Knowledge to Support Creation: Integrating Academic Databases with Open Innovation Platforms

Ricardo Eito-Brun

abstract: Open innovation makes an open, collaborative process of creating new or improved ideas, methods, or products, based on the exchange of information and knowledge between different agents. Several Web-based platforms have been developed to support this collaborative process. These platforms act as "innovation markets," virtual meeting places that connect organizations and innovators based on Web 2.0 technologies, which enable online sharing of information or material users have created. Organizations can publish a challenge—that is, a call to participate in finding an improved process or product—and participants can propose innovative solutions. The platform acts as a mediator between the agents involved. Such platforms, which aim to support the collaborative effort behind ideas and innovations, have exploded in popularity during the 2000s. Similar growth can be observed in platforms that give access to scientific and technical content. Some are based on the open access philosophy, the movement to make scholarly research and publications freely available to the public online, without restrictions. This paper analyzes the opportunities offered by the integration of open innovation platforms with scientific databases and repositories, and how these knowledge tools can support the development of collaboration networks to promote capabilities for innovation.

Introduction

Innovation management studies the rules that govern the creation, diffusion, and adoption of new ideas, methods, or products and the relationship between the inputs and outputs of the process. The Oslo Manual, published by Organisation for Economic Co-operation and Development and Eurostat, the statistical office of the European Union, defines *innovation* as "a new or improved product

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or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)."[1]

Joseph Alois Schumpeter (1883–1950), an Austrian American economist, is considered the father of innovation management as a discipline and the originator of its theoretical basis. Traditionally, innovation was understood as a linear, closed process, made up of a sequence of activities executed by a single entity, from basic research to launch of a new product or service in the market. In that model, the success of innovations heavily depended on the planning, funding, and execution of internal R&D activities and the acquisition of technologies. Later, linear models were replaced by approaches based on the interaction with external agents.[2] Maria Busse and her coauthors report that the typical phases in the innovation process (basic research, prototype development, test and validation, series production, launch to the market, and diffusion) no longer occurred sequentially but instead were based on feedback cycles.[3] In 1988, Eric von Hippel put users into focus in the process,[4] an idea previously discussed by Christopher Freeman in 1968 and Nathan Rosenberg in 1976.[5] In a seminal study in 2003, Von Hippel identified that a significant percentage of innovations in scientific instruments had been developed by lead users, customers who want a new product before the rest of the market and who are especially sensitive to the future evolutions of the market.[6]

Innovation requires the collaboration of several agents, including end users, companies, and suppliers.[7] The identification, creation, and diffusion of information and knowledge have become critical for the development of innovative products. Studies highlight the concept of innovation as a process of knowledge recombination in response to changes.[8] The open innovation model proposed by Henry Chesbrough in 2003 and based on the use of both internal and external ideas has become the standard approach.[9] Open innovation involves the capture and integration of external knowledge from clients, providers, competitors, universities, and research centers, and the development of alliances to combine complementary competences and technologies.[10] Open innovation strategies are supported by Web-based tools or platforms that connect offer and demand, virtual spaces where organizations can publish challenges and participants can propose innovative solutions. These tools support collaboration and the exchange of knowledge, essential for open innovation.

Open innovation involves the capture and integration of external knowledge from clients, providers, competitors, universities, and research centers

In parallel to the development and consolidation of the open innovation concept, the scientific and technical community has observed an unprecedented growth of open access repositories and document databases. More and more content is made available through such means. Although open repositories and open innovation platforms serve different purposes, the potential benefits of their integration should be explored. A link between these types of tools could provide valuable knowledge and expertise for the innovation process.

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This paper analyzes the opportunities offered by the integration of open innovation platforms with scientific and technical databases and repositories. The analysis shows how such connections can help develop knowledge and collaboration networks to leverage the innovation capabilities of organizations. The paper describes how Web-based open innovation platforms could be improved with the integration of access to databases of scientific documents.

Innovation and Knowledge

Innovation management is a continuous activity that explores the synergies between the knowledge internal to an organization and that acquired from external sources. Blandine Laperche highlights the role of intellectual capital—information and knowledge created, acquired, and used in the process of creating value—as the most important pillar of innovation. She suggests that intellectual capital is built on the cooperation that an organization develops with third parties.[11] Frank van Harmelen and his coauthors report that innovations typically are based on a knowledge transfer channel that grows with the results of research activities.[12] Innovation requires access to knowledge and transforms it into results with commercial value. Companies must commit to the market in a learning process and pay attention to developments in the social and institutional environment around them.

Innovation requires access to knowledge and transforms it into results with commercial value.

