How Do Community Ecology and Structure Shape Digital Innovation Strategy?

Abstract

Pondering whether, when, and how to innovate with digital technologies, managers are navigating a complex and dynamic landscape. To help with this challenging undertaking, we draw on organizational ecology and network theories to conceptualize the organizational communities that support digital innovations. Empirically, we analyzed news articles about Customer Relationship Management (CRM) and its stakeholders and found that organizations’ strategy to provide or adopt the CRM technology depended on two ecological processes: (1) legitimation of CRM attracted organizations to enter the CRM community; (2) competition for resources deterred such entries. Further, more efficient structure of the community was linked to higher rate of entry by organizations to provide the CRM technology. This study brings organizational ecology theory from the population/industry level to the higher, community level, contributes a holistic perspective to the repertoire of theories on digital innovations, and demonstrates the potential to advance digital innovation strategy research along multiple dimensions.

Keywords: Digital innovation, strategy, organizational ecology, scale-free network, innovation community, discourse analysis, customer relationship management

Introduction

Digital technologies are enabling transformational change in many facets of the economy and society (Lucas Jr. et al. 2013). The landscape of innovation is also changing as numerous processes, products, and services are digitized (Bharadwaj et al. 2013). Traditional industry boundaries are being blurred and broken. For example, firms typically from outside the automotive industry are now offering new devices, networks, services, and content working on the computing platform of new cars (Yoo et al. 2010). In developing innovative products or services, the tasks of designer and customer are merging (Henfridsson and Lindgren 2010; von Hippel 1988) on multi-sided digital platforms (Tan et al. 2015). The roles of
developer and adopter are overlapping (Chesbrough 2012), thanks to various open innovation mechanisms enabled by globally connected digital devices and networks. Navigating in this complex and dynamic landscape, therefore, is not an easy undertaking for business and IT managers, as they ponder whether, when, and how to innovate with digital technologies.

We are just beginning to understand the implications of the complex and fast changing digital innovations to policy-making, corporate strategy, and IT management (Barrett et al. 2015; Bharadwaj et al. 2013; Fichman et al. 2014; Yoo et al. 2012; Yoo et al. 2010). Thus far mainstream innovation research has treated innovation development and diffusion separately. On the one hand, Information Systems (IS) scholars have thoroughly studied the adoption and implementation of a wide array of digital innovations (Fichman 2004). On the other hand, Technology and Innovation Management (TIM) research has a long tradition of investigating the development of technological innovations (including digital innovations) (Ruttan 2001). Within each discipline, research has been so focused on one aspect of innovation that other aspects are assumed unproblematic. For example, IS research on innovation diffusion is focused on the demand side of innovations, assuming the supply of innovations is plentiful. Similarly, TIM research concentrates on the design and development of innovations, with much less attention to the actual use of the innovations. This division of labor has been increasingly challenged. In TIM, Eric von Hippel (1988) reminded that innovative design ideas often come from the users of innovations. In IS, the rise of Design Science is shifting focus to the design and evaluation of technological artifacts (Hevner et al. 2004), often masked under surrogate measures in traditional innovation diffusion research (Orlikowski and Iacono 2001). Hence, a lesson learned is that both development and diffusion of an innovation, both its supply and demand, both its design and use matter. Yet, still lacking is a holistic theory that can piece together a comprehensive picture of today's digital innovations and bridge the division between innovation studies in IS and in other related fields.

Recent research on innovation ecosystems is promising in the development of a much-needed holistic theory of digital innovation. Innovation ecosystems have been conceptualized as aggregations of interdependent actors and activities supporting innovations at organizational (Adner 2006; Autio and Thomas 2014; Woodard and Clemons 2014), industry (Van de Ven and Garud 1993), and national (Fukukda and Watanabe 2008) levels. Researchers adopting this perspective have the potential to break new ground in innovation research because they examine factors and actors (often treated separately in previous research) and their interdependencies together. However, beyond this inclusive view and basic concepts such as competition and symbiosis, innovation research has thus far used the term "ecosystem" just as a metaphor, and an "everything-is-related-to-everything-else" explanation implied in some metaphorical treatments is not an adequate theory.

In this study, we take the "eco" in innovation ecosystems seriously by focusing on the ecological processes in an innovation community, comprised of interdependent populations of organizations with interests in producing and/or using a focal innovation. Applying organizational ecology theory and network theory, we address the research question: How do the ecology and structure of a digital innovation's community shape innovation strategy? Specifically, we examine the community ecology and structure of Customer Relationship Management (CRM), a category of enterprise software that enables innovations in marketing and customer services in multiple industries, in order to explain the strategic moves organizations made to innovate with CRM. By analyzing news articles on CRM published in a 10-year period and employing an ecological modeling technique (density-dependence modeling) and a novel network metric (scale-freeness), we have found that organizations’ decision to provide or adopt the CRM technology depended on two ecological processes: (1) legitimation of CRM attracted organizations to enter the CRM community to offer or adopt the technology; (2) competition for resources deterred such entries. Above and beyond legitimation and competition, more efficient structure of the community was linked to higher rate of entry by organizations seeking to provide the CRM technology.

This study brings organizational ecology theory from the population/industry level to the higher, community level, contributes a holistic perspective to the repertoire of theories on digital innovations, and demonstrates the potential to advance digital innovation strategy research along multiple dimensions: scope, scale, speed, and value realization (Bharadwaj et al. 2013).

