Social Networks, Collaborative Institutions, and Learning for Sustainable Regional Planning

Adam Douglas Henry
School of Government and Public Policy
University of Arizona
adhenry@email.arizona.edu

Abstract

Decision-making for sustainability in regional transportation and land use planning is often confounded by the complex and ideologically divisive nature of planning issues. Some agents, however, tend to be much more successful than others in learning to deal with these challenges. This study draws on network-theoretic perspectives to explain learning as a function of information-exchange relationships amongst multiple policy actors. Data on learning and networks are collected from policy elites involved in three regional planning processes in California. This study underscores the importance of non-hierarchical information exchange relationships in promoting learning within complex issue domains, although the results also suggest that persistent ideological conflict is an important barrier to learning.

*** Paper prepared for submission to the Design and Dynamics of Institutions for Collective Action Conference, Utrecht University, The Netherlands, 29 November – 1 December, 2012.**

The Challenge of Learning in Land Use and Transportation Planning

Transportation and land use planning is a prototypical issue of sustainable development. Most regions of the world – and nearly all regions of the United States – will be forced to deal with rising populations and corresponding demand for infrastructure and services. At the same time, it is increasingly clear that promoting human well-being in the long term depends on the preserving the integrity of environmental systems. The successful practice of sustainable development, including sustainable regional planning, requires striking a balance between these seemingly incommensurate goals. In order to do this, planning processes must overcome a number of challenges. One prominent challenge is to design decision-making institutions that promote successful social and policy learning (Social Learning Group 2001; Parson and Clark 1995). "Learning" refers to the process by which stakeholders and decision-makers hone their ability to deal with complex problems by drawing upon diverse sources of information, developing common understandings of problems to be addressed, and collectively produce innovative policy solutions.

Many regions recognize the need for planning processes that promote increased agreement and policy innovation, and have begun to experiment with various types of "collaborative" planning efforts. These processes typically seek to engage a broad array of stakeholders, enhance cooperation between local jurisdictions and vertical levels of government, and integrate multiple functional domains such as transportation, land use, and habitat. It is commonly assumed that collaborative processes lead to improved

outcomes because they create networks that span traditional schisms that cause friction between policy participants (Schneider *et al.* 2003). Although there is a general euphoria surrounding the potential of collaborative policy, there is sparse evidence that collaborative institutions and the social networks they produce actually promote learning and more sustainable outcomes (Lubell 2004). This underscores a central problem with the literature on the design of planning institutions: The *process* of learning is usually treated as a black box, and we defer instead to strategies that, anecdotally, have appeared to be successful in the past. Understanding how learning occurs by and amongst networked groups of agents will lend more theoretical power to the important question of institutional design to promote learning for sustainability (Innes and Booher 1999).

This paper uses social networks as the main organizing concept through which to explore learning in three regional planning processes in California. I seek to explain why some organizations involved in planning successfully learn and others do not, as a function of their network position and attributes of their information sources within the network. While the focus here is on regional transportation and land use planning, the methods and general approach are also applicable to a wide variety of other policy domains that deal with complex human/environment interactions, placing this research firmly within the emerging field of sustainability science (Kates *et al.* 2001; Clark 2007).

Why a challenge?

The practice of planning, whether for transportation, land use, or any other human activity, is very much an effort to deal with complex adaptive systems. Human behavior is complex, as are the interactions between human and ecological systems. Dealing

effectively with problems of sustainability requires that decision-makers be able to successfully assimilate ("learn") emerging and uncertain information and engage in policy experimentation (Holling 1978). In addition, there is an often-realized possibility that decision-makers and other stakeholders do not agree on the basic parameters of the issue to be addressed, and bring conflicting information to bear on policy debates. In such a situation, networks may be characterized as ideologically polarized, with multiple divergent belief systems competing to push policy choices in different directions. Such situations are common in technically complex and value-laden issue areas (such as transportation and land use), leading to environments where the norm is political stalemate rather than constructive discussion and policy improvement (Sabatier and Jenkins-Smith 1999).

Social networks are a vital component of learning because they act as a constraint on information exchange and the pooling of knowledge at multiple scales. Multiple perspectives on a problem are useless, for example, if there is no mechanism for synthesizing these perspectives. Networks are crucial because they are the medium for information sharing, dialogue, persuasion, negotiation, and any other social process that leads to belief change or knowledge production.

