority was having a concrete impact on the real problem.

True	More True Than False	More False Than True	False	The Structure of the Collaboration
				1. The membership of our group included those stakeholders affected by the issue.
				2. Our membership was not dominated by any one group or sector.
				3. Our collaboration has access to credible information that supports problem solving and decision making.
				4. Stakeholders have agreed on what decisions will be made by the group.
				5. Stakeholders have agreed to work together on this issue.
				6. Our group has set ground rules and norms about how we will work together.
				7. We have a method for communicating the activities and decisions of the group to all members
				8. There are clearly defined roles for group members.

True	More True Than False	More False Than True	False	Collaboration Members
				1. Members were more interested in getting a good group decision than improving the position of their home organization.
				2. Members were effective liaisons between their home organizations and our group.
				3. Members trusted each other sufficiently to honestly and accurately share information, perceptions, and feedback.
				4. Members are willing to let go of an idea for one that appears to have more merit.
				5. Members are willing to devote whatever effort is necessary to achieve the goals.

True	More True Than False	More False Than True	False	The Collaboration Process
				1. Members are willing to devote whatever effort is necessary to achieve the goals.
				2. The openness and credibility of the process helped members set aside doubts and skepticism.
				3. We set aside vested interests to achieve our common goal.
				4. We have an effective decision making process.

True	More	More	False	

	True Than False	False Than True		The Results of the Collaboration
				1. Our group was effective in obtaining the resources it needed to accomplish its objectives.
				2. The time and effort of the collaboration were directed at obtaining the goals rather than keeping the collaboration in business.

Appendix 2: Process Quality Instrument

The following is a brief survey for evaluating the overall quality of a process. "Process" refers to how a group of people is working together to deal with a problem they have in common or a goal they are trying to achieve. When you rate the following items, you should be thinking of the following group: The Community Coalition working on the following problem or goal: The Nurse Home Visitation Program.

There are no right or wrong answers to this survey. Regardless of what you think, you can be sure that there are others who will agree with you. Please rate all of items. When you have finished, please look back over the items on more time, to see if you have left any items unrated. Please circle the scale interval that best represents your evaluation of the process.

1. The people involved in the process usually are focused on broader goals, rather than individual agendas.
Strongly Agree   Agree   Agree more than disagree   Disagree more than agree   Disagree   Strongly Disagree

2. The process is free of favoritism.
Strongly Agree   Agree   Agree more than disagree   Disagree more than agree   Disagree   Strongly Disagree

3. Often decisions are made in advance and simply confirmed by the process.
Strongly Agree   Agree   Agree more than disagree   Disagree more than agree   Disagree   Strongly Disagree

4. In the process, everyone has an equal opportunity to influence decisions.
Strongly Agree   Agree   Agree more than disagree   Disagree more than agree   Disagree   Strongly Disagree

5. The process gives some people more than they deserve, while shortchanging others.
Strongly Agree   Agree   Agree more than disagree   Disagree more than agree   Disagree   Strongly Disagree

6. The process responds fairly to the needs of its members.
Strongly Agree   Agree   Agree more than disagree   Disagree more than agree   Disagree   Strongly Disagree

7. Decisions made in the process are based on fair criteria.
Strongly Agree   Agree   Agree more than disagree   Disagree more than agree   Disagree   Strongly Disagree

8. In the process, some people's "merits" are taken for granted while other people are asked to justify themselves.
Strongly Agree   Agree   Agree more than disagree   Disagree more than agree   Disagree   Strongly Disagree

9. In the process, strings are being pulled from the outside, which influence important decisions.
Strongly Agree Agree Agree more than disagree Disagree more than agree Disagree Strongly Disagree

10. The allocation of resources is decided fairly.
Strongly Agree Agree Agree more than disagree Disagree more than agree Disagree Strongly Disagree

11. The criteria for allocations are fairly applied.
Strongly Agree Agree Agree more than disagree Disagree more than agree Disagree Strongly Disagree

12. In the process there is sufficient opportunity to challenge decisions.
Strongly Agree Agree Agree more than disagree Disagree more than agree Disagree Strongly Disagree

13. In discussions about decisions or procedures, some people are discounted because of the organization they represent.
Strongly Agree Agree Agree more than disagree Disagree more than agree Disagree Strongly Disagree

14. The decisions made in the process are consistent.
Strongly Agree Agree Agree more than disagree Disagree more than agree Disagree Strongly Disagree

15. Decisions are based on accurate information.
Strongly Agree Agree Agree more than disagree Disagree more than agree Disagree Strongly Disagree

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