In the balance of the paper, we first review organizational ecology theory, apply it to study digital innovations, and develop the hypotheses. We then describe the methods and report the findings from an
empirical study of CRM. Lastly, we acknowledge the study’s limitations, discuss the theoretical and practical implications, and conclude by laying out the next steps for future research.

**Toward an Ecology Theory of Digital Innovation**

We first provide a brief overview of organizational ecology, before applying it to study digital innovations.

**Organizational Ecology**

The ecology of organizations is a theoretical approach to understanding the "forces that shape the structures of organizations over long time spans" (Hannan and Freeman 1989, p. xi). Unlike theories assuming that organizations adapt to their environment rationally and rapidly, ecology theory recognizes the limits of organizations' abilities to adapt to the environment and suggests that different environmental conditions favor different types of organizations. Therefore, the fate of particular organizations depends not only on their characteristics and strategies, but also significantly on the conditions in the environment in which the organizations operate. The theory is applicable especially to highly uncertain, fast changing, and/or politically-charged environments (such as those for digital innovations) where an organization’s ability to control its own fate by adaptation is often constrained.

An organization depends on its environment for resources to survive and grow. Organizations that rely on the same environment must find ways to coexist and this coexistence is often a double-edged sword. On the one hand, presence of similar organizations provides legitimacy for that type of organization (Meyer and Rowan 1977) and opportunities for them to learn from each other (Ingram 2002). On the other hand, similar organizations rely on a common pool of resources, forcing them to compete for the ultimately finite resources they need. As a population of similar organizations emerges, increasing legitimacy attracts new organizations and reduces the chances of failure for those already in the population. As the population grows, increasing competition discourages entries and makes incumbents more likely to fail. Accordingly, population density is routinely used as an indicator for both legitimation and competition among organizations in a population or industry (Hannan et al. 1995). Further, competition is not the only type of interorganizational relationship; organizations in a population may also collaborate.

Beyond a given population comprising organizations of a similar type (such as automobile manufacturers, five-star hotels, and research universities), different populations may also compete for resources and can collaborate by playing complementary functions in an ecological community (Astley 1985). Symbiotic and competitive ties bind interdependent organizations in a population (Baum and Amburgey 2002), bind interdependent populations in a community (Rao 2002), and, further, bind interdependent communities in an ecosystem. At each level, through symbiosis and competition, the organizational structure fittest for the environment is likely to dominate. As the environment changes, a different structure may dominate as a result of restructured symbiosis and competition. For nearly four decades, organizational ecologists have studied ecological processes at the population level, and more recently, at the boundaries between populations (Hannan 2010). The theory and associated methods they have developed provide a foundation for moving to higher levels where we can examine the ecology of communities and ecosystems such as those associated with digital innovations.

**Digital Innovation**

A digital innovation refers to an idea, practice, or object that is perceived as new and is embodied in and enabled by digital technology (Fichman et al. 2014). Just as ideas are ontologically different from physical practices or objects, an innovation exists in conceptual and/or material forms (Wang 2009). The conceptual form of an innovation is a set of ideas that describe the attributes, processes, and possible consequences of the innovation. For example, ideas underlying a CRM innovation may include definitions of customer data and methods to capture and analyze the data. In contrast, the material form of an innovation refers to the existence of the innovation in the physical world. For instance, the material forms of a CRM innovation may include a CRM software package, a CRM implementation project, resources and processes involved in using CRM, and the customer data going into and coming out of a CRM system. Therefore, while developers and adopters directly interact with the materials associated with a digital innovation, they also join others, such as investors, analysts, journalists, consultants, and researchers, in
discussing the innovation as a concept. This is why discourse is crucial to the development and use of digital innovations.

The material form of an innovation is often associated with specific organizations such as a lab, where the core technology underlying the innovation was invented, and a company, which commercializes the technology. In contrast, the development, promulgation, and consumption of innovation concepts are not confined within the boundary of any organization, but require the work of many in multiple industries. For example, in the late 1990s researchers at IBM invented the "Loyalty Suite," a business method that integrates CRM operational processes, customer collaboration touchpoints, and CRM analytical processes to identify factors which engender customer loyalty. Granted a patent for this invention, IBM named it "customer relationship management business method" (US Patent #6915270 B1). Despite the patent and its ambitious title, the CRM concept has never been confined to IBM. Others participate in the discourse that develops, spreads, or critiques the concept. Such collective concept development is undertaken in a community of organizations interested in the innovation.

**Innovation Community**

An innovation community is comprised of interdependent populations of organizations with interests in producing and/or using a focal innovation. Regarding the production of innovations, drawing substantially on TIM literature, Hage and Hollingsworth (2000) conceptualized "idea innovation networks" consisting of six functional arenas (basic research, applied research, product development, production research, quality control, and commercialization), where various organizations engage in the production of innovations. This framework broadened the traditional view of innovation production from research and development (R&D) to all parties involved in producing innovations. In ecological terms, innovations are supplied by not only populations of R&D organizations, but also populations of design companies, venture capital firms, advertising agencies, wholesalers, and retailers, whose activities are regulated by industrial or professional organizations and/or the government. Symbiosis and competition take various forms within and among these populations.

Yet, this broader view of innovation production reveals only half of the puzzle. Innovations must be used to realize their social and economic value (Edgerton 2007). From the Diffusion of Innovation perspective (Rogers 2003), Swanson and Ramiller (2004) characterized the core activities of applying information technology (IT) innovations as comprehension, adoption, implementation, and assimilation. These can, if the conditions are not right, lead at any point to abandonment of the innovation. For this reason, each adopter's innovation journey is supported and affected by populations of consultants, industry research firms, news media, universities, and financial institutions.