Unfortunately, the ways in which networks self-organize often inhibit the effective synthesis of information for policy learning. One reason for this is that values and beliefs play an important role in determining network interactions. Thus, as values and beliefs change, individuals may tend to adjust their surrounding networks accordingly. What if actors tend to resist the formation of network ties with others who do not share their values, background, or basic policy preferences? There is convincing

evidence that normative beliefs play an important role in determining the structure of policy networks (Weible and Sabatier 2005; Weible 2005). This poses a serious challenge for learning, since a bias for communicating with like-minded individuals only serves to reinforce prior knowledge, and makes it difficult for new ideas to "infect" ideologically homogeneous groups.

The precise mechanisms though which network structures influence actual innovation and policy improvement, however, are not well-understood. Given that network structures often evolve in a way that poses a challenge for sustainability, can variance in learning be explained as a function of alters' actual position within a network? The next section discusses hypotheses that explicitly link network structure with learning.

Learning as a Function of Network Position

The way in which agents are embedded in larger social network structures impacts their capacity for learning for two reasons. First, network position influences the raw amount of information that a particular agent has access to. Second, the patterns of connectivity between a focal agent and their surrounding partners influences the way in which this information is passed through the network and synthesized, interpreted, and used by the recipient. In the following discussion of these effects, I use the convention of naming the focal agent "ego" and actors with whom ego is connected as network "alters." Network linkages are defined as lines of information exchange; a link from node *A* to node *B* indicates that *A* seeks information or advice from *B*.

Network centrality and learning

The social networks literature employs various measures of centrality to assess how close an agent is to the natural "center" of a network (Freeman 1979). One such measure is expansiveness, also known as outdegree centrality. This is defined as the count of linkages emanating from a particular node to other network actors. In the context of the information exchange networks studied here, expansiveness measures the raw amount of information that is directly available to a particular actor. Generally speaking, successful learning is conditional first and foremost on having adequate access to policy-relevant information. Thus, when agents occupy network positions with high outdegree centrality, they are more likely to have access to the information needed to successfully address complex planning issues.

> Expansiveness Hypothesis: Network positions that provide access to large amounts of policy-relevant information are conducive to successful learning and innovation.

Learning and reciprocity

Although having a large number of information sources likely increases the potential for successful learning, it should be noted that *access* to information is a necessary but not sufficient condition for learning. The likelihood that information access will aid in learning how to deal effectively with policy problems also depends on how information exchange relationships are structured amongst multiple agents. The literature on the impact of discussion on political choices, for example, indicates that

highly hierarchical information exchange structures (such as when one individual "broadcasts" a message to many passive agents) are less effective in promoting the adoption of new ideas than are information exchange structures that allow for discussion after a message has been broadcasted (Kerr and Kaufman-Gilliland 1994).

Reciprocity is a commonly-used network measure that allows us to describe these opportunities for discussion. This measure captures the number of times that an actor's information-gathering linkages are reciprocated, such that ego seeks information from actor *A*, and actor *A* also seeks information from ego. These relationships tend to work against hierarchical information exchange structures, and are potentially inefficient when a goal of the network is the rapid diffusion of information. In many policy domains, hierarchical information exchange networks are primarily beneficial for those few central agents who can more efficiently influence the policy choices of a broad range of network actors. Evidence from the field suggests that innovation within collaborative planning rarely occurs through such steamrolling efforts (Innes and Booher 1999). Rather, the primary benefit of information exchange relationships is that they provide a platform for agents to mutually synthesize knowledge and ideas. Because of this, I hypothesize that network actors embedded within highly reciprocated, non-hierarchical network structures are better positioned to successfully learn to deal with planning problems.

> Reciprocity Hypothesis: Network positions embedded within many reciprocated information-exchange relationships are conducive to successful learning and innovation.

Learning and brokerage

One prominent idea from the social networks literature is that actors occupying boundary-spanning network positions are generally better off, because they can act as brokers between disparate and fragmented groups (Burt 2004). Figure 1 illustrates a case where ego enjoys a high-brokerage position, because the groups of nodes to the left of ego (including alters *A* and *B*) and to the right of ego (including alters *C*, *D* and *E*) would be disconnected if ego did not span the boundary between them. Although ego seems to occupy an advantageous position in this hypothetical network, the implications of this position on ego's capacity to learn is unclear. The literature supports two competing hypotheses, one claiming that brokerage positions inhibit learning, and one claiming that brokerage promotes learning.