The Oslo Manual explains the links between innovation and information sources that provide access to knowledge on technologies, business practices, and resources. These connections could be of three types:

1. Open information services, which do not require the acquisition of technologies, payment of royalties, or interaction with the source of the information and which bear no additional or marginal costs. Participation in conferences, subscriptions to journals, membership in professional associations or informal networks, as well as the use of patent databases and technical standards are included in this group.
2. Acquisition of knowledge and technology, where external knowledge is gained through goods and services in which it is embedded, without direct interaction with the entity that generated the knowledge. This category includes consultancy services, acquisition of software licenses, rights to use patents, and payment for intellectual property rights.
3. Cooperation, which requires a greater investment and active collaboration with other entities to develop the innovation.

Open innovation tries to widen an organization's capabilities beyond its boundaries through two complementary processes:

1. Inbound process, also called outside-in, consists of the exploration and integration of external resources to develop internal knowledge. It relies on the capability to recognize the value of external information, assimilate it, and apply it for commercial purposes. This process includes activities to monitor and survey technologies, acquire them, and collaborate with third parties.[13]

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2. Outbound process, or inside-out, leverages the internal capabilities of a company to expand its market through the external use of innovations generated by the organization. This process includes selling licenses to intellectual property rights, producing spin-offs, and similar methods.

Inbound process is tied to absorption capacity, a prerequisite for open innovation. Absorption capacity refers to how external knowledge is captured and transformed into new understandings that can be applied in the development of innovations. Wesley Cohen and Daniel Levinthal define *absorption capacity* as the ability "to recognize the value of new, external information, assimilate it, and apply it to commercial ends."[14] Absorption capacity requires established procedures to acquire and integrate information and knowledge, and it depends on the availability of qualified staff who can internalize that information and on collaboration with intermediaries who help search for and exploit external knowledge.

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Information Needs in the Innovation Process

The innovation process is typically represented as a funnel that filters and reduces the initial group of ideas by applying well-defined criteria—in other words, a process where suggestions are collected, evaluated, filtered, and finally selected. Those ideas that pass successfully through the different filters become a product concept. This product concept travels again through different filters, where its technical and economic feasibility and its potential market value are reassessed.

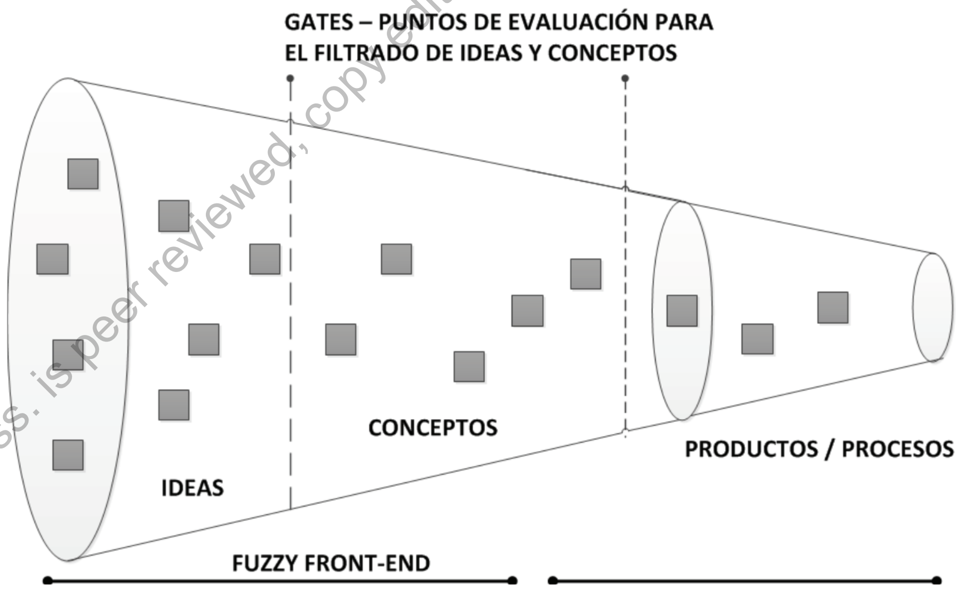

Figure 1. The author's visualization of the Stage-Gate® or funnel model representing the innovation development process. The front-end phase, often called the *fuzzy front end*, has greater information demands and is characterized by more uncertainty.

The funnel view—known as the Stage-Gate® model—was developed in 1983 by Robert Cooper.[15] He made revisions and adaptations in subsequent papers,[16] and the model has been readapted by other authors,[17] becoming a standard way to represent the innovation development process. Stage-Gate promotes a systematic approach to decision-making, instead of an intuitive, ad hoc activity that could be biased by subjective preferences or individual experience. The model distinguishes two phases: front end and back end. The first refers to the preliminary development and research of new ideas; the second to the work needed to build a new product or service following well-established, routine, and predictable methods.

