Collective Innovation: Novelty, Reuse and their Interplay

Harris Kyriakou
Stevens Institute of Technology
ckyriako@stevens.edu

Abstract

Reuse of prior work involves multiple search processes within it and has been characterized as the most common innovation creation method. However, reuse carries the risk of imitating. Another important element for any successful innovation endeavor is novelty, which is often linked to unpractical solutions. These seemingly contradictory forces affect innovation processes, yet little is known about them. Digital artifacts in various forms and contexts present an opportunity to examine both of these processes openly and in unprecedented scale. This research examines 35,727 product designs submitted to the largest 3D printing online community from January 2009 to June 2013, showing how (i) digital artifact reuse, (ii) novelty and (iii) their interaction affect design usage. I use a mixture of research methods to draw insights about how members of open innovation communities search to create something new and how they build upon preexisting work. A novel computer graphics method and a topic modeling method are used to objectively measure the distance between the 3D product designs in terms of i) their shape and ii) their semantic differences. These methods are used to quantify the degree of novelty of a proposed design at the time of its submission, as well as the distances between parent and final designs. In contrast to prior work, my findings indicate that designers benefit from reuse. We find that reuse processes where designers combine their prior work with the work of others yield better designs. A theory of innovation as a search process to evolve prior designs and as a search process to create novel designs is described to explain how reuse of prior work and novelty synergize in collaborative innovation communities.

Summary

Reuse is the most widely used innovation creation method (van den Bergh 2008; Kogut and Zander 1996; Schumpeter 1934). However, research on the actual mechanics of such a process has been limited (Benner & Tushman, 2003) and combining others prior work may sometimes be considered as copying or lacking novelty (Faraj et al. 2011).

In order for an invention to be classified as creative, it is expected to possess novelty (Amabile 1996; Finke et al. 1992; Mumford 2003). Novel solutions are shown to emerge from creative thinking processes (Davenport 2013; Woodman et al. 1993), but these processes are surprisingly scarce in organizations (Scott 1987; Staw 1990) despite their importance for organization survival (Massetti 1996). Unfortunately, novelty is also often linked to unpractical solutions.

This research synthesizes two seemingly disparate perspectives on innovation: first, innovation as a search process for novelty (Chidambaram and Tung 2005, 2005; Dellarocas 2005; Dennis et al. 1996, 1997; Jessup et al. 1990; Sinha and May 1996), and, second, innovation as a search process of evolution with reuse playing a vital role in the success of proposed innovations (Aral et al. 2012; Burt 2004; Hargadon and Sutton 1997; Jarvenpaa and Majchrzak 2010; Tiwana et al. 2010; Yoo et al. 2010).

Reuse networks provide a way of tracing innovation processes and detecting the emergence of new ideas, combination of disparate ideas. Understanding the underlying mechanisms that drive combinatorial innovation and specifically the decisions made at the individual level by designers is a goal in its own right. To gain a deeper understanding, I analyzed the creative methods and efforts of product designers in Thingiverse, the largest online 3D printing community where participants freely exchange, modify or combine existing designs. In addition, a computer graphics method is used to measure the novelty of proposed product designs by comparing their 3D shape distance (Figure 1 and Table 1) to any preexisting design.

Products have been traditionally shared as complete work, but a shift is under way. Recently, users have gained extensive access to product designs as digital artifacts through collaborative and open online communities. These digital artifacts of products are intentionally incomplete, reprogrammable, reproducible, recombinable and perpetually in the making (Faulkner and Runde 2009; Garud et al. 2008; Kallinikos et al. 2013; Yoo 2010; Yoo et al. 2010; Zittrain 2008). Digital artifacts are commonly deployed within these online communities (Ma and Agarwal 2007). However, little is still known about how digital artifacts become generative, meaning the extent that they will be remixed by others (Yoo et al. 2012). Most of the research on online peer production has focused on the most successful projects (Crowston et al. 2008; Hill and Monroy-Hernández 2012). My work on the other hand a complete corpus of product designs in an effort to gain a more complete understanding of the dynamic processes involved.