Therefore, in innovating with digital technologies, organizations do not act alone. Rather, they come together, both informally and formally, to create communities which engage the material and discursive aspects of producing and using innovations. Such a community emerges to make sense of the innovation and orchestrate material activities related to the innovation (Swanson and Ramiller 1997). The collection of actors in the community evolves dynamically, as the collective attention to the innovation evolves. The community dissolves once the collective attention disappears.

**Ecology of Innovation Community**

Since innovation communities encompass diverse populations producing and/or using innovations, we need a community-level theory to explain the ecology of innovation community. Organizations from different populations are differentiated, in part, by the interests that motivate them and by the roles they play in an innovation community. For example, Table 1 shows a list of roles that some organizations play in the CRM innovation community, including academic researcher, adopter, consultant, industry researcher, and technology provider.

Through these roles, organizations become interdependent. Community members can be materially interdependent, participating in a mutually reliant "industrial infrastructure" of designers, suppliers, and customers that emerges to materialize the innovation (Van de Ven and Garud 1993). There is also interpretive interdependence: As organizations in an innovation community participate in developing and spreading the innovation, they make sense of the innovation. Each member's understanding of the innovation depends on the collective learning that occurs in the community (Wang and Ramiller 2009).
These symbiotic interdependencies can be embedded in the legitimation process at the community level. As previously mentioned, legitimation at population level renders legitimacy to organizations with certain structure. Legitimation occurs at innovation community level when diverse populations of organizations join an innovation community and stay to play their roles. As more and more organizations join and stay, the innovation gains more legitimacy, which, in turn, attracts even more organizations to join, through imitation (Ruckman et al. 2015) or other mechanisms. For example, when studying the innovation community for cloud computing, Sun and Wang (2012) found a significant positive relationship between the density of various organizations in the cloud computing community and the rate at which other organizations entered the community.

Although this finding reveals the legitimation process at the community level, a more nuanced analysis may be useful. Because different organizational populations play different roles in the community and a community may have different capacities to accommodate organizations playing different roles, the relationship between organizational density and entry rate may differ depending on the roles organizations play in the community. For example, hypothetically, the global CRM innovation community may be able to accommodate hundreds of technology providers and hundreds of thousands of adopters. Therefore, while the relationship between organizational density and entry rate would be positive for both technology providers and adopters, organizations playing each role may go through a legitimation process at their own scale and pace. In other words, 50 vendors, for example, would convey much legitimacy, but 50 adopters may indicate a legitimation process that has just begun. Hence,

Hypothesis 1: Legitimation is positively associated with the entry rate of organizations playing each role in a digital innovation community.

Besides symbiotic interdependencies among organizations and their populations, competition is also prevalent, sometimes severe and even dysfunctional (Tang et al. 2014), in an innovation community. Within-population competition arises directly from organizations’ need for similar resources. As ecology theory holds, populations compete in an innovation community as well. Especially in the competition for mindshare in the marketplace for ideas, population vary both in their attention spans and in their opportunities to express their differentiated views on the design options, economic incentives, application domains, benefits, or hidden costs of an innovation. Therefore, as more and more organizations occupy an innovation community, the increasing crowding will deter new organizations from entering the community. Indeed, Sun and Wang (2012) found a negative relationship between competition and organizational entry rate in their study of the cloud computing innovation community. Pursuing a more nuanced theory, we posit that such crowding effect may also vary depending on the specific roles organizations play in the community due to the differences in the nature and scale of competition. Regarding the nature of competition, interorganizational competition can take many forms, including, but

<table>
<thead>
<tr>
<th>Role</th>
<th>Organization</th>
<th>Sample Sentence in News Articles</th>
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<tbody>
<tr>
<td>Academic</td>
<td>NCR is working with the Integrated Media Systems Center at the University of Southern California (USC) in Los Angeles on a project called E-Motions. (Computerworld, 12/03/2001)</td>
<td></td>
</tr>
<tr>
<td>Adopter</td>
<td>Tipper Tie</td>
<td>Last fall, Tipper Tie began implementing Siebel Systems’ standalone call center and sales-force CRM modules. (CIO magazine, 09/15/2000)</td>
</tr>
<tr>
<td>Consultant</td>
<td>Indeed, Joe Murray, a principal at KPMG Peat Marwick LLP’s customer management practice in Irvine, Calif., says companies should think about providing financial incentives if they want users to adopt CRM systems. (Computerworld, 03/15/1999)</td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>The Gartner Group, a market research firm, estimated that half of all customer relationship management projects fail to achieve the goals they set out to accomplish. (New York Times, 10/01/2001)</td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td>SAP AG</td>
<td>SAP AG reportedly is nearing a deal to resell software made by a Nortel Networks Inc unit, in an effort to jump-start its offerings in the fast-growing market for customer relationship management (CRM) systems. (Wall Street Journal, 03/30/2000)</td>
</tr>
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</table>
not limited to, competition among innovation adopters for experts' time and knowledge, among consultants for willing innovation users, and among technology providers for development partners, implementers, media coverage, and, ultimately, adopters. Regarding the scale of competition, again, each community may have different capacities for organizations play different roles. Therefore,

Hypothesis 2: Competition among organizations playing each role in a digital innovation community is negatively associated with the entry rate of such organizations.

