Routledge
Taylor & Francis Group

Research-Technology Management

ISSN: 0895-6308 (Print) 1930-0166 (Online) Journal homepage: http://www.tandfonline.com/loi/urtm20

A Path to Collaborative Innovation Through Internal Boundary Breaking

Sung-Mahn Lee & Juneseuk Shin

To cite this article: Sung-Mahn Lee & Juneseuk Shin (2017) A Path to Collaborative Innovation Through Internal Boundary Breaking, Research-Technology Management, 60:4, 26-32

To link to this article: http://dx.doi.org/10.1080/08956308.2017.1325688

FEATURE ARTICLE

A Path to Collaborative Innovation Through Internal Boundary Breaking

Open innovation tools applied within the organization helped LG Chem Research Park build a culture that nurtures collaborative innovation.

Sung-Mahn Lee and Juneseuk Shin

OVERVIEW: This paper describes LG Chem Research Park's process of transforming a large, closed R&D center into a collaborative organization. Experiments with open innovation intermediaries unveiled internal boundaries, both formal and informal. That experience led the organization's leadership team to seek ways to "unfreeze" the organizational culture. The internal application of open innovation tools broke down formal boundaries between individuals and teams. Informal communities allowed researchers to build relationships, thereby breaking informal boundaries. Easing researchers' anxieties about collaboration, and then building researchers' trust, in others and in the organization's commitment to collaboration, were crucial cultural shifts. The transition process at LG Chem Research Park can serve as a model to guide R&D organizations seeking to broaden internal collaboration and move toward deeper open innovation.

KEYWORDS: Open innovation, Internal boundaries, Internal collaboration

Open innovation is defined as the use of inflows and outflows of knowledge, driven by a business model, to create innovation (Chesbrough 2006). Open innovation efforts either absorb external knowledge for use inside the company or exploit internal knowledge by moving it out across the boundary so that external parties may use it. The effective implementation of open innovation depends on the organization's awareness of its organizational boundaries, the line between itself and the players (Huizingh 2011). However, studies of successful open innovation efforts, such as NASA@work (Davis, Richard, and Keeton 2015), show that in large R&D organizations, internal boundaries must also be considered when implementing open innovation. In an effort to increase efficiency and deepen expertise, large R&D organizations may group similar R&D activities and facilitate intragroup knowledge exchanges. This approach may improve R&D performance, but it can reduce intergroup knowledge flows. Internal boundaries can emerge and harden, and the psychological burden of both formal and informal collaboration across boundaries can become quite high, leading to negative attitudes toward collaboration. The purposive use of knowledge flows—the core of open innovation—may be limited if internal boundaries obstruct knowledge flow within the organization.

LG Chem Research Park, the primary R&D organization of LG Chem, began its open innovation journey as many organizations do—by using open innovation intermediaries to facilitate access to external knowledge sources. This approach did allow the organization to identify solutions to some problems, but it never developed into anything more than an alternative R&D tool—the organization's mindset remained largely closed. This was the result of internal boundaries that limited internal collaboration and thus left researchers unprepared for the idea of external collaboration.

Changing LG Chem's mindset required breaking internal boundaries to allow the company to leverage its existing R&D capabilities through internal collaboration. Once these internal boundaries were recognized and eliminated, allowing cross-divisional innovation and unfreezing the company's culture, LG Chem could design and institutionalize an internal collaboration process, one that made

Sung-Mahn Lee serves as the director of the Technology Planning Department at LG Chem. He focuses on technology foresight, strategy, and planning. He has spent more than 20 years in innovation and technology management in South Korea. He earned a BS from the Korea Advanced Institute of Science and Technology and an MBA from the University of Washington. sungmahn@lgchem.com

Juneseuk Shin is an associate professor in the Department of Systems Management Engineering and the Graduate School of Management of Technology at Sugnkyunkwan University. His research focuses on innovation strategy, corporate foresight, business models, and R&D management. He received his BS, MS, and PhD in industrial engineering from Seoul National University. jsshin@skku.edu

DOI: 10.1080/08956308.2017.1325688

collaboration not just a tool but a mindset and could eventually allow the company to move toward true open innovation. The experience of LG Chem Research Park offers a practical transition process model that can guide other R&D organizations in breaking down the internal boundaries that may hinder internal collaboration and thus block any move toward truly open innovation.