A body of open innovation literature is emerging from fields including information systems, which can serve as a reference discipline for new product development (Nambisan 2003). However, this literature rarely considers how product architectures affect strategic choices (Ulrich 1995; Yoo et al. 2010) and little attention has been given to studying the impact of information systems on product development (Banker et al. 2006; Krishnan and Ulrich 2001). While this literature considers many aspects of open innovation, the dynamics concerning the reuse of digital artifacts have been overlooked.

This research builds upon and aims to extend theories pertinent to digital artifacts, open innovation and online communities. The relationship between two seemingly contradicting forces, novelty and digital artifact reuse, was assessed. Novel designs not only yield more popular designs, but are also more practical. Designs that built upon prior work also yield better designs than their counterparts. I also find that the impact of ambidextrous remixing processes is noticeably higher than the impact of any other remixing process. In addition, I present results indicating that novelty and reuse of prior work synergize in open innovation communities.

In the open innovation community discussed, designs very novel at the time of invention attract 2.4 times more downloads, 2.1 times more likes, and are 2 times more generative than very imitative designs. In addition, very novel designs were manufactured 1.9 times more than very imitative designs. This last result is particularly noteworthy because the instantiation of product designs can be seen as an indication of utility. In most studies of creativity, novelty is thought to tradeoff with utility: in this community, novel designs have better outcomes.

Designs that were both novel at the time of their submission and inherited ideas from preexisting designs were 2.6 times more popular, were manufactured 3 times more, used 3.8 times more and remixed 4.1 times more. An exponential regression model controlling for factors identified in prior literature suggests that novelty and remixing processes have a positive impact on the use of an open innovation design.

Literature

Amabile, T. M. 1996. *Creativity and innovation in organizations*, Harvard Business School.

Aral, S., Brynjolfsson, E., and Van Alstyne, M. 2012. "Information, Technology, and Information Worker Productivity," *Information Systems Research* (23:3-part-2), pp. 849–867.

Banker, R. D., Bardhan, I., and Asdemir, O. 2006. "Understanding the Impact of Collaboration Software on Product Design and Development," *Information Systems Research* (17:4), pp. 352–373.

van den Bergh, J. C. 2008. "Optimal diversity: increasing returns versus recombinant innovation," *Journal of Economic Behavior & Organization* (68:3), pp. 565–580.

Burt, R. S. 2004. "Structural holes and good ideas1," *American journal of sociology* (110:2), pp. 349–399.

Chidambaram, L., and Tung, L. L. 2005. "Is out of sight, out of mind? An empirical study of social loafing in technology-supported groups," *Information Systems Research* (16:2), pp. 149–168.

Crowston, K., Wei, K., Howison, J., and Wiggins, A. 2008. "Free/Libre open-source software development: What we know and what we do not know," *ACM Comput. Surv.* (44:2), pp. 7:1–7:35.

Davenport, T. H. 2013. *Process innovation: reengineering work through information technology*, Harvard Business Press.

Dellarocas, C. 2005. "Reputation mechanism design in online trading environments with pure moral hazard," *Information Systems Research* (16:2), pp. 209–230.

Dennis, A. R., Valacich, J. S., Carte, T. A., Garfield, M. J., Haley, B. J., and Aronson, J. E. 1997. "Research Report: The Effectiveness of Multiple Dialogues in Electronic Brainstorming," *Information Systems Research* (8:2), p. 203.

Dennis, A. R., Valacich, J. S., Connolly, T., and Wynne, B. E. 1996. "Process structuring in electronic brainstorming," *Information Systems Research* (7:2), pp. 268–277.

Faraj, S., Jarvenpaa, S. L., and Majchrzak, A. 2011. "Knowledge collaboration in online communities," *Organization Science* (22:5), pp. 1224–1239.