Structure of the Innovation Community

It is common to see the communities of two IT innovations have similar sizes in the innovations' emergent years. One innovation comes to be the "next big thing," but the other does not "pan out." Their different destinies suggest that legitimation and competition may not be sufficient to explain the strategic initiatives organizations take to innovate. What other factors might be in play? A further step is to examine the relationships among organizations in an innovation community.

Communities of the same size may have very different structure composed of different types of relationships and organizations related in different ways. Thus the structure that can utilize the resources in the community more efficiently can accommodate more organizations in the community. We draw from contemporary network theory and in particular consider scale-freeness because it measures the efficiency of a network's structure. A scale-free network has nodes that are connected not randomly or evenly, but includes a few "highly-connected" nodes (Barabási 2003). In scale-free networks, the distribution of node degree follows a power law in which most nodes have only a few connections and some have a large number of connections (Barabási and Albert 1999). Prior work suggested that "highly-connected" nodes are very efficient in spreading information in the network (Li et al. 2005), thus a positive relationship exists between the scale-free network topology and the performance of the dynamic networks (Dezsö and Barabási 2002). We suggest that this positive relationship may help in understanding the relative resource efficiency of an innovation community. All types of relationship are conduits of information. While it is understandable that information about adoption and collaboration tends to draw new members to the community, information about competition is also valuable to prospective entrants. Thus a smooth, highly-efficient flow of information, as facilitated by scale-free networks, would be a positive condition for organizational entry.

Hypothesis 3: The scale-freeness of a digital innovation community is positively associated with the organizational entry rate.

Methods

To study the ecology of an innovation community, population-level methods used in previous organizational ecology research may not be readily applicable because organizations from different populations may have different characteristics. For instance, the scale and duration of the adopter data might not match those of the vendor data, making it difficult to include both the adopters and vendors in one study.

Data Collection

A solution may derive from the fact that most organizations, despite belonging to different populations, engage in discourse, as they produce and/or use an innovation.

Discourse as Recorder, Normalizer, and Enabler

A discourse is "an interrelated set of texts, and the practices of their production, dissemination, and reception, that brings an object into being" (Phillips and Hardy 2002, p. 3). An innovation's discourse is both the texts and the practices of producing, disseminating, and receiving these texts, that bring the innovation into being. Because discourse can be shared across population and community boundaries, discourse provides a common denominator for observation. By identifying the actors and actions referenced in the discourse, we can create a representation of the innovation community, despite the heterogeneity of the participants. Further, discourse is not just a practical tool to normalize heterogeneity
(so that indirect/secondary discourse data can be plugged into homogeneous ecological models). Discourse both reflects and enables the production and use of innovations (Green 2004; Miranda et al. 2015; Phillips et al. 2004; Ramiller et al. 2008; Suddaby and Greenwood 2005). Hence, discourse is not only the result of the actions of innovation community members, but also a critical part of their actions. Taking this discourse approach, specifically, we collected news articles about CRM.

**CRM as Digital Innovation**

CRM is a class of enterprise software that enables an organization to support effective marketing, sales, and service across customer interaction channels, in order to maximize customers' long-term value to the enterprise (Greenberg 2004). CRM began in the early 1990s as an automation tool for improving the efficiency of an organization's sales forces. Then the scope of CRM expanded to include backbone technologies for enhancing the effectiveness of customer services, especially call center operations. Since the turn of century, CRM has increasingly become a tool for collecting and analyzing customer and business partner data from multiple channels. Siebel Systems dominated the CRM software market in the late 1990s and early 2000s, reaching 46% market share in 2002, but could not fend off fierce competition from cloud-based CRM vendors such as Salesforce.com. As a result, Siebel Systems was acquired by Oracle in 2005 and Salesforce.com became the market leader, claiming 16% of the worldwide CRM software market of $20.4 billion in 2013, according to industry research firm Gartner. U.S. and Europe-based firms in industries such as high-tech, banking, insurance, securities, telecommunications, pharmaceutical, and consumer goods are leading the adoption of CRM software.

CRM is both a widely adopted digital platform with a layered modular architecture (Yoo et al. 2010) and a notable class of digital innovation. The generative potential of CRM lies not only in the product innovations offered by CRM vendors, but also in the numerous process, product/service, and business model innovations that CRM adopters from diverse industries can undertake based on the core CRM digital platform (Fichman et al. 2014). It is through such adopter-led "organizational co-innovations" that firms couple digital technology with complementary organizational elements to realize and maximize value from the innovations (Fichman 2012). The CRM innovation community is suitable for this study because it has attracted diverse organizational participants from multiple populations that play various roles in producing and using CRM. CRM is one of the few enterprise software innovations that have penetrated most industries in so many countries around the world. So the size and diversity of the community offer a great opportunity to apply and advance ecological models at the community level. Nonetheless, the success of CRM was not always undeniable. At times, participants of the CRM community struggled to sustain its momentum and many decided to leave or were forced to leave the community (Wang and Swanson 2008). Therefore, in addition to the size and diversity of the CRM community, it also provides ample variance in these properties over time, for community ecology theory and models to account for.

**Source of Discourse Data**

We collected news articles about CRM from outlets including *Computerworld, CIO magazine, New York Times, USA Today, Washington Post, and Wall Street Journal*. Unlike specialized venues such as press releases or academic journals, newspapers and magazines capture the opinions and actions of a wide spectrum of actors, including various organizations participating in the CRM innovation community. While our goal is not to draw a sample that represents the entire CRM discourse worldwide, the outlets we selected did reach broad and diverse audiences and cover a large range of noteworthy IT, business, and general news that might have been related to CRM, to varying degrees. As detailed next, these outlets allowed us to create a dataset large and diverse enough to test the hypotheses within the universe that these selected outlets represent.