The Move Toward Open Innovation

LG Chem is the 11th largest chemical company in the world, with $17.8 billion in sales in 2016 across three main businesses—chemical, electronic, and energy solutions—spanning 15 countries. LG Chem Research Park, LG Chem's main R&D organization, is composed of five divisions comprising more than 4,400 employees. It is a typical large, centralized R&D organization in Korea, the company's base country.

In 2006, LG Chem Research Park announced its intention to shift its central R&D approach to open innovation. The decision was spurred by a product incident in 2004. That year, the US Consumer Product Safety Commission announced that the batteries used in Apple's laptop computers, which were made by LG Chem, could overheat, forcing Apple to recall 28,000 batteries. This recall resulted in the first deficit for LG Chem's battery business.

According to internal documents from 2005, the incident led the company to conclude that its closed R&D system was not sufficient to keep up with accelerating advances in battery technology. In order to compete with global incumbents in the overseas markets, LG Chem executives recognized that the company had to be more aggressive in creating and seizing technology-driven opportunities. The existing R&D system was unable to meet strategic objectives for rapid R&D at the technology frontier and global technological opportunity identification and problem solving.

In addition, the leadership team recognized that within LG Chem's diversified structure the R&D team had strong ties to the business units, but the alignment with business units had created silos. Researchers in one business area did not know what others were doing or could do. Collaboration across silos was rare. Some managers felt that examining the organizational structure could identify ways of facilitating internal as well as external collaboration, increasing R&D productivity. Thus, open innovation was seen as an approach that could meet the firm's strategic objectives while providing solutions in the field.

The strategic direction was clear, but the methods of execution remained nebulous. To identify an appropriate method to begin to implement open innovation, LG Chem Research Park conducted a benchmark study of 20 large R&D organizations, which identified two main methods of implementation. Some global organizations focused on the active use of company-owned foreign R&D centers, which defined internal R&D challenges, identified external open innovation opportunities that addressed those challenges, evaluated the available collaboration partners, and designed and initiated partnerships either to absorb external knowledge or to exploit internal knowledge through external channels.

> **Researchers' fear of the unknown and lack of experience with open innovation posed challenges for LG Chem Research Park's move toward openness.**

Another approach was to combine external open innovation intermediaries with a dedicated internal open innovation planning department that would identify internal innovation challenges and knowledge that could not be used or adequately exploited internally. Such a department would manage relationships with intermediaries, who would be tasked to identify both external solutions and opportunities to move internal knowledge out to external partners.

The team conducted executive discussions and interviews with researchers to determine the best open innovation approach for LG Chem. Ultimately, executives and R&D leaders agreed that foreign R&D centers would not improve customer responsiveness, as customer needs tended to be similar across countries. Moreover, foreign branches could increase the risk of information leakage.

The team also recognized another set of risks that had to be addressed in researchers' beliefs about and capabilities to support open innovation. The researchers were trained to make evidence-based decisions; they were as a result reluctant to engage with a new approach for which they had little empirical evidence of success. Some skeptics argued that open innovation had been successful in business-to-consumer companies, but not in business-to-business companies or in Asian capital-intensive companies. They were pessimistic about the possibility of getting viable solutions from individual experts, small enterprises, universities, or others, and thought that the global companies that might have solutions would be willing to share them only at a very high cost.

Another concern was researchers' capability; moving to open innovation would require them to shift their roles from problem solving to seeking and evaluating external solutions. Most researchers had little understanding about what open innovation was in practice or how they might use it. Even those who welcomed the new approach wished for a detailed guide to the new processes and tools. Researchers' fear of the unknown and lack of experience with open innovation posed real challenges for LG Chem Research Park's move toward openness.

With these risks in mind, the organization decided to pursue the use of external open innovation intermediaries, based on the belief that this approach would enable rapid access to external knowledge relevant to the firm's challenges and interests and minimize risks. Further, experienced intermediaries could help researchers understand the advantages and efficiencies of open innovation (Euchner 2013). The president of LG Chem Research Park directed the establishment of an open innovation planning department (OIPD), which was assigned responsibility for the design, implementation, and coordination of open innovation efforts and given authority over the allocation of funding for these efforts as well as organizational changes needed to support the move. In support of Research Park's initiative, LG Chem announced a corporate open innovation strategy and provided funding and other needed resources.

The first pilot project, with NineSigma, was begun in 2006. The project had two objectives: 1) reduce researchers' anxiety about open innovation through hands-on experience, and 2) assess the potential of open innovation. After investigating the needs of LG Chem Research Park and its researchers, NineSigma posted four challenges to its global solution provider network, to which it received 21 responses.

