Ecological and Rational Choice Models of Endogenous Change

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Citation: Ruef, M. (2017). Ecological and rational choice models of endogenous change. *Rationality and Society*, 29(1), 55–62.
https://doi.org/10.1177/1043463116685664

DellaPosta, Nee, and Opper (2017; hereafter DNO) offer an intriguing model of endogenous institutional change, rooted in the premise that deviations from existing social institutions occur when agents see utility gains from deviation, when network externalities contribute to the diffusion of those deviations, and when political actors tend to accommodate (rather than sanction) deviations that are adopted by a large number of agents. In this brief essay, I will compare their rational choice model with another model of bottom-up change rooted in organizational ecology and evolutionary theory (Hannan and Freeman 1977; Carroll and Hannan 2000; Aldrich and Ruef 2006). I highlight common ground between the models and note where technical differences might contribute to new insights.

Despite superficial distinctions in perspective, DNO's rational choice model shares a number of conceptual parallels with ecological models. First, both models emphasize endogenous dynamics within populations as the basis for macro-level change, thereby distinguishing them from sociological theories that begin with an exogenous shock as an initial impetus to contention (e.g., Fligstein and McAdam 2012). Second, both rational choice and ecological models recognize that agents' reactions to their "neighbors" – whether defined in spatial, network, or categorical terms – represent a crucial aspect of endogenous change. Finally, both models are well-suited to explain the rise of an institutional innovation or new organizational form as long as the boundary around the population of agents is clearly delineated. While ecological models have more often been applied to examine the evolution of established populations and DNO seek to explain how "innovators operate beyond the boundaries of the established order", this distinction is essentially one of semantics.[1] Both models assume that the population of adopters for an institutional deviation can be identified.

[1] Due to the frequent application of ecological models to established populations, these scholars have also tended to privilege the cognitive dimension of institutionalization, i.e., addressing how categories of agents come to be accepted by audiences (Scott 2013). As is the case in DNO's empirical applications, however, some ecological treatments have also emphasized the regulative dimension, considering when dynamics among agents lead to approval by the state (e.g., Ruef 2000).

Differences in Ecological and Rational Choice Models

I now turn to technical differences between the models introduced by DNO and the specification of population evolution and form emergence that ecological and evolutionary theorists have developed since the 1970s. To ensure conceptual similarity, I apply both models to a known population of autonomous yet interdependent agents with a binary state. In the DNO model, this binary state entails a decision between institutional deviance and compliance. In the ecological model, it entails a decision between committing to some new organizational form, routine, norm, or other social practice and doing nothing. The conventional nomenclature for the first category (institutional deviants or agents engaged in novel action) is commonly that of the "entrepreneur", though many rational choice and ecological theorists eschew this terminology.

With those parallels in mind, I will suggest that there are three major differences in the formal model employed by DNO and ecological models. These differences not only point to technical variation in modeling strategy, but variation in underlying theoretical assumptions and, possibly, the inferences that will be drawn with respect to the endogenous dynamics of change.

(1) Utility Gain from Compliance: In DNO's rational choice perspective, agents assign a utility to compliance with existing institutional norms (equation 1). Classic ecological perspectives do not rely on such utility calculations, but assume instead that agents will tend toward inertia for a variety of structural reasons (e.g., Hannan and Freeman 1984). This conception of institutional persistence is consistent with the idea of "taken-for-grantedness" in sociological versions of neoinstitutional theory, where action is often dictated by shared scripts and constraints in lieu of interests (Clemens and Schneiberg 2006; Scott 2013). Rather than being based on calculations of utility gain, institutions exist precisely so as to reduce or eliminate the cognitive load that accompanies decision-making in more open-ended and uncertain situations.

From a modeling perspective, this implies that parameter $\boldsymbol{A}$ in DNO's agent-based specification (which scales the utility of compliance) would be removed in a corresponding ecological model. As a result, the utility of compliance $\boldsymbol{U(C)}$ is ignored and analytical attention shifts to $\boldsymbol{U(D)}$, the utility of deviation. We will return to the latter term momentarily, but, for now, we should consider

what is potentially lost in taking ***U(C)*** out of the model. In DNO, agents opt for compliance or deviation as a function of the difference between ***U(D)*** and ***U(C)*** (equation 4). In reduced form, that is:

$$U(C) - U(D) = A\left(1 - \frac{\sum_{j=1}^{N_i} D_j}{N_i}\right) - B\left(\frac{\sum_{j=1}^{N_i} D_j}{N_i}\right)(1 - f_i) \quad (1a)$$

$$= A - A(N_D) - B(N_D) + B(N_D)(f_i) \quad (1b)$$

where $\boldsymbol{N_D}$ is the density of deviating agents in a neighborhood, aside from the focal agent.[2] Ecological theory then proposes that this expression is best reparameterized in terms of two variables (Carroll and Hannan 2000). One corresponds to the extent to which a deviation has found acceptance, or *cognitive legitimation (**L**)*, among the neighbors of the agent (***L*** = ***A*** + ***B***). The other corresponds to the extent to which the deviating agent faces sanctions or *competition* (***C*** = ***B***) from other agents. Ignoring the ***A*** term as a constant, this expression becomes:

