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Management Insights

Cooperation in Evolving Social Networks

Nobuyuki Hanaki, Alexander Peterhansl,
Peter S. Dodds, Duncan J. Watts

How do online market places such as eBay sustain trade between tens of millions of strangers without centralized enforcement of fair exchange? The question is important because the success or failure of such market places ultimately depends on whether participants behave cooperatively among themselves. However, a standard result in the evolution of cooperation literature is that the larger the population size, the more difficult it is to sustain cooperative behavior. So what enables cooperative behavior to prevail in decentralized exchange markets, even as membership numbers are increasing exponentially? Our study sheds light on this question by analyzing a model in which individuals not only learn which strategy to adopt, but also choose with whom they should interact. We show that sustained cooperation can be achieved in such *evolving networks*, even in conditions that are by default hostile to cooperation, by striking a trade-off between *local reinforcement* and *global expansion*. Taking the example of eBay, a member's freedom to choose with whom to trade functions as a local reinforcement mechanism, which encourages cooperative members to interact among themselves. But existing members' apparent willingness to trade with new entrants whose previous (and future) behavior is unknown to them, acts simultaneously as a global expansion mechanism. Our study shows that together, these mechanisms can sustain cooperation between existing cooperators, as well as recruiting of new cooperators, regardless of the population size.

Bilateral Collaboration and the Emergence of Innovation Networks

Robin Cowan, Nicolas Jonard,
Jean-Benoît Zimmermann

The recent surge in R&D alliances signifies a new way of innovating by looking to outside partners for missing knowledge resources. But with whom should a firm ally, and how should it manage its portfolio of alliances? To maximize innovation, can a partnership be formed solely on the basis of immediate innovative effect, or should impact on partners' portfolios also be considered? In this paper, we develop a computational network model of R&D alliance formation and examine numerically two factors affecting how firms choose

partners to create efficient networks: (1) the extent to which innovation projects can be decomposed into (roughly) independent subprojects each carried out by the more competent partner, and (2) how a firm learns about potential partners via direct experience, as well as social information (e.g., from professional associations and meetings). We find that looking beyond immediate output to consider network implications does not increase the amount of knowledge a firm produces relative to other firms. However, knowledge production can be increased (a) when projects are highly decomposable, by increasing the number of different partners; and (b) when social information is valuable relative to direct experience, by becoming part of a small group of tightly interlinked firms.

Patterned Interactions in Complex Systems: Implications for Exploration

Jan W. Rivkin, Nicolaj Siggelkow

Managers who must make numerous, related decisions face a difficult question: How broadly should they explore the array of possible sets of choices? Should they encourage their organizations to consider a wide-ranging variety of possibilities or focus on a handful of nearby options? Prior research shows that the answer hinges on the degree of interaction among the constituent decisions. When decisions are highly interdependent and everything depends delicately on everything else, it is important to encourage broad exploration. Otherwise, the organization runs the risk of getting trapped in conflicting constraints and tapping out improvement opportunities at low performance levels. Our research looks not at the *degree* of interaction but the *pattern* of interaction—what depends on what. We take certain patterns of interaction that have been observed in recent studies of organizations, social networks, and technical systems, and use a simulation to examine which patterns demand broad exploration. We find, first, that the pattern of interaction matters a great deal. The number of ways that firms can “get trapped” rises or falls dramatically depending on the pattern of interaction, holding fixed the degree of interaction. Second, there are straightforward rules of thumb for identifying systems that pose many potential traps and therefore require broad exploration. Using these rules, a manager should be able to look at two sets of decisions with different patterns of interaction and determine quickly which one deserves greater investment in exploration.

Membership Herding and Network Stability in the Open Source Community: The Ising Perspective

Wonseok Oh, Sangyong Jeon

Despite the widespread adoption of open source software (OSS) by the business community, managers who make IT-related decisions have limited understanding of why some OSS projects succeed and others fail. We investigate the relationship between membership dynamics and collaboration network structures in OSS communities. Due to reciprocity and collective actions among voluntary OSS members, a lack of participation by or departure of a participant may create a hole in the community's social fabric and therefore result in sudden changes in its membership base and collaboration structures. The findings from this study suggest that (1) the roles and responsibilities of leaders and active interaction among members are critical components for the sustainability of these volunteer-based organizations, and (2) collaboration network structures play an important role in minimizing the risks related to negative membership dynamics. These findings can help managers identify stable OSS communities and leverage them to effectively support their IT strategy.

Call-Center Labor Cross-Training: It's a Small World After All

Seyed M. R. Iravani, Bora Kolfal, Mark P. Van Oyen

Labor accounts for the majority of the cost of operating a call center. Furthermore, call centers are notorious for having very high labor turnover rates and also experience large variations in workload and service mix. Both of these problems can be mitigated through the use of agent cross-training. However, predicting the benefits of specific cross-training strategies typically requires time-consuming simulation analysis. In this paper, we formulate simple network models and utilize the average shortest path length metric of "small world networks" to provide an efficient method to help managers choose among alternative cross-training strategies. The computational simplicity of our method permits greater insight and avoids the need for simulation, which makes it a practical tool for use in call-center labor management software.