This first effort suffered from a fatal drawback. The four challenges chosen were all extraordinarily difficult; these were problems for which the organization had previously sought workable solutions from outside, with no success—the solutions provided by partners did not meet performance acceptance criteria. These problems had already proven nearly impossible to solve, and therefore, few responses were offered; none of them resulted in solutions. However, the 21 submissions that were offered enabled the researchers to see the technical challenges from different perspectives; they didn't solve the problems, but they did provide fodder for further work. The experience also reduced researchers' skepticism about open innovation, allowing them to recognize its potential value. And the new OIPD learned how open innovation tools and processes worked and saw what open innovation could achieve.

In 2008, LG Chem Research Park contacted InnoCentive and YourEncore for another round of open innovation efforts. These platforms offered different approaches from NineSigma's—NineSigma searches for and connects with organizations capable of solving a posted problem, while InnoCentive provides a web-based platform through which individual solution providers may connect with challenges, and YourEncore finds the best experts in its network and invites them to aid in problem solving. In connecting with additional platforms, the open innovation leadership team hoped to expand its pool of potential partners and explore the wider potential of different open innovation approaches. By 2012, the organization had run 14 challenges on InnoCentive and issued six awards totaling $71,375. Fourteen YourEncore challenges produced six consulting contracts by 2013.

These first experiments were highly successful on another count: the experience mitigated researchers' doubts about open innovation. In addition, the company was able to extend its global collaboration network to include individual experts, universities, and small and medium-sized enterprises. The OIPD learned how to decide which solvers it needed and then contact and collaborate with solvers. Anxieties about the unknown approach were assuaged, and the attitudes of many researchers changed.

However, the experience was not wholly positive. Although the experiments with open innovation intermediaries produced several strong cross-disciplinary solutions, the leadership team was discouraged by the long processing time and high costs associated with these platforms. A more efficient way was needed.

At about the same time this discussion was developing, OIPD found a high-quality solution for one of the open innovation challenges posted by the energy solution team—in work being done by a new-materials team at Research Park. The siloed structure of the organization meant the teams had been unaware of each other's work.

The attempt at open innovation also revealed cultural issues within the organization. Researchers' anxiety about open innovation, it emerged, was a product of the wider organizational culture. Under the previous system, researchers were encouraged to increase individual expertise rather than to collaborate with others or develop connections across disciplines. As a result, there was little communication or collaboration between researchers and teams with different technical backgrounds. Boundary-spanning collaboration was difficult to accomplish and not considered in performance evaluations.

In this context, researchers worried about the company's new collaboration-based innovation strategy because they feared it could result in project failures, low performance evaluations, and other negative outcomes for them personally, as well as for the organization. A tightly siloed structure, which limited exchange between business units and even across project teams, exacerbated these cultural obstacles by making it inefficient to connect with other researchers, reducing interorganizational knowledge flow and increasing the cost—and perceived cost—of internal collaboration.

In acknowledging these challenges, LG Chem Research Park executives recognized that the open innovation tools they had been experimenting with could be applied internally to address them. The logical model was simple. The organization's siloed structure was a problem because it prevented seekers and solvers within the organization

Executives recognized that the open innovation tools they had been experimenting with could be applied to address internal challenges.

from finding each other. If the more than 4,400 researchers in LG Chem Research Park could be efficiently connected using open innovation tools, ideas could flow freely and internal collaboration could develop naturally. With this goal in mind, the company proceeded with a program to implement tools similar to those they had seen open innovation intermediaries use to facilitate intraorganizational knowledge flow—relying on OIPD and the other administrative structures put in place to support open innovation.

Executives also recognized the necessity of a reliable performance evaluation and reward system that could motivate researchers to participate in the process and engage in collaboration. A new evaluation system was designed to evaluate activities of internal collaboration as well as output. In the new system, collaborative knowledge-sharing, learning, and problem-solving activities are measured and evaluated so that researchers who engage in collaboration can be recognized and rewarded for those activities.

The lessons learned from open innovation intermediaries enabled LG Chem Research Park to build its own internal collaboration tools.