[FIGURE 1 ABOUT HERE]

The argument supporting the view that brokerage inhibits successful learning is similar to the argument in support of the Reciprocity Hypothesis. Synthesizing ideas from diverse information sources into a practical understanding of how to effectively solve problems must be more than an individual effort on the part of ego. Thus, while it is beneficial for ego to actively engage in reciprocal information sharing relationships with her alters, it is also important for ego's alters to engage in mutual information sharing, as in the linkages between *E* and *F*, or *B* and *A* in Figure 2. These linkages also serve to embed ego in "clustered" triadic relationships that tend to reinforce and strengthen network ties (Granovetter 1973). Consider, for example, the relationship between ego and alter *D*. The fact that *E* also goes to *D* for information sends a signal to

ego that *D*'s information is both a legitimate and trustworthy – especially if ego also considers E to be a trustworthy information source.

Finally, it should be noted that ego's embeddedness in triadic relationships – such as the interactions between ego and alters *E* and *D* – is at odds with ego's position as a broker. In order to maintain this brokerage position, for example, no linkages may be formed between nodes *A*, *B* and *C*, *D*, *E*. Such an information sharing link would increase ego's triadic embeddedness, but would also obviate her role as a boundary-spanner. Thus, I hypothesize that ego's learning is positively correlated with triadic embeddedness, and (by implication) inversely correlated with brokerage.

> Triadic Embeddedness Hypothesis: Network positions embedded within many triadic information-exchange relationships are conducive to successful learning and innovation.

On the other hand, one may also view ego's brokerage position as advantageous because it allows ego to draw information from more diverse viewpoints (Burt 2004). This view relies on the additional assumption that tightly networked actors tend to share similar systems of knowledge and beliefs, because many opportunities exist for learning within their clustered portion of the network. In Figure 2, ego's linkage with both *A* and *B* is redundant and therefore unnecessary – in this case, *B* will most likely have the same information as *A*. Thus, ego maximizes her access to fresh information by exploiting "weak ties" (Granovetter 1973) and seeking information outside of clustered triads. Having a position with high brokerage is therefore desirable because it allows ego to

sample many different paradigms and beliefs regarding the best way to tackle policy problems.

Brokerage Hypothesis: Network positions high in brokerage are conducive to successful learning and innovation.

I use Burt's (2004) structural constraint measure as an indicator of brokerage. This hypothesis is included for the sake of completeness; however, this viewpoint suffers from two limitations. Firstly, it presumes that policy learning is largely an individual process that relies solely on having access to many different ideas and knowledge systems. In the contentious commons governance issues such as the ones studied here, it is unlikely that any single actor can unilaterally make a difference in producing better outcomes.

Secondly, the notion of brokerage is a description of ego's embeddedness within a network structure. The idea these positions also promote learning relies entirely on the implicit assumption that high-brokerage positions also provide access to highly diverse knowledge systems. This is a compelling argument, but this aspect of the Brokerage Hypothesis should be made explicit by including additional hypotheses that link learning with the attributes of information exchange alters.

Learning as a Function of Alter Attributes

The structure of information-sharing relationships likely effect the overall usefulness of alters' knowledge for policy learning, but equally important is whether the

diversity and quality of this information is conducive to successful learning. Three potential effects of alter attributes on ego's propensity to learn are explored: the scope of information available, the diversity of available information and opinions, and the overall similarity of beliefs between ego and her information sources.

Scope of information sources

In order for information to actually make a difference in policy choices, it must be, among other things, relevant to the needs and problems faced by individual policy actors (Mitchell *et al.* 2006). Scope is one important determinant of relevance. Unfortunately, many governance systems wrangling with issues at the local or regional scale use information produced primarily at the state or federal level, as is the case with Marine Protected Areas in California (Weible and Sabatier 2005). Local knowledge systems are often ignored or marginalized within planning debates, making sustainable outcomes far more difficult to achieve (Cash *et al.* 2003). Many decision-makers in regional planning lack information that is tailored to their particular problems. Thus, I hypothesize that access to information and advice produced at a scale similar to the one in which a given agent operates increases their potential for successful learning and innovation.

> Shared Scope Hypothesis: Agents with access to information produced at a scale similar to the one in which they operate have a higher propensity to learn and innovate.

Diversity of information and beliefs

Burt's (2004) essential argument still stands as a compelling hypothesis of learning for sustainability: access to diverse sets of fresh ideas increases the "risk" that an agent will be innovative. This also holds true in cases such as ours, where innovation is not a purely individual endeavor, but rather networked groups of agents are collectively working to solve particular problems. The agent-based modeling literature, for example, has found that groups of problem solvers high in "functional diversity" – where agents have many different ways of framing and solving problems – are more likely to collectively innovate and learn (Hong and Page 2004).