The front-end phase has greater information demands, is characterized by more uncertainty, and requires creative thinking for the development and assessment of the product or service. Some authors have used the term *fuzzy front end* to highlight the uncertainty that characterizes this phase.[18] The team of Stefan Hallerstede and Angelika Bullinger-Hoffmann and that of Johan Frishammar, Emmy Dahlskog, Charlotte Krumlinde, and Kerem Yazgan proposed a subdivision of the fuzzy front end into four stages: (1) ideation, (2) concept gate, (3) concept development, and (4) innovation gate.[19]

Ideation consists of the collection and generation of ideas from lead users, competitors, partners, sales force, professional or academic literature, internal employees, and the like. This stage depends on the company environment, its internal knowledge base, and the techniques and strategies to connect them. Ideation can utilize technology surveillance, bibliometric or textual analysis of documents,[20] conjoint analysis, which measures the value that consumers place on features of a product or service,[21] and input from lead users through interviews or focus groups.[22]

The concept gate is the stage where a decision is made about investing in the development of the idea. The decision is based on the idea's technical feasibility, benefits, alignment with corporate strategy, originality, and impact on the market.

Concept development involves creating a prototype to demonstrate the feasibility of an idea. In this stage, the idea becomes tangible, with a preliminary version of the future product, service, or process. User representatives play an important role in this stage, as their feedback provides valuable inputs to assess the results.

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Innovation gate is the last phase, where the outcomes of the previous phase are assessed from a technical and economical perspective. Based on this evaluation, the company may decide to move to the development or industrialization phase.

The Stage-Gate model is part of national standards dedicated to innovation management, such as the Spanish standard UNE-CEN/TS 16555-3:2015 EX Part 3: Innovative thinking. The standard, published by the Normalización Española (Spanish Association for Standardization), proposes a structured approach to gather information about problems and opportunities, validate them, and search solutions using creative thinking. Later, those solutions can be verified through prototypes, discussions with target users, and other techniques until one is selected. The Spanish standard distinguishes six phases:

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1. Gathering information about the problem or opportunity, in close contact with end users' representatives;
2. Identification of potential solutions, where ideas are proposed to solve the problem or to take advantage of the opportunity;
3. Fast learning, where solutions are explored through prototypes and other experiments;
4. Validation of the solutions by interested parties, using such techniques as focus groups and structured questionnaires;
5. Synthesis of the options, where the technical and market feasibility is assessed; and
6. Results, where the best solution is selected.

The Generation and Assessment of Ideas

To be effective, the innovation development process requires access to information and knowledge and the establishment of collaboration networks with experts who can provide ideas and assess the proposed solutions. Various tools have been designed to support the generation and assessment of ideas, such as IdeaFisher™ or ThoughtOffice™. But the main contributions of information technologies to innovation management are the Web-based collaborative platforms used to collect new ideas. For example, YourEncore by Procter & Gamble supports a network of around 800 engineers and more than 100 companies. Similar platforms have been developed by Samsung Electronics Company and SK Hinix Inc. to search and exploit external knowledge.[23] Thomas Lackner describes the experience of Siemens and its IDEA (Improving Design and Engineering for All) Contest. The competition involves external agents, university students and members of the public who are invited to submit ideas to solve transportation challenges. The company also holds Innovation Jams, contests where questions are addressed to internal staff, who must provide an answer to a problem using no more than 500 words.[24]

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Several scholars have written about these technology-mediated solutions. Kathrin Möslein classifies them into (1) innovation contests, (2) innovation markets, (3) innovation communities, and (4) tool kits.[25] Innovation contests, linked to Web 2.0, are defined as "Web-based competitions of innovators who use their skills, experiences and creativity to provide a solution for a particular contest challenge defined by an organizer." Websites that support this approach include innovation-community.de, designboom.com, crowdspring.com, deviantArt.com, and newsgrounds.com.

Innovation markets are virtual meeting places that connect offer and demand, also based on Web 2.0 technologies. Organizations can publish challenges to which participants propose solutions.[26] The innovation market acts as a mediator or e-broker between those agents. Within this group are Web platforms such as InnoCentive, founded in 2001

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by Eli Lilly and Company and used by such organizations as Procter & Gamble, Roche, and the National Aeronautics and Space Administration. Other sites that use this model are NineSigma, Atizo, YourEncore, Battle of Concepts, iBridge, Quirky, and Yet2.com, and the software developers Brainfloor and Topcoder.

The third group of tools cited by Möslein are co-creation communities, aimed to develop ideas in a collective way. This group includes open source communities or platforms such as unserAller.de, where consumers discuss their suggestions and vote for the best ideas.[27]

Finally, tool kits offer an environment to adapt or design products combining different options and configuration parameters.[28] The tool kit collects the feedback on a set of variants and possible combinations after user interaction.