Addressing Internal Barriers to Collaboration

Initially, the implementation of internal collaboration tools similar to those used by open innovation intermediaries faced obstacles arising from the company's culture. Researchers were uncomfortable with formal collaboration, for a number of reasons identified in employee interviews. One common sentiment was that it was too time-consuming to search for potential solvers, contact them, negotiate with them, and complete the paperwork required for collaboration. At an individual level, researchers were afraid that offering an incorrect solution would damage their reputation. And, of course, the siloed structure meant that researchers had no experience with this kind of collaboration and were reluctant to trust others. To address these attitudes and bring down the barriers to internal collaboration, the company launched a two-pronged program to facilitate formal collaboration and nurture informal collaboration.

Formalizing Internal Collaboration

The external open innovation tools the company had been experimenting with offered some solutions to these practical barriers. The tools offered mechanisms to protect the reputation of solvers and allow experts to self-evaluate their expertise and select the problems they felt qualified to solve. With these advantages in mind, LG Chem Research Park developed and launched three tools to facilitate formal collaboration across boundaries:

- i-OnePAd (collaboration across teams),
- i-Challenge (connections between anonymous seekers and solvers), and
- i-Expert (collaboration between an individual seeker and an expert).

Via these tools, OIPD undertook the search, meeting arrangements, and coordination for collaborations on behalf of the researchers, taking the administrative burden off individual researchers. To facilitate search and matching, OIPD collected data on possible solution providers, including research expertise, history of project involvement, and laboratory equipment skills, and created a searchable database. Dedicated collaboration facilitators were placed in each research division to coordinate with OIPD, manage collaborative activities, and resolve conflicts with other research divisions and researchers, further reducing the administrative burden on researchers by keeping the tools to support collaboration close at hand.

i-OnePAd. OnePAd stands for "one point advice." This tool is intended to connect a solution-seeking team with a potential solver team through OIPD matching. When a team cannot break through a technology bottleneck, it asks OIPD to identify a collaboration partner. OIPD matches the problem against the specialties of internal researchers to identify the teams with the most qualified experts and arranges meetings with these teams. The groups share problems, discuss ideas, and identify possible solutions. If two teams agree that collaboration is beneficial to both parties, a new collaborative project is created. i-OnePAd was initiated in 2008; by 2016, 11 i-OnePAd engagements had been completed, involving 110 researchers. Those 11 engagements had resulted in breakthrough technologies and products, which in turn led to increased sales and profits. For example, one important project was to develop a lithium-ion battery for power tool machines. However, the team had difficulty controlling the electrode breakage caused by machinery vibration. The project managers took advantage of i-OnePAd to contact teams involved in coating, adhesives, and fluid dynamics. The adhesive team provided a solution that allowed the battery design to proceed, resulting in a product that sold 70 million units in 2014.

i-Challenge. i-Challenge is an internal competition platform similar to InnoCentive. Solution seekers post challenges, and anyone with LG Chem credentials can provide solutions. Seekers can only view the profile of the solver who provides the best solution, protecting the reputation of unsuccessful solvers. Initiated in 2008, i-Challenge drew an organization-wide response. Through 2016, 78 challenges attracted more than 600 submissions; 72 of the challenges resulted in winners—in other words, more than 92 percent of challenges produced workable solutions. Winning solvers—those whose solutions were selected as the best by an evaluation committee that included executives and solution seekers—earned awards amounting to $14,000, paid out of LG Chem's corporate fund.

i-Expert. i-Expert is an individual seeker/solver matching tool similar to YourEncore. Where i-OnePAd and i-Challenge connect teams, i-Expert connects individuals. Via the i-Expert platform, a researcher can search for experts whose expertise and experience match the project's needs and contact them for technical advice. i-Expert is useful for finding solutions for small technical issues. More broadly, it connects individuals across formal boundaries who may not have previously worked together or be aware of each other.

These tools stimulated internal collaboration. In the intranet platform for i-Challenge and i-Expert, an average of 900 challenges was posted each year in the period 2008–2016. The average number of solutions submitted per challenge increased from 2 in 2008 to 4.5 in 2016. Challenges led to an average of 640 usable solutions each year.

The lessons learned from open innovation intermediaries enabled LG Chem Research Park to build its own internal collaboration tools. i-OnePAd and i-Challenge broke boundaries across teams; i-Expert broke boundaries between individual researchers. Taken together, the three tools broke down organizational silos and increased cross-divisional collaboration at both the team and individual levels. The tools also created a pathway into the open innovation system: researchers first used internal tools to find solutions. When a solution could not be found internally, they could then explore open innovation intermediaries.