Functional diversity in policy actors' information sources is likely to be an important determinant of their capacity to learn, although it is also necessary to be cautious about the differences between diversity in problem *framing* and problem *solving*. These can be quite different in the context of regional planning issues. Problem framing refers essentially to issue importance: amongst the wide set of problems faced in a given region, which problems are most pressing and which issues need less attention? These perceptions of issue importance are also related to expertise – agents who work in particular issues will tend to attach more importance to those issues relative to other regional planning problems. Teachers, for example, will tend to view overcrowding of schools as a serious issue, marine biologists may attach more importance to water pollution issues, and transportation planners (depending on their vintage) may view traffic congestion or outdated land use plans as most pressing.

I hypothesize that agents with access to information high in functional diversity on the basis of problem framing are in a better position to innovate, because they are in a

position to benefit from multiple skill sets and learn about a broad range of planning issues.

> Issue Importance Diversity Hypothesis: Agents with access to diverse information about issue importance have a higher propensity to learn and innovate.

While problem framing guides perceptions of the problems to be addressed, problem solving refers to beliefs regarding how to effectively address these problems. Having access to diverse problem-solving paradigms gives agents a larger sample of ideas to synthesize and fashion into a solution to their own particular problems. This is included as a separate, complementary, hypothesis.

> Issue Solution Diversity Hypothesis: Agents with access to diverse information about how to solve policy problems have a higher propensity to learn and innovate.

The empirical analysis will explore the effect of diversity on the basis of several different types of "problem-solving" beliefs that are particularly relevant within regional transportation and land use planning efforts.

Belief and value similarity

The Advocacy Coalition Framework (ACF; Sabatier and Jenkins-Smith 1993; Sabatier and Jenkins-Smith 1999; Sabatier and Weible 2007) is one promising theoretical lens on the policy process, and indicates that belief and value similarity of an agent's information sources is likely to impact their capacity to learn. The ACF adopts the concept of "biased assimilation" from the social psychology literature, which assumes that agents tend to interpret politically-relevant evidence in a way that tends to support their prior beliefs and values (Innes 1978; Lord, Ross, and Lepper 1979; Munro and Ditto 1997; Munro *et al.* 2002). The immediate effect of biased assimilation on information-exchange relationships is that agents with divergent belief and value systems tend to interpret evidence differently, which breeds distrust between them. There is reasonable empirical evidence in support of this hypothesis in the ACF literature (Leach and Sabatier 2005).

Despite the negative effect of biased assimilation on information-exchange between ideologically dissimilar agents, it is still common for policy actors to seek information and advice from sources they do not necessarily agree with. There are several reasons why this may happen. First, more information is usually better than less information, especially from the point of view of boundedly-rational agents who routinely operate under a severe dearth of information. Second, there may not be enough information sources to give agents the option to get information from ideologically similar sources. Third, it is usually advantageous to know what one's competitors are up to, and going to them for information is a useful way to better understand their strategies and resources.

But do information-seeking relationships with ideologically-dissimilar alters promote learning and innovation? From an ACF perspective, the answer is no. This information may be useful for the formulation of instrumental political strategies, but it is not likely to be trusted or used in the formulation of proposed policy solutions. Thus, having access to information from ideologically-similar sources amounts to having more usable information in the learning process and increases an agents' propensity to successfully learn.

> Belief Similarity Hypothesis: Agents with access to information from sources with belief and value systems similar to the agents' belief and value system have a higher propensity to learn and innovate.

Research Design: Regional Planning in California

Hypotheses of learning are tested using survey data from policy elites involved in land use and transportation planning within three California regions: Sacramento and surrounding counties (N = 197), San Diego (N = 76), and Riverside County (N = 71). Multiple archival sources were used to identify the relevant actors, including a database of environmental impact reports, lists of land-use planners in California, and websites of individual local governments. Although each of these regions contains a unique collaborative policy process designed to integrate land-use and transportation planning, this research was specifically designed to include actors from a wide diversity of institutional processes and was not limited to collaborative policy participants.

Network relationship data were gathered by asking respondents to name organizations that they go to for information or advice, as well as organizations they represent in regional planning issues. Network structures are then estimated at the level of organizations and stakeholder groups. Thus, networks are made up of organizational nodes and the relationships between them are estimated based on individual survey responses. These are unvalued, binary networks – an information linkage from organization *A* to organization *B* exists if at least one individual affiliated with organization *A* named organization *B* as a source of information or advice.