Specifically we downloaded news articles from the LexisNexis Academic database because, besides its easy search and downloading functions, its indexing of newspapers and magazines covers nearly the whole course of CRM's evolution, from its origin in the early 1990s, over its peak in popularity circa 2002, and through its more recent transformation. We focus on the ten-year observation window between 1998 and 2007, because CRM attracted significant attention and media coverage during this period. Within LexisNexis, we specified each outlet and searched for the phrase "customer relationship management" in the subject headings the database assigns to each article published between 1998 and 2007. LexisNexis
assigns subject headings to articles by an automatic topic modeling process. Each article is assigned multiple subject headings. Each subject of an article carries a percentage value, which indicates the level of relevance of the subject to the article. Our search resulted in 303 articles whose subject headings include CRM at or above the 80% relevance level (articles with the CRM subject below 80% only mentioned CRM in passing, based on our reading). The first two authors of the paper read the 303 articles independently and agreed to remove 17 articles that did not address the CRM software or technology, leaving 286 articles in the dataset for further processing and analysis.

**Data Processing**

We processed the remaining articles in three steps. First, we imported the full text of these articles into ATLAS.ti (version 6.0.15), a popular qualitative analysis software application. We then identified organizations that have been involved in any aspect of producing and/or using CRM. For each organization so identified, we determined what specific role it played in the CRM innovation community (see the list of community roles and examples in Table 1) based on our reading of the context where the organization was mentioned. Some organizations always play just one role. For example, Siebel Systems always played the role of a technology provider. Others, however, played more than one role. For instance, some consulting firms not only provided consulting services on CRM but also adopted CRM for their own use.

When two or more organizations were mentioned in the same paragraph of an article, we also coded the dyadic relationships between them. Besides random co-occurrences, two organizations may be mentioned together in the same paragraph for a number of reasons. We identified five types of relationships, listed in Table 2. First, when an organization adopted CRM and its supporting technologies from a technology provider, this relationship was coded as an *adoption*. Second, some organizations teamed up to develop a product package or portfolio or to implement CRM in *collaboration*. Third, when not collaborating, technology providers tended to engage each other in *competition*. Fourth, like any business-oriented domain, the CRM community is replete with *mergers, acquisitions, and divestitures* (MA&D). Lastly, both academic and industry researchers may study particular organizations and thus develop *research* relationships with the subjects of their studies. Using ATLAS.ti, the first two authors independently coded organizations, community roles, and relationships that appeared in the 286 articles. After coding each article, they compared their coding results and discussed and reconciled the few differences, if any.

<table>
<thead>
<tr>
<th>Relation</th>
<th>Organizations</th>
<th>Sample Sentence from CRM Articles</th>
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<tbody>
<tr>
<td>Adoption</td>
<td>GSA and Siebel Systems</td>
<td>The GSA also plans to use the Siebel system for other large projects, such as building federal courthouses and IRS service centers, ... (Washington Post, 08/12/2002)</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Boss Group and Microsoft</td>
<td>Bill Hilf, Microsoft’s director of technical platform strategy, said the company has a similar collaboration with another open-source firm, The Boss Group. (Computerworld, 02/14/2006)</td>
</tr>
<tr>
<td>Competition</td>
<td>Microsoft and Salesforce.com</td>
<td>Microsoft Corp is setting up showdown with Salesforce.com Inc in $11 billion customer-relationship management, or CRM, software market. (Wall Street Journal, 12/07/2005)</td>
</tr>
<tr>
<td>Merger, Acquisition, &amp; Divestiture (MA&amp;D)</td>
<td>PeopleSoft and Vantive</td>
<td>PeopleSoft Inc. agreed yesterday to acquire the Vantive Corporation for stock valued at $433 million, in a deal that adds Vantive’s customer-focused services to PeopleSoft’s E-business offerings. (New York Times, 10/12/1999)</td>
</tr>
<tr>
<td>Research</td>
<td>Forrester Research and Siebel Systems</td>
<td>&quot;Companies want to buy by the drink, but Siebel offers them a nine-course meal,&quot; says Erin Kinikin of Forrester Research. (USA Today, 05/04/2004).</td>
</tr>
</tbody>
</table>

In the second step of data processing, we exported to Microsoft Excel the coded organizations, their community roles, and relationships, along with the timestamps of these entities indicated by the publication dates of the articles. We split the data by quarter into 40 sets (representing the 40 quarters between 1998 Q1 and 2007 Q4). To explore the evolution of the CRM innovation community, we used
NodeXL, an Excel add-on module to prepare the visualization of temporal organizational networks. The nodes are the organizations and the edges between the nodes represent their relationships. NodeXL is flexible and versatile, allowing us to group the organizations in each quarter into clusters using the clustering function embedded in the software (Hansen et al. 2010). The third step was to prepare the data for quantitative analysis (so we could test the hypotheses) according to the requirements detailed next.

**Data Analysis**

One of the best known ecological modeling techniques frequently employed in organization ecology research is the density-dependence model. The evolution (emergence, growth, decline, and demise) of an organizational population may be signaled by its vital rates such as entry rate (or founding rate, the rate at which new organizations enter the population) and exit rate (or mortality rate, the rate at which incumbents leave the population). Both rates depend on two ecological processes: legitimation and competition. The former increases entry rate and decreases exit rate and the latter has the opposite effects (Hannan et al. 1995). Density, the number of organizations in the population, drives both processes, hence the name "density-dependence." At the population level, the model has repeatedly proved to be effective in explaining the evolution of organizational populations. At the community level, however, evidence of effectiveness is limited. Sun and Wang (2012) applied the density-dependence model to study the cloud computing innovation community and their results demonstrated the utility of the model at the community level. However, cloud computing has been in existence for just a few years and studies at the community level on innovations with longer history such as CRM are warranted.