In addition to developing these tools, the OIPD also worked to continuously improve its evaluation system. At the outset, the evaluation system focused on acknowledging and valuing all internal collaboration activity, including use of internal collaboration tools, engagement in knowledge exchange, and creation of collaborative proposals, largely through quantitative criteria. The system sought to stimulate individual researchers' participation in collaborative activity by recognizing both individual and team-level collaboration activities. Once researchers became accustomed to internal collaboration and the mechanisms developed to facilitate it, the OIPD reduced quantitative activity-related criteria—such as number of collaborative proposals—and improved the evaluation system to better capture the quality of researchers' contributions to collaborative projects, thus encouraging researchers to engage productively with internal collaboration.

Nurturing Informal Collaboration

Despite the successes of the online tools, OIPD found that some researchers remained indifferent toward or skeptical about collaboration, whether internal or external. Some said they felt nervous about formal collaboration and were more comfortable with informal communication and collaboration. However, informal approaches were limited by the size of each researcher's personal network, and researchers found it difficult to make contacts through informal boundaries.

In order to break down the informal boundaries that limited informal collaboration, the organization created two structures for informal communities: Communities of Technology (CoT) and Research Informals. To develop CoTs, OIPD analyzed project proposals to identify teams that developed similar technologies and arranged informal meetings of researchers in these teams. When researchers found common ground, they voluntarily created a CoT that met regularly to share technological challenges and knowledge. OIPD supported CoTs with funding for experiments and benchmarking activities emerging from CoT contacts and meetings.

Research Informals were self-organized informal communities created to develop and improve on researcher ideas. Members of a Research Informal met regularly to work on an idea and improve it. The open innovation advisory committee, made up of relevant executives and senior experts, reviewed the objectives of each Research Informal, recommended members, and gave advice on the progress of the idea. Once an idea was sufficiently developed, the Research Informal members could present it to the evaluation committee in the formal R&D project selection process, and, if it fit with the company's larger goals, receive funding to support further development.

These informal communities were supported with resources, including space and time to meet. Informal communities were allowed to meet during business hours and use company facilities after work hours. However, members were not required to pursue anything specific and could freely explore new ideas.

The informal communities have been well received and attracted wide participation. In 2016, more than 900 researchers were involved in 64 CoTs and 38 Research Informals—20 percent of the company's research workforce. Approximately 70 percent of CoT members report that they depend on their CoTs more than on the formal collaboration tools. The communities have generated many success stories for the business as well. One Research Informal group came up with an idea for a wire-type battery. The group eventually developed into a formal research team that created the world's first flexible wire-type battery; the idea generated applications for 78 patents worldwide, including 38 US patents, by 2016.

Breaking Down Internal Boundaries

At LG Chem Research Park, the call for increased collaboration, both external and internal, was initially met with skepticism and anxiety. Researchers were doubtful of the benefits of open innovation or internal collaboration and felt collaboration was just too hard—finding and contacting potential partners took too long and too rarely yielded concrete results. These challenges arose from psychological, formal, and informal boundaries rooted in the organization's closed and highly siloed R&D system. To address them, the Research Park leadership team took a stepwise approach, leveraging the lessons from the company's experiments with open innovation to make researchers more comfortable with the idea of collaboration and ease the organizational barriers to it.

The early experiments with open innovation intermediaries illustrated both the power and limitations of open innovation—or external collaboration—as typically practiced. The experience enabled the organization to design three tools to support formal internal collaboration, which helped break down boundaries between divisions and allow researchers to more efficiently access internal expertise. These tools provided formal supports to ease the process of identifying those with relevant knowledge and evidence, mechanisms to support connections across organizational boundaries, and—perhaps most importantly—evidence of management's support for collaboration. They allowed researchers to learn how collaboration might work while garnering the immediate benefits of problem solving. Embracing the potential value of open innovation, they were prepared to move forward. Internal collaboration, in effect, was the unfreezing tool that freed internal culture blocks and enabled the organization both to use its existing knowledge more effectively and to move toward open innovation, suggesting a modification of Slowinski and Sagal's (2010) Want–Find–Get–Manage model: Want–Find (*internal first*)–Get–Manage. This experience is also typical of the Unfreezing–Moving–Refreezing process of cultural change described by Lewin (1947).