Faulkner, P., and Runde, J. 2009. "On the identity of technological objects and user innovations in function," *Academy of Management Review* (34:3), pp. 442–462.

Finke, R. A., Ward, T. B., and Smith, S. M. 1992. "Creative cognition: Theory, research, and applications.,"

Garud, R., Jain, S., and Tuertscher, P. 2008. "Incomplete by design and designing for incompleteness," *Organization Studies* (29:3), pp. 351–371.

Hargadon, A., and Sutton, R. I. 1997. "Technology brokering and innovation in a product development firm," *Administrative science quarterly*, pp. 716–749.

Hill, B. M., and Monroy-Hernández, A. 2012. "The remixing dilemma: The trade-off between generativity and originality," *American Behavioral Scientist*.

Jarvenpaa, S. L., and Majchrzak, A. 2010. "Research Commentary—Vigilant Interaction in Knowledge Collaboration: Challenges of Online User Participation Under Ambivalence," *Information Systems Research* (21:4), pp. 773–784.

Jessup, L. M., Connolly, T., and Galegher, J. 1990. "The effects of anonymity on GDSS group process with an idea-generating task," *Mis Quarterly*, pp. 313–321.

Kallinikos, J., Aaltonen, A., and Marton, A. 2013. "The ambivalent ontology of digital artifacts," *Mis Quarterly* (37:2), pp. 357–370.

Kogut, B., and Zander, U. 1996. "What firms do? Coordination, identity, and learning," *Organization science* (7:5), pp. 502–518.

Krishnan, V., and Ulrich, K. T. 2001. "Product development decisions: A review of the literature," *Management science* (47:1), pp. 1–21.

Ma, M., and Agarwal, R. 2007. "Through a glass darkly: Information technology design, identity verification, and knowledge contribution in online communities," *Information Systems Research* (18:1), pp. 42–67.

Massetti, B. 1996. "An Empirical Examination of the Value of Creativity Support Systems on Idea Generation," *MIS Quarterly* (20:1), pp. 83–97.

Mumford, M. D. 2003. "Where have we been, where are we going? Taking stock in creativity research," *Creativity Research Journal* (15:2-3), pp. 107–120.

Nambisan, S. 2003. "Information systems as a reference discipline for new product development," *Mis Quarterly*, pp. 1–18.

Schumpeter, J. A. 1934. *The Theory of Economic Development: An Inquiry Into Profits, Capital, Credit, Interest, and the Business Cycle*, Transaction Publishers.

Scott, W. R. 1987. "The adolescence of institutional theory," *Administrative science quarterly*, pp. 493–511.

Sinha, A. P., and May, J. H. 1996. "Providing design assistance: A case-based approach," *Information Systems Research* (7:3), pp. 363–387.

Staw, B. M. 1990. "An evolutionary approach to creativity and innovation," in *Innovation and creativity at work: Psychological and organizational strategies*, Oxford, England: John Wiley & Sons, pp. 287–308.

Tiwana, A., Konsynski, B., and Bush, A. A. 2010. "Research commentary-Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics," *Information Systems Research* (21:4), pp. 675–687.

Ulrich, K. 1995. "The role of product architecture in the manufacturing firm," *Research policy* (24:3), pp. 419–440.

Woodman, R. W., Sawyer, J. E., and Griffin, R. W. 1993. "Toward a theory of organizational creativity," *Academy of management review* (18:2), pp. 293–321.

Yoo, Y. 2010. "Computing in Everyday Life: A Call for Research on Experiential Computing.," *Mis Quarterly* (34:2), pp. 213–231.

Yoo, Y., Boland Jr, R. J., Lyytinen, K., and Majchrzak, A. 2012. "Organizing for innovation in the digitized world," *Organization Science* (23:5), pp. 1398–1408.

Yoo, Y., Henfridsson, O., and Lyytinen, K. 2010. "Research Commentary—The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research," *Information Systems Research* (21:4), pp. 724–735.

Zittrain, J. 2008. *The future of the internet–and how to stop it*, Yale University Press.