$$= -L(N_D) + C(N_D)(f_i) \quad (1c)$$

with $\boldsymbol{L > C > 0}$. In other words, the probability of compliance decreases to the extent that a deviation is seen as being cognitively legitimate and increases to the extent that the deviation faces sanctions or competition from other agents. From the standpoint of ecological theory, this expression can be stated equivalently without reference to compliance, i.e.:

$$U(D) = L(N_D) - C(N_D)(f_i) \quad (1d)$$

where entrepreneurs assign a utility to deviations from institutionalized norms (e.g., founding a new type of organizations or using a new type of routine) as a positive function of the cognitive legitimation of that deviation and as a negative function of competitive threat.

[2] The agent-based model in DNO treats this density as a proportion. For ecological models, it is more commonly treated as a raw count of deviating agents. This difference becomes important empirically when density is subject to mathematical transformation (e.g., via power or ceiling functions) and when the risk set of potential adopters is unknown. But it has little conceptual impact as long as neighborhoods assume a uniform size across agents.

(2) Source of Threat: A second technical difference arises in specifying the source of threat to an institutional deviation – i.e., in the interpretation of the f_i term. In DNO, the primary source of threat is the state, which may sanction deviation directly (by imposing penalties on the agent) or indirectly (by imposing penalties on the agent's neighbors, which serves as an object lesson against deviation). In ecological theories, the primary source of threat involves other agents, who either compete directly with the focal agent (by seeking to profit from the same deviation) or indirectly (by adopting routines, norms, or organizational forms that serve as an alternative to the deviation). The competitive landscape among agents is the principle focus of ecological theories, while variation in the "carrying capacity" for a deviation -- as a function of state regulation or other sociopolitical challenges – tends to be a secondary concern (Aldrich and Ruef 2006).

Given these differences in interpretation, ecological theory suggests some additional assumptions in the specification of the f_i term. First, the weight that agents place on the state sanctions they experience personally is small, or even negligible ($\theta \rightarrow 0$). This assumption is likely to be dubious in the case of politically centralized societies such as China, but may apply more readily outside of heavily regulated sectors in decentralized societies such as the United States. Second, agents do not feel threatened by sanctions against their neighbors, but by the competitive pressures exerted by those neighbors, especially as a deviation becomes more widely accepted .[3] With these assumptions in mind, the equation for threat to institutional deviation can be rewritten as:

$$f_i = \theta S_i + (1-\theta)\left(\frac{\sum_{j=1}^{N_i} D_j}{N_i}\right) \tag{2a}$$

$$\approx \left(\frac{\sum_{j=1}^{N_i} D_j}{N_i}\right) = N_D \tag{2b}$$

[3] Some ecological models also specify competition as a function of the *carrying capacity* for a deviation, or the maximum proportion of deviating agents that the environment could theoretically support. In DNO, the implicit assumption is that all agents have the possibility of transitioning from compliance to deviation and carrying capacity becomes an irrelevant constraint.

where $\boldsymbol{N_D}$ again is short-hand for the density of deviating agents in a neighborhood. When we substitute $\boldsymbol{f_i}$ back into equation 1d, we obtain a *density-dependence* model akin to those models used in ecological theory (e.g., Carroll and Hannan 2000), i.e., a model where the utility of further deviation in a neighborhood depends on the existing density of deviating agents ($\boldsymbol{N_D}$) and is influenced by parameters for legitimation ($\boldsymbol{L}$) and competition ($\boldsymbol{C}$):

$$U(D) = L(N_D) - C({N_D}^2) \tag{3a}$$

(3) Institutional Alternatives: A final technical difference between ecological models of endogenous change and the rational choice model in DNO is that the latter approach does not explicitly address institutional alternatives to deviation and compliance. Consider the default assumption in organizational ecology, in which managers and other agents are subject to structural inertia and comply with existing institutional norms by following taken-for-granted scripts.[4] One alternative is "active" rather than "passive" compliance. For instance, one might argue that the political and economic entrepreneurs who actively supported state-owned manufacturing enterprise in the Yangzi delta region were different from both private manufacturing entrepreneurs, who deviated from institutional expectations, and rural entrepreneurs, who had traditionally been left out of China's system of central labor allocation and, thus, operated in quiet compliance (Nee and Opper 2012). Institutional alternatives may also arise insofar as there are multiple forms of deviation. In my analysis of the emergence of organizational forms in the American healthcare field, health maintenance organizations (HMOs) began to diffuse in the 1970s as one deviation from traditional medical insurance plans, but so did other organizational alternatives, such as preferred provider organizations (PPOs) and insurance/risk pools (Ruef 2000).