The unit of analysis in this paper is the individual organization, although it is assumed that learning by an organization is dependent upon their relationships with other organizations and the attributes of their information sources. I turn next to the measurement of learning and organizational attributes.

Dependent variable measurement

Two different measures of learning are used, both of which are included as individual items on the survey. *Innovation* measures organizations' perception that regional planning processes generate innovative policies. This measure is based on an individual survey question that asks respondents to rate, on a 7-point Likert scale, "the frequency with which regional land-use and transportation planning generates innovative policies in your area." The responses are then aggregated to the organizational level by averaging survey responses across all respondents who represent a given organization or stakeholder group. High scores on the innovation measure indicate a high degree of innovation, whereas low scores indicate a low degree of innovation.

A second measure of learning is *problem improvement*. This is another 7-point Likert scale that measures respondent perceptions of "the likelihood that current land-use and transportation planning processes will improve regional problems in your area." Once again, these scores are averaged out for organizations, and high scores indicate more intense perceptions that planning processes will improve regional problems.

Organizational attributes: Scope of involvement

The variable *scope* describes organizations' scope of involvement in planning issues. This variable is constructed based on survey responses that solicit the geographic scale at which respondents typically get involved in planning issues, ranging from their local town or city up to the entire State of California. Higher scores indicate larger geographic scopes, while lower scores indicate smaller scales of activity.

The variable *alter scope* is defined as the similarity between a given organization's scope of activity, and the scope of activity of all the organization's named information sources. Thus, organizations with small *alter scope* scores tend to have access to more information produced at their own geographic level of involvement.

Organizational attributes: Policy-relevant information and beliefs

Measuring the beliefs of individual organizations is accomplished by measuring the positions of individual survey respondents on seven belief scales. *Environmentalism* is a 3-item scale derived from the New Ecological Paradigm scale of Dunlap *et al.* (2000) (Cronbach's alpha = 0.78). *Economic conservatism* is a 4-item scale measuring the respondent's beliefs concerning the authority of government in interfering with private

property rights (Cronbach's alpha = 0.75). *Inclusiveness* is a 3-item scale that measures beliefs concerning the proper scope of public participation in government, focusing in particular on whether planning processes should involve broad public engagement (Cronbach's alpha = 0.53). *Smart Growth* is a 6-item battery measuring the respondent's agreement with Smart Growth principles (Cronbach's alpha = 0.69). Economic conservatism, inclusiveness, and Smart Growth primarily represent beliefs concerning policy solutions, while environmentalism is essentially a measure of values.

Beliefs regarding issue-importance are measured based on responses to a series of 7-point Likert scales concerning the severity of problems within the individual planning regions. Problem severity scales are created separately for each region, since there is significant regional variation in the types of planning issues being discussed. A principal components factor analysis of problem severity questions identified three clear types of issues within each region. A common label is given to the resultant scales for convenience, although the underlying dimensions differ considerably across study areas. In Riverside County, for example, concerns regarding water pollution and inadequate water supply scale well with general urban sprawl issues – these issues group naturally into the *environment and urbanization* problem severity scale. On the other hand, concerns regarding air pollution are an important component of the environment and urbanization scale in every region <u>except</u> Riverside; in Riverside, air pollution severity groups more naturally into the *infrastructure and crowding* scale (because of the connection to transportation and traffic congestion). The *costs* scale is roughly congruent across all regions, with the exception of SACOG. In all regions, this scale encompasses perceptions that rising taxes and costs of regulation are problematic – in addition, the cost

issue in SACOG tends to encompass infrastructure pressures as well (such as overcrowded schools and traffic congestion). The reliability of these scales is summarized in Table 1.

[TABLE 1 ABOUT HERE]

For each belief scale, a belief score is assigned to each organization by taking the average belief score (for that scale) of all respondents affiliated with the organization[1].

With these seven belief scales, the five belief-related variables used to predict policy learning were constructed. *Issue importance diversity* measures the diversity of an organization's information sources with regard to their perceptions of problem severity; this is the average Euclidean distance between all information sources on the basis of the *costs, environment and urbanization*, and *infrastructure and crowding* scales.

Three different variables are created to describe alter diversity in problem-solving beliefs. Smart Growth diversity is defined as the average Euclidean distance between all alters' Smart Growth scores. Similarly, *economic conservativism diversity* and *inclusiveness diversity* are the average Euclidean distance between alters' *economic conservativism* and *inclusiveness* belief scores, respectively.

Overall similarity in beliefs and values is measured by creating the *ideological similarity* variable – this is the average Euclidean distance between the focal organization and the organization's alters on the basis of all seven belief scales.