**Dependent Variables**

Between the two vital rates, we focused on entry rate because it is more easily defined in the context of discourse data than exit rate. Because the hypotheses in this study emphasize specific roles that organizations play in an innovation community, we calculated the entry rate of organizations playing specific roles. We focused on the entry rates of technology providers and adopters because they were the two most populous groups in the CRM community and their data are the richest for analysis. As the hypothesized theory suggests, the ecological processes for each group of organizations are likely to differ by the roles they play, and so we treated the adopter entry rate and technology provider entry rate as two dependent variables. Specifically, the entry rate is measured by the number of organizations (adopter or technology provider) that first appear in the CRM articles each quarter.

**Independent Variables**

Usually two independent variables appear in a density-dependence model: one is density itself as a measure of legitimation; the other is also density, except in its quadratic form, as a measure of competition. This specification allows legitimation to increase at a decreasing rate and competition to increase at an increasing rate (Hannan et al. 1995). Following this approach, we have two independent variables in each analytical model: one for legitimation and the other for competition. However, in the context of news articles about CRM, calculating density is not so straightforward as in studies of population ecology because it is difficult to determine when an organization leaves the community. Although mergers, acquisitions, or bankruptcies of major organizations are reported, those of less well-known organizations and strategic withdrawals from a market space are seldom reported. Considering these issues, we made different assumptions in calculating the density of organizations playing different roles. For technology providers, we employed a 6-month window to monitor presence (and absence). If a technology provider had not been mentioned in any article over 6 months, we assumed that it had exited the community. In this way, we counted the number of technology providers still assumed to be in the community each quarter as the density of technology providers. For adopters, because it is unusual for any news agency to report adoption continuously and because abandonment of CRM software is even rarer, we assumed that adopters did not leave the community. Therefore, density of adopters is the number of adopters we recorded cumulatively from quarter to quarter, along a classic S-shaped adoption curve.

With respect to network scale-freeness, Li et al. (2005) characterized that “highly-connected” nodes are the ones that have high degree centrality and betweenness centrality, and serve as the hubs in the network. They formulated a "scale-free metric." Briefly, $g$ is a graph with edge-set $\varepsilon$, and the degree (number of
edges) at a vertex $i$ is $d_i$. The scale-free level is $s(g) = \sum_{j \neq i} d_i d_j$. It is maximized when high-degree nodes are connected to other high-degree nodes. The scale-freeeness ratio is defined as $s(g) = s(g)/s_{max}$, where $s_{max}$ is the maximum value of $s(h)$ for $h$ in the set of all graphs with an identical degree distribution to $g$. A network with low $s(g)$ is “scale-rich;” and a network with $s(g)$ close to 1 is “scale-free.” We calculated the scale-freeness of the networks of CRM technology providers and other organizations with direct relationships with the technology providers. We did not calculate the scale-freeness of the networks of CRM adopters because adopters do not usually have direct relationships with each other. Adopters have indirect relationships, often through their common technology providers, but the effect of these indirect relationships on adopters’ entry rate has not yet been theorized.

Control Variables

Since we are modeling temporal dynamic processes, the dependent variable (entry rates) each quarter may be influenced by entry rates in the previous periods, especially the most immediately previous quarter. On the one hand, there might be a trending effect, meaning that the entry rate in the present quarter would be similar to the entry rate in the previous quarter. On the other hand, there might also exist an effect of previous periods similar to that of density. For example, a surge of entries in the previous period might deplete the pool of potential entrants and thus may weaken the effect of trending in the current period. Therefore, following prior population ecology research (Carroll et al. 1993; Carroll and Swaminathan 1992), we included the entry rate in the previous quarter and its quadratic term as control variables. Additionally, to control for potential impacts of idiosyncratic changes in the environment, we added dummy variables to represent five two-year periods in our observation window (1998-2007).

Analytical Models

We constructed three analytical models. Model 1 is for the technology providers’ entry rate using measures of legitimation and competition.

$$
\lambda(t)_{TP} = \beta_0 + \beta_1 \lambda_{t-1,TP} + \beta_2 \lambda_{t-1,TP}^2 + \lambda_{t-1,TP} + \beta_4 \lambda_{t-1,TP} + \sum_{i=1}^{5} \gamma_i \eta_i + \beta_0
$$

where $\lambda(t)_{TP}$ denotes the entry rate of technology providers in quarter $t$; $\lambda_{t-1,TP}$ denotes the number of technology providers (density) in the community in the previous quarter $t-1$; $\lambda_{t-1,TP}$ is the entry rate of technology providers in the previous quarter $t-1$; $\gamma_i$ is the dummy variable for the two-year period $i$ (the base 2006-2007; $\gamma_1$ is for 1998-1999; $\gamma_2$ for 2000-2001; $\gamma_3$ for 2002-2003; and $\gamma_4$ for 2004-2005).