Interfirm Collaboration Networks: The Impact of Large-Scale Network Structure on Firm Innovation

Melissa A. Schilling, Corey C. Phelps

Strategic alliances are widely-used and important vehicles for firm growth and innovation. As firms form and maintain alliances, they weave a network of direct and indirect relationships. The pattern of these

relationships constitutes the *structure* of the alliance network. In this paper, we posit that a firm benefits when it participates in a network that exhibits both high *clustering* and high *reach*. A highly clustered network is one in which subsets of firms in the larger network are densely connected to each other, even if the broader network is not particularly dense. Clustering enables information to travel quickly and with high fidelity because it creates redundant paths between firms and increases the level of cooperation among them. A network in which firms are directly or indirectly connected to many others via short paths has high reach. Reach increases the amount and diversity of information available to a firm by increasing the number of other firms that provide information and by decreasing the path length the information has to travel. To test our prediction, we analyzed the innovative performance of 1,106 firms in 11 industry-level alliance networks over a six-year period, and concluded that large-scale alliance networks that exhibited high levels of clustering and reach enhanced firm innovation.

The Statistical Mechanics of Complex Product Development: Empirical and Analytical Results

Dan Braha, Yaneer Bar-Yam

Product development (PD) is a problem-solving activity that may involve hundreds or thousands of designers carrying out tasks and revising their actions based on input from others. In this paper, we analyze information flow networks of large-scale PD projects in several major companies, and characterize their structure and dynamics. Strikingly, we observe that the patterns of information flows embedded in real-world PD networks are similar to those discovered in other information, technological, and biological networks. We show that these properties make PD networks robust to errors and unplanned design changes. However, we identify specific information flow patterns that present "information bottlenecks," which can cause the activity to degenerate into an endless cycle of revisions. Informed managers who identify and safeguard these bottlenecks can help protect their PD systems from escalation of effort and cost. We suggest several mitigation strategies, which include preferential resource allocation, decoupling of task activities, task modularization, and reuse of prior solutions. Focusing efforts in this way can improve process efficiency and boost performance significantly.

Analyzing Consumer-Product Graphs: Empirical Findings and Applications in Recommender Systems

Zan Huang, Daniel D. Zeng, Hsinchun Chen

Automated recommender systems, such as those deployed at Amazon and Netflix, have become critical to the competitiveness of the online business. A

key approach to automated recommendation is *collaborative filtering*, which analyzes customers' collective historical sales transactions to predict individual customer future purchases. The implicit assumption behind the collaborative filtering is that sales transactions are nonrandom and therefore predictable. Our study represents one of the first attempts to explicitly analyze the nonrandomness of real-world e-commerce sales transaction data using the random graph theory. In our work, sales transactions are represented as a consumer-product graph, which is compared against hypothetical graphs generated from a series of models, ranging from the purely random model to models consistent with the specific assumptions made by various collaborative filtering algorithms. This enables us to detect the existence of non-random patterns in the real-world sales data, thus providing foundational justification for the use of collaborative filtering methods. Furthermore, our analysis provides guidance on which specific recommendation algorithm provides the best fit for a given dataset. Finally, our analysis leads to development of a new collaborative filtering algorithm, motivated by the specific clustering characteristics of the real-world consumer-product graphs.

Complexity and the Character of Stock Returns: Empirical Evidence and a Model of Asset Prices Based on Complex Investor Learning

[Scott C. Linn, Nicholas S. P. Tay](#)

The dynamics of financial security returns are at the heart of practical portfolio management. Understanding how investor learning about companies and securities impacts return dynamics can be a valuable tool for portfolio managers. In this study, we approximate how investors learn using a model based on induction and fuzzy logic. Learning in the model leads to predictions about the future prices and dividends of a financial security, which are used to determine investor demands for the security. We use these demands in an electronic artificial stock market to determine prices for a financial security in a sequential multiperiod

environment. This enables us to examine how the posited learning scheme influences the volatility and probability distribution of the returns. Comparisons of our simulation results with actual stock price changes for a sample of NYSE traded stocks, shows that our model reproduces the behavior of actual stock price changes remarkably well. We argue that inductive reasoning and the application of fuzzy logic can be a realistic description of learning behavior in complex ill-defined settings such as dynamically changing stock markets. As such, our model has the potential to form the basis for a predictive framework of security returns and return volatility.

Emergent Properties of a New Financial Market: American Venture Capital Syndication, 1960–2005

[Bruce Kogut, Pietro Urso, Gordon Walker](#)

Managers make deals on the basis of local knowledge—whom they can trust, who has appropriate expertise, and what are good markets. But it is hard for them, as it is for anyone, to predict the larger consequences of their decisions. The science of complexity permits insight into the larger structural outcomes of local decisions. For example, if a venture capital company changes its rule and starts to do deals with new entrants, how will the firm be placed in the future? Will it have more opportunities or fewer opportunities? Will it be more highly regarded or less so? We show how the search to balance trust, expertise, and diversification generates a network of firms who form the backbone of the venture capital market. We also reject the popular view that investments require “dense interactions” among investors within a region. On the contrary, we show that national capital flows are critical from the start. Our results provide a tempering recommendation to policy makers who believe that regional success in venture capital is based upon tight local networks by showing how regional development is interdependent with the wider national development of the venture capital market.