[1] For example, suppose that we sampled two respondents, *A* and *B*, who report an affiliation with organization *X*. Suppose also that *A* scored a "3" on the environmentalism scale and a "2" on the Smart Growth scale, while *B* scored a "5" on the environmentalism scale and also a "2" on the Smart Growth scale. Then organization *X* is assigned a "4" on the environmentalism scale, and a "2" on the Smart Growth scale – the average of *A* and *B*'s score for each belief type.

Organizational network position

Hypothesis of the influence of network position on learning are tested by including network-theoretic measures as independent variables. These include:

1) *expansiveness*, or the number of information sources sought by the focal organization,
2) *log reciprocity*, or the natural log of the number of outgoing information-seeking ties that are reciprocated by alters,
3) *log triads*, or the natural log of the number of redundant ties between the focal organization's information alters, and
4) *constraint*, or Burt's measure of structural constraint (brokerage) for the focal organization.

Linear regression models

Learning is modeled as a linear function of the above independent variables. All organizations from all three study areas are included in a single regression model, yielding an *N* of 71. Potential interdependencies between observations are accounted for by using ordinary least squares with robust standard errors.

Linear Regression Results and Discussion

Table 2 summarizes results linear regression results for the innovation and problem improvement measures of learning. The first thing to be noted about these results is that the influences of network position and alter attributes are actually quite different between the two operationalizations of learning, innovation and problem

improvement. Although these two variables are reasonably well-correlated, it is not surprising that important differences exist between them. Innovation, for example, is more likely to be a precondition for problem improvement. It is plausible that many organizations are embedded in network structures where there is a great deal of innovation, but their view of the political climate across the entire region may lead them to believe that these innovations will not ultimately make a major difference for policy. This is supported by the results: the general trends (in terms of direction of coefficients) are roughly similar, although the policy innovation model explains much more variance in the dependent variable.

[TABLE 2 ABOUT HERE]

One consistent and surprising result is that the Reciprocity Hypothesis seems to be disconfirmed across both models. Thus, organizations with many information sources that reciprocate the information-seeking relationship tend to have a decreased propensity for successful learning and innovation. There are two potential explanations for this. The first explanation could be that the policy system is truly comprised of "producers" and "consumers" of information, and that preserving hierarchical one-way relationships produces more efficient and effective results. Another potential explanation is that the network contains a few influential actors that are often cited as information sources, and that going to these particular actors for information is driving policy learning. Since these actors have very high in-degree, they cannot possibly reciprocate all ties – this makes it look like reciprocity damages actors' potential to learn. This possibility will have to be explored in a future iteration of this study, probably by re-running regression models after deleting one or more of the higher-degree organizations from the network.

The results for the Triads Hypothesis also support the possibility that reciprocity is negative mainly because of the influence of well-cited organizations. In particular, it seems that embeddedness within triadic relationships is a strong predictor of learning. This further supports the idea that brokerage is generally undesirable for innovation in planning, that learning is inherently a multi-agent activity, and that discussion produces better results.

The weak results for similarity in scope perhaps does not warrant much discussion, although it is notable that the positive direction of the coefficient does support the view that access to geographically-salient information is extremely important for policy learning. This lends strong support for the idea that collaborative institutions should actively seek to engage alternative forms of knowledge as inputs into the planning process, paying particular attention to the inclusion of actors from multiple geographic scales in the knowledge-production process.

The results for the ideological diversity variables are somewhat mixed for different types of beliefs. Contrary to the Issue Importance Diversity Hypothesis, diversity amongst information alters on the bases of perceptions of issue importance tends to have a significantly negative effect on learning. This, combined with the positive coefficients on Smart Growth and inclusiveness diversity, indicates that agents generally benefit much less from contrasting opinions of *what problems we want to solve* than from contrasting opinions over *how to solve these problems*. The negative coefficient on economic conservativism diversity may be a result of a misclassification of this belief scale – it may be better classified as a more immutable "value" than a malleable set of policy strategies. Indeed, this view would also help to explain the

negative coefficient on issue diversity, since perceptions of problem severity are likely to be strongly driven by values.

In conclusion, these results support looking at network position as a critical variable influencing agents' propensity to learn and innovate. The amount of variance explained by these models is impressive; in the case of innovation, over 50% of the variance is explained merely by network position and alter attribute variables. Unfortunately, the data are not as clean as they could be – thus, I conclude by calling for more empirical analysis to support the development of coherent theory linking the structure of social networks to policy learning within transportation planning and other commons governance systems.