In Model 2, we added the term for the scale-freeness of the network encompassing technology providers and other organizations directly linked to the technology providers, denoted by $s_{f}(t-1,TP)$.

$$
\lambda(t)_{TP} = \beta_0 + \beta_1 \lambda_{t-1,TP} + \beta_2 \lambda_{t-1,TP}^2 + \beta_3 \lambda_{t-1,TP} + \beta_4 s_{f}(t-1,TP) + \sum_{i=1}^{5} \gamma_i \eta_i + \beta_0
$$

Model 3 uses measures of legitimation and competition to explain the adopters’ entry rate. The entry rate of adopters in the previous quarter and its quadratic term were used as control variables.

$$
\lambda(t)_{A} = \beta_0 + \beta_1 \lambda_{t-1,A} + \beta_2 \lambda_{t-1,A}^2 + \beta_3 \lambda_{t-1,A} + \beta_4 \lambda_{t-1,A}^2 + \sum_{i=1}^{5} \gamma_i \eta_i + \beta_0
$$

Results

In this section, we first describe how the CRM innovation community evolved in the observation window, and then explain why the community evolved that way, using the ecology and structure of the community to understand the technology providers’ and adopters’ community entry strategy.

Evolution of the CRM Innovation Community

The ten-year observation window (1998-2007) was an interesting period for digital innovations. It was a period when the dot-com bubble peaked and then burst, when many firms adopted brand new enterprise systems out of fear of the Y2K bug, and when a new crop of technology companies so dominant in today’s economy (e.g., Google, Salesforce.com, Facebook, and Twitter) were founded. The evolution of CRM as an innovation and as a community should be understood in this important historical context.
While in the late 1990s ERP was leading the enterprise software buying frenzy, CRM was an important part of it. The last two years of the 1990s (1998-1999) witnessed 76 technology providers in our dataset with IBM, Oracle, and SAP leading the crowd. On the other hand, 69 adopters from diverse industries were mentioned in the articles. This momentum carried on into 2000-2001 when more technology providers, adopters, and others joined the community. Starting in 2001 and 2002, the community gradually showed signs of decline with fewer organizations mentioned in a dwindling CRM discourse, as corroborated by Figure 1. The figure also juxtaposes the CRM discourse volume (paragraph count) with the entry rates of organizations playing the two leading roles in the community. Respectively labeled in the figure, the peak of technology providers’ entry rate in 2000 was followed by the peak of paragraph count in 2002 and the twin peaks of adopters’ entry rate in 2002 and 2003. The three trajectories are highly correlated with each other.

![Figure 1. Trajectories of CRM Discourse Volume and Entry Rates 1998-2007](image)

**Effects of Community Ecology and Structure on Entry Rate**

The descriptive statistics of the variables (except the period dummies for brevity) are in Table 3. In the ten years, on average, 8.00 technology providers and 10.10 adopters entered the CRM community each quarter. The community on average hosted 20.75 technology providers and 210.82 adopters each quarter. Most correlations are statistically significant, raising the concern of multicollinearity. Some highly correlated pairs (such as Variables 1 and 2, Variables 8 and 10) were not included in the same regression, thus posing no problem. Others (such as Variables 3 and 4 and Variables 6 and 7) between the basic and quadratic forms of the same measure are bound to have high correlations with each other. Before doing regression analysis, we calculated the tolerance values of all explanatory variables and found these values were all above 0.10, indicating no serious problem of multicollinearity in the analysis (O’Brien 2007).

Because the dependent variables are counts and the data are overdispersed (conditional variance exceeds the conditional mean of both technology provider and adopter entry rates), we employed negative binomial regression (Cameron and Trivedi 1998). The results of the regressions based on the three analytical models described above are shown in Table 4.
All three models are significant as indicated by the Pearson Chi-square test results in the bottom row of the table. In Model 1, the prior entry rate of technology providers and its quadratic form, as control variables, are significant in this model. The legitimation measure (density of the technology providers) has a positive association with entry rate, whereas the competition measure (the quadratic term) has a negative association with entry rate. Therefore, for organizations playing the technology provider's role, Hypotheses 1 and 2 are supported. Model 2 added the scale-freeness measure, which turned out positively significant, thus supporting Hypothesis 3. The effects of legitimation and competition on entry rate remained significant in Model 2. Finally, Model 3 is based exclusively on adopter data. The results in this model are similar to those from the first two models: significant positive effect of legitimation and significant negative effect on entry rate. Therefore, for organizations playing the adopter's role in the CRM
community, Hypotheses 1 and 2 are supported as well. In sum, legitimation attracts organizational entries but competition deters them. The scale-freeness, as a network efficiency measure, is positively associated with technology providers’ entry into the CRM innovation community.

**Discussion**

**Limitations**

Any empirical study is confined to its data and analysis. Regarding the data, this study relies on a set of newspapers and magazines, one type of digital innovation (CRM), and a ten-year observation window (1998-2007). It is therefore inevitably limited to the influence of these parameters of research design. Despite the global reach and large circulation of the prominent news outlets we chose and the importance of this historical period, more sources over longer time frames could be utilized to build richer datasets to represent communities and ecosystems for digital innovations. Although CRM has had a colorful history with interesting twists and turns, which is highly desirable for theory building and testing, it has been an exceptional type of innovation and thus comparison with other innovations should be in order.