From a modeling standpoint, perhaps the simplest way to incorporate such alternatives into the agent-based model in DNO is to distinguish those deviating agents within the neighborhood of a focal agent ($\boldsymbol{N_D}$) from deviating agents that are located outside of the neighborhood ($\boldsymbol{N_O}$). In ecological perspectives, $\boldsymbol{N_D}$ is conceived of as a population of agents that pursue a closely-related

[4] Ecological theory has traditionally considered organizations as the unit of analysis for such passive compliance (Hannan and Freeman 1984). In more recent versions of the theory, the persistence of institutionalized identities tends to occur at the population or field level (e.g., Hsu and Hannan 2005).

deviation from previous institutional norms, while $\boldsymbol{N_O}$ includes other populations of agents that are considering one or more institutional alternatives. Extending the density dependence model above, this suggests the following equation for the utility of deviation:

$$U(D) = L(N_D) - C\left(N_D{}^2\right) + \sum_{j \neq i}^{J} c_{ij}(N_{Oj}) \qquad (3b)$$

where $\boldsymbol{j}$ indexes other neighborhoods in the lattice and $\boldsymbol{c_{ij}}$ represents the symbiotic or competitive effect of the corresponding populations of agents on the utility of deviation in the focal neighborhood. While ecological theory points to a variety of possible relationships between populations of agents (Aldrich and Ruef 2006: Chapter 11), the analytical tractability of this model usually calls for some simplifying assumptions. My community ecology model, for example, posits that relations between populations are competitive ($\boldsymbol{c_{ij}} < 0$) for agents that are in proximate neighborhoods and irrelevant for agents in distant neighborhoods ($\boldsymbol{c_{ij}} = 0$) (Ruef 2000).

Analytical and Empirical Implications

Based on the preceding comparison, it is possible to envision DNO's model of endogenous institutional change as an extension of ecological models, in which the state can directly sanction a focal agent ($\boldsymbol{\theta} > 0$) and there is an explicit weight assigned to institutional compliance ($\boldsymbol{A}$). It is also possible to characterize the ecological specification as an extension of DNO's model, in which agents view deviating neighbors as competitors as well as exemplars ($\boldsymbol{f_i} = \boldsymbol{N_D}$) and other institutional alternatives may compete with or support a deviation in a focal neighborhood ($\boldsymbol{c_{ij}} \neq 0$). Enterprising model builders may find it useful to develop an agent-based specification that combines insights from rational choice and ecological perspectives.

While the development of such an integrated model is beyond the purview of this essay, I would like to conclude by drawing out some analytical and empirical implications of the modeling differences I have sketched. With respect to the spread of an institutional deviation over time, both models anticipate an S-shaped trajectory for a typical successful deviation. In DNO's model, the exceptions tend to occur when the expectation of sanctions from the state is high (which shifts the trajectory toward a lazy J-shaped curve [see Figure 1]) or when the weight assigned to the

utility of deviation is low (which can prevent the deviation from diffusing at all [see Figure 3]). In the ecological model, the exception tends to occur when competition from institutional alternatives is strong, which may either prevent the deviation from diffusing or yield a checkerboard pattern across neighborhoods in the lattice. Both approaches do not seem particularly well-suited to explaining cyclical patterns of institutional deviation and compliance, which have sometimes been modeled by assuming that there are temporal lags in how agents react to the activities of neighbors or the sanctions imposed on them (e.g., Ruef 2006).

With respect to empirical application, the models can be applied readily when the trajectory of a successful innovation is observed to occur in an S-shaped form, albeit with different explanations. In tracking the diffusion of gay bars in San Francisco between the mid-1960s and late 1970s, DNO point to the high profitability of these drinking establishments as an initial catalyst to their founding, followed by network externalities, as entrepreneurs opened new gay bars near existing ones and established collective associations (such as the Tavern Guild and Golden Gate Business Association). Ecological theorists are more likely to point to inter- and intrapopulation conditions to account for this pattern. In particular, many of the early owners of gay bars were conservative, heterosexual businessmen who benefited from the legitimacy that the city already accorded to drinking establishments outside the gay community. Once these businessmen had established a critical mass of bars oriented toward a gay clientele, it became easier for entrepreneurs within the LGBT community to start their own bars. The diffusion process slowed in the late 1970s, as gay bars had become institutionalized in San Francisco and competed more intensely with one another.

Empirical evidence is unlikely to adjudicate between ecological and rational choice models of endogenous institutional change. The models rely on constructs that are not easily measured over the extended intervals in which institutional change tends to occur, be it the mechanisms of legitimation and competition in the ecological approach or expectations of utility gain and sanctioning in the rational choice approach. The kinds of research designs deployed by scholars in these two traditions also tend to be different. Rational choice models require that the risk set of agents who are contemplating an institutional deviation be clearly defined; ecological models often avoid this empirical complication by emphasizing entry rates into a new and/or deviant population (Carroll and Hannan 2000). Nevertheless, a review of analytical differences between the two

models does suggest that they may each have selective advantages in explaining institutional evolution outside of the ideal-typical case of S-shaped diffusion. Consequently, both models represent valuable implements in the toolbox of social scientists who seek to account for the dynamics of endogenous institutional change.

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