Two organizational factors were important in this movement; these factors were similar to those noted in previous studies (for instance, Chesbrough and Crowther 2006; Chiaroni, Chiesa, and Frattini 2010). The first was top management commitment. Researchers feared that the company's pursuit of a collaboration-based innovation strategy would result in negative outcomes. Reducing that anxiety and encouraging researchers to engage required a consistent approach to the new strategy and evident, strong top management support. The second factor was the coordination capability of the OIPD. When teams got stuck in collaboration obstacles, the OIPD identified the causes of the bottlenecks and helped both sides of the collaboration find win-win solutions. In addition, the OIPD minimized the cost and time of search, negotiation, and collaboration structuring, allowing researchers to focus on the work, and helped to break down formal boundaries across teams and individuals. Facilitators in each research division provided immediate help while taking the administrative burden off researchers.

The informal community tools completed the move to a more collaborative approach to R&D. CoTs and Research Informals allowed researchers to become familiar with and connected to an internal community where they could share ways of thinking, work together to find solutions to problems, and collaborate with each other. The relationships developed in these informal contexts resulted in projects that moved into the formal process and generated innovation. In this way, the informal boundary-breaking activities facilitated the needed cultural change.

LG Chem Research Park has continued to redesign its collaboration tools and structures to meet the changing needs of researchers. The tools have also been reorganized to increase efficiency and reflect learning from the initial efforts. The organization is also now focusing again on its external boundaries, conducting both inbound and outbound open innovation. Researchers now look first for internal solutions using the internal collaboration tools and communities. When no internal solution is available, they look to open innovation.

> **Internal collaboration freed internal culture blocks and enabled the organization both to use its existing knowledge more effectively and to move toward open innovation.**

Conclusion

LG Chem Research Park's closed R&D system had reached its limit, but the company's experiments with open innovation revealed cultural and organizational barriers to collaboration—barriers that hampered researchers' ability even to collaborate or access knowledge internally. Faced with this reality, Research Park's leadership team took a stepwise approach to help facilitate internal collaboration and ease researchers' anxieties about collaboration in general. Formal tools, facilitated by the OIPD, helped lower bureaucratic challenges, and informal communities allowed researchers to build relationships that led to further collaboration. As a result, the organization's mindset changed from a siloed approach to a more open, collaborative attitude.

A cultural shift crucial to the transition involved trust. At the outset of the transition, researchers trusted only themselves and their knowledge, and the knowledge available within their teams or divisions. With its collaboration tools, OIPD encouraged researchers to broaden that trust, to include other researchers and the internal collaboration systems. Building researchers' trust in the organization's commitment to collaboration in general opened the way for the company to move toward open innovation. Ultimately, supporting this internal shift led to an "unfreezing" of the company's culture that allowed it to pursue new strategies.

The transition process at LG Chem Research Park offers important lessons for other large R&D organizations seeking to broaden internal collaboration and move toward deeper open innovation. R&D leaders should recognize internal boundaries as well as cultural and organizational issues that may hinder collaboration. Addressing these internal barriers can help R&D be more efficient and effective even in the absence of a push to open innovation, even as it can prepare the organization to engage more powerfully with true open innovation. The internal application of tools typically associated with open innovation, along with dedicated organizational resources to embody the organization's commitment to collaboration and broaden researchers' trust, can break down formal and informal boundaries, thereby facilitating internal collaboration. The purposive use of knowledge inflow and outflow can be valuable within the corporate boundary, as well as across it.

References

Chesbrough, H. W. 2006. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston, MA: Harvard Business Press.

Chesbrough, H. W., and Crowther, A. K. 2006. Beyond high tech: Early adopters of open innovation in other industries. *R&D Management* 36(3): 229–236.

Chiaroni, D., Chiesa, V., and Frattini, F. 2010. Unravelling the process from closed to open innovation: Evidence from mature, asset-intensive industries. *R&D Management* 40(3): 222–245.

Davis, J. R., Richard, E. E., and Keeton, K. E. 2015. Open innovation at NASA: A new business model for advancing human health and performance innovations. *Research-Technology Management* 58(3): 52–58.

Euchner, J. 2013. The uses and risks of open innovation. *Research-Technology Management* 56(3): 49–54.

Huizingh, E. K. 2011. Open innovation: State of the art and future perspectives. *Technovation* 31(1): 2–9.

Lewin, K. 1947. Frontiers in group dynamics. *Human Relations* 1:5–41.

Slowinski, G., and Sagal, M. W. 2010. Good practices in open innovation. *Research-Technology Management* 53(5): 38–45.