In regard to data analysis, this study's variance approach is efficient in testing hypotheses, but does not offer detailed insights on how legitimation and competition were conducted by individuals and organizations in the field, where other analytical approaches such as process research and case studies can complement ours. In addition, both legitimation and competition, the two key ecological processes examined in this study, were measured by indirect measures (density of technology providers and density of adopters). While this parsimonious method has been proved effective in organizational ecology research, its limitations (such as its questionable internal validity and primary focus on within-population ecological processes) are also very well-known (Hannan et al. 1995; Zucker 1989). Finally, the current analysis of both the technology providers and adopters provide a broader view of the ecology and structure of the CRM innovation community, a truly holistic analysis will need to take organizations playing other roles (such as consultants and analysts) into consideration.

**Contributions to Research on Digital Innovation Strategy**

**A Holistic Perspective on Digital Innovation**

Since today's digital innovations involve products and processes far more complex than in the past (Yoo et al. 2010), besides vivid metaphors that help get points across, we need a holistic theory with sophisticated methods to explore strategic innovation activities organized according to the digital architecture and infrastructure. The holistic approach must be applicable across industry and disciplinary boundaries. As illustrated at the onset of this paper by the divide between IS and TIM research, a holistic perspective that brings together factors, actors, and activities traditionally treated separately is likely to enrich and advance our understanding of digital innovations. In this spirit, the current study is an early attempt to examine diverse actors in a digital innovation community. In processing the discourse data, we performed discourse analysis and generated a longitudinal roster of organizations playing different roles and interacting in different relationships. Then we focused on technology providers representing the supply side and on adopters representing the demand side and examined the ecological processes on both sides. Further, by analyzing the community structure, we have demonstrated that scale-free network of organizations playing different roles, linked through diverse relationships, tended to attract technology companies to innovate with CRM by entering this community. This finding suggests that it could be fruitful to bridge the gaps between supply and demand, between development and diffusion, and between design and use. Ecology theory, as a new addition to the repertoire of theories on digital innovations, is especially constructive for bridging the divisions between various streams, traditions, and disciplines in the research on digital innovation communities (Wang and Ramiller 2009), platforms (Cusumano 2010), and ecosystems (Autio and Thomas 2014).

**Advancing Digital Innovation Strategy Research**

An important part of digital business strategy, as a fusion between IT strategy and business strategy (Bharadwaj et al. 2013), is digital innovation (Fichman et al. 2014). This study has potential to advance
digital innovation strategy research along all four dimensions outlined by Bharadwaj et al. (2013). First, the scope of digital innovation has already transcended the traditional IT function to penetrate multiple business functions, and to reach beyond organizational and industry boundaries. The ecological perspective, as this study begins to explore, will provide a holistic and coherent framework to conceptualize a firm's competitive (and collaborative) environment and its relationship with the firm's strategic posture such as timely entry into the marketplace and the varying degrees of engagement in the particular market category (Hannan 2010; Mithas et al. 2013). Second, the scale of digital innovation corresponds to the density of the innovation community. Firms can scale up or down according to the opportunities that exist in their specific collaborative and competitive relationships in the community's structure. This ecological view of scale complements economic and financial views in digital strategy research (Drnevich and Croson 2013). Third, the speed and timing of new digital product launch or adoption can be framed in a richer way as being attributes of entries into an innovation community and explained by the community's ecology and structure. Finally, regarding the realization of value from digital innovations, those "highly-connected" nodes in scale-free communities of innovation are essentially in the positions of strategic value (Woodard et al. 2013) and hold many "control points" (Pagani 2013), where value is created and captured. We argue that the dynamic evolution of the community structure may help to explain why some organizations develop or move into such favorable strategic positions.

**Implications to Digital Innovation Practice**

Ecological thinking may benefit the practice of digital innovations as well. As many IT and business managers deal with the vendor-analyst-adopter triangle relationship (Pollock and Williams 2009), the ecological perspective may offer fresh insights. For the developers of digital technologies, this study echoes prior literature that suggests closely tracking partners and potential adopters in an innovation ecosystem (Adner 2006), except that it also reminds us that this ecosystem is much broader than a firm-based platform and entities around it. In this broader innovation community, legitimation, competition, and an efficient network of diverse relationship shape the strategic decisions on innovation. For those who have adopted or are considering adopting the innovation, the broader community offers more resources than analysts’ reports. Hence, knowing when and where to find what resources also requires tracking closely the community and its evolution. For everyone pondering whether to enter, stay in, or exit an innovation community, ecological thinking can help time such strategic moves to optimize symbiotic and competitive relationships.

**Conclusion**

As we conclude this paper, we are launching a new research program to apply and advance ecology and network theories in digital innovation research. In the near term, we plan to replace the indirect density measures of legitimation and competition with direct measures such as the relationships we identified from the news articles. We would also like to include the organizations playing roles other than technology providers and adopters in a more holistic analysis. In the longer term, we encourage digital innovation researchers to pursue exciting directions on this fertile new ground. First, the ecologies of more types of innovations can be studied and compared: successful innovations vs. failed innovations; enterprise innovations vs. personal innovations; business innovations vs. public-sector innovation, etc. While digital technologies and core ecological processes may be among the common themes across different innovation types, research may also discover key differences that set the scope condition of the theories. Second, in addition to the newspapers and magazines used in this study, more discourse outlets (e.g., press releases, books, advertisements, and social media) can be utilized. Data from different sources may be analyzed separately to explore sub-cultures. Or they can be pooled to construct a virtual observatory of digital innovations. This approach is especially compatible with the holistic, ecological perspective. Finally, to accomplish research on multiple innovations using multiple data sources, manual analysis will soon reach its limit and therefore data scientists are invited to join this adventure and help tailor computational methods for ecological analysis of digital innovations. We hope that our research program leads to a successful digital innovation strategy for IS research.
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References