Literature Cited

Burt, Ronald S. (2004) "Structural Holes and Good Ideas." *American Journal of Sociology*, Vol. 110, No. 2: 349 – 399.

Cash, David W., William C. Clark, Frank Alcock, Nancy M. Dickson, Noelle Eckley, David H. Guston, Jill Jäger, and Ronald B. Mitchell (2003). "Knowledge systems for sustainable development." *Proceedings of the National Academy of Sciences*, Vol. 100, No. 14: 8086 – 8091.

Clark, William C. (2007). "Sustainability Science: A room of its own." *Proceedings of the National Academy of Sciences*, Vol. 104, No. 6 (February 6, 2007): 1737 – 1738.

Freeman, Linton C. (1979). "Centrality in Social Networks: I. Conceptual Clarification." *Social Networks*, Vol. 1: 215 – 239.

Granovetter, Mark S. (1973). "The Strength of Weak Ties." *American Journal of Sociology*, 78(6): 1360 – 1380.

Holling, Crawford S. (1978). Adaptive Environmental Assessment and Management. John Wiley & Sons, New York.

Hong, Lu and Scott E. Page. "Groups of diverse problem solvers can outperform groups of high-ability problem solvers." *Proceedings of the National Academy of Sciences (PNAS)*, Vol. 101, No. 46 (November 16, 2004): 16385 – 16389.

Innes, J.M. (1978). "Selective Exposure as a Function of Dogmatism and Incentive." *The Journal of Social Psychology*, Vol. 106: 261 – 265.

Innes, Judith E. and David E. Booher (1999). "Consensus Building as Role Playing and Bricolage: Toward a Theory of Collaborative Planning." *Journal of the American Planning Association*, Vol. 65, No. 1 (Winter 1999): 9 – 26.

Kates, Robert W., William C. Clark, *et al.* (2001). "Sustainability Science." *Science*, Vol. 292: 641 – 642.

Kerr, Norbert L. and Cynthia M. Kaufman-Gilliland (1994). "Communication, Commitment, and Cooperation in Social Dilemmas." *Journal of Personality and Social Psychology*, Vol. 66, No. 3: 513-529.

Leach, William D. and Paul A. Sabatier (2005). "To Trust an Adversary: Integrating Rational and Psychological Models of Collaborative Policymaking." *American Political Science Review*, Vol. 99, Issue 04 (November 2005): 491-503.

Lord, Charles G., Lee Ross, and Mark R. Lepper (1979). "Biased Assimilation and Attitude Polarization: The Effects of Prior Theories on Subsequently Considered Evidence." *Journal of Personality and Social Psychology*, Vol. 37, No. 11: 2098 – 2109.

Lubell, Mark (2004). "Collaborative Environmental Institutions: All Talk and No Action?" *Journal of Policy Analysis and Management*, Vol. 23, No. 3: 549 – 573.

Mitchell, Ronald B., William C. Clark, David W. Cash, and Nancy M. Dickson (Eds.) (2006). Global Environmental Assessments: Information and Influence. MIT Press.

Munro, Geoffrey D. and Peter H. Ditto (1997). "Biased Assimilation, Attitude Polarization, and Affect in Reactions to Stereotype-Relevant Scientific Information." *Personality and Social Psychology Bulletin*, Vol. 23, No. 6: 636 – 653.

Munro, Geoffrey D., Peter H. Ditto, Lisa K. Lockhart, Angela Fagerlin, Mitchell Gready, and Elizabeth Peterson (2002). "Biased Assimilation of Sociopolitical Arguments: Evaluating the 1996 U.S. Presidential Debate." *Basic and Applied Social Psychology*, Vol. 24, No. 1: 15 – 26.

Parson, Edward A. and William C. Clark (1995). "Sustainable Development as Social Learning: Theoretical Perspectives and Practical Challenges for the Design of a Research Program." In Gunderson, Lance H., C.S. Holling, and Stephen S. Light. Barriers and Bridges to the Renewal of Ecosystems and Institutions. New York: Columbia University Press.

Sabatier, Paul A. and Hank C. Jenkins-Smith (Eds.) (1993). Policy Change and Learning: An Advocacy Coalition Approach. Boulder: Westview Press.

Sabatier, Paul and Hank Jenkins-Smith (1999). "The Advocacy Coalition Framework: An Assessment." In Sabatier, Paul (Ed.). Theories of the Policy Process. Westview Press, 1999, pp. 117 – 166.

Sabatier, Paul A. and Christopher M. Weible (2007). "The Advocacy Coalition Framework: Innovations and Clarifications." In Paul A. Sabatier (Ed.) Theories of the Policy Process. Second Edition. Westview Press: Boulder, Colorado.

Schneider, Mark, John Scholtz, Mark Lubell, Denisa Mindruta, and Matthew Edwardsen (2003). "Building Consensual Institutions: Networks and the National Estuary Program." *American Journal of Political Science*, Vol. 47, No. 1: 143 – 158.

Social Learning Group (2001). Learning to Manage Global Environmental Risks (Volumes 1 and 2). The MIT Press.

Weible, Christopher M. (2005). "Beliefs and Perceived Influence in a Natural Resource Conflict: An Advocacy Coalition Approach to Policy Networks." *Political Research Quarterly*, 58(3): 461 – 475.

Weible, Christopher M. and Paul A. Sabatier (2005). "Comparing Policy Networks: Marine Protected Areas in California." *The Policy Studies Journal*, 33(2): 181 – 201.

Figure 1:
Hypothetical information exchange network, with *EGO* as the focal learning agent

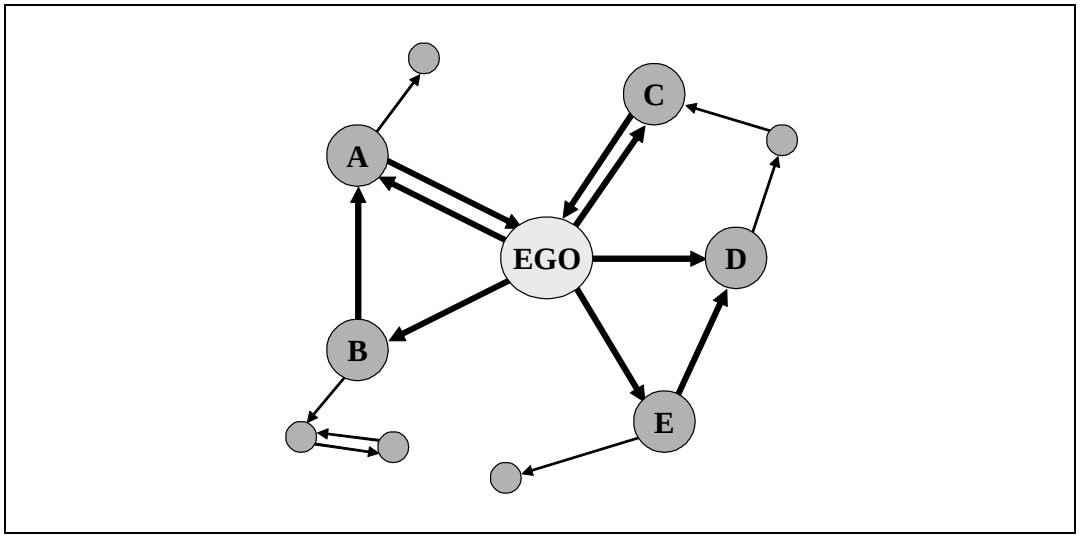

Table 1:
Reliability of regional problem severity belief scales

		Regional problem severity belief scale		
		Costs	**Environment & urbanization**	**Infrastructure & crowding**
Region	**Merced**	2-item scale α = 0.73	4-item scale α = 0.77	6-item scale α = 0.71
	Tri-County	3-item scale α = 0.64	4-item scale α = 0.74	4-item scale α = 0.68
	Riverside	2-item scale α = 0.72	7-item scale α = 0.79	5-item scale α = 0.55
	San Diego	2-item scale α = 0.77	5-item scale α = 0.82	5-item scale α = 0.69
	SACOG	7-item scale α = 0.75	4-item scale α = 0.83	1-item scale

Note: "α" denotes Chronbach's alpha for the associated problem severity scale.

Table 2:
Robust linear regression results for problem improvement and innovation
(N = 71 organizations)

	Innovation (R^2 = 0.53)	*Problem improvement* (R^2 = 0.28)
log reciprocity	-0.25 **	-0.26 *
log triads	1.93 ***	0.05
alter scope similarity	0.34 *	0.18
expansiveness	-0.09 ***	0.01
issue importance diversity	-0.84 ***	-0.65 **
Smart Growth diversity	0.34	1.14 **
economic conservativism diversity	-0.63 **	-0.47
inclusiveness diversity	1.24 *	1.22 **
ideological similarity	0.07	-0.22

Note: Stars indicate statistical significance levels: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.