Frank Piller and Christoph Ihl proposed a different classification for technology-mediated innovation development tools in 2013.[29] They identified four categories of tools using two criteria: the level of collaboration the tools support and the freedom they offer to users. Ideas contests and tool kits show the lowest level of collaboration, as there is no interaction between users, only between each user and the organization. Co-creation communities allow more interaction between users, and the organization acts merely as a facilitator. In such communities, the users suggest concepts, assess and select the ideas, and even commit to the adoption of the final, resulting product.

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Innovation markets are perhaps the tools that have gained widest acceptance. On those platforms, organizations post a challenge or problem, and users propose potential solutions. The organization that announces the challenge will select the most adequate and feasible suggestion. Typically, the authors of the solution receive some sort of reward. The effectiveness of innovation markets—in particular, InnoCentive—was analyzed by Karim Lakhani,[30] who concluded that user communities solved 30 percent of the problems that the organization could not work out internally. He also reported that two of three persons who posted winning solutions had doctoral degrees in scientific areas.

Despite their benefits and advantages, the functionality and effectiveness of Web-based open innovation platforms might be improved by incorporating additional functions for accessing external document databases. The growing availability of open databases and repositories of scientific and technical content could help ensure that everyone involved in the definition of challenges and the assessment of solutions have access to relevant content that supports their decisions.

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Adding access from open innovation platforms to external document databases would improve the overall process. Authors who pose challenges

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and users who provide answers could find additional, trusted information on the challenge topics. In addition, people assessing and filtering the proposed solutions could find out the background and expertise of the individuals and groups offering the suggestions to evaluate their technical capability.

To test the usefulness of scientific databases to open innovation, the author completed two activities: (1) interviews with managers of open innovation programs at three biomedical companies (Philips Healthcare, Eli Lilly, and GlaxoSmithKline) and (2) development of a software prototype that shows how to connect open innovation platforms with document databases.

Goals of the interviews included:

- acquiring knowledge about the open innovation practices followed by the company;
- identifying the aspects that are considered when evaluating the capability of third parties in open innovation programs; and
- determining best practices regarding knowledge and information management in the open innovation process.

Each interview included 22 questions (a subset is included in Table 1). The questions dealt with information needs during the innovation development process and with the role of knowledge and technology transfer entities. Interviews were completed by phone, after distributing the list of questions by e-mail.

Analysis of the answers led to several conclusions. Companies want to promote interaction with end users and other collaborators, and capture systematically the information they provide, from ideation to the commercialization of innovations. Companies also want to establish agreements with external agents in open innovation programs, with dedicated platforms such as Lilly Open Innovation Drug Discovery.

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The managers who were interviewed reported that they use several criteria to assess the potential value of a collaboration partnership, including, in order: the previous experience of the partner in similar projects; the partner's explicit knowledge of the domain, technologies, methods, and tools (in the form of publications, patents, and the like); and the partner's implicit knowledge (staff qualifications, training, and experience). When assessing ideas from third parties, the managers considered several aspects besides the idea itself. The following list of aspects is sorted by relevance, ranked on a Likert scale with five levels, where 1 means low value and 5 great value:

1. The interviewees considered as most relevant the professional experience of the person or group that proposed the idea in the domain specific to the problem, giving that aspect an average value of 4.2.
2. Articles, papers, or patents published by the person or organization that offered the idea came next, with an average value of 3.6.
3. The size of the company or group was assessed with an average value of 2.

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Table 1.
Interview questions

Has your company collaborated with external parties in the design, manufacturing, delivery, or commercialization of innovative products or services?

When you evaluate the capability of third parties to participate in the development of an innovation, what factors are more relevant for your decision?

- Results obtained in previous, similar projects.
- Explicit knowledge of the problem's domain and subject (patents, publications, etc.)
- Explicit knowledge of technologies, methods, and tools that are applied (evaluated through patents, publication, etc.).
- Implicit knowledge (staff training, experience, competences).
- Size of the company or group.
- Other (please specify).

What methods does your company use to identify opportunities to improve its products and services?

When making the trade-off among different technical choices to implement a product or service, what information sources do you use to support this analysis?

- Technical and professional documents.
- Documents and knowledge on competitors.
- Academic and professional journals.
- Internal documents generated in previous research activities.
- Patents.
- External consultancy.
- Implicit, internal, undocumented knowledge, from the company's own staff.
- Other (specify).

As an R&D professional, when you have to make an assessment of the ideas and innovation opportunities proposed by third parties, which are the criteria that help you assess their potential value?

- Innovative characteristics of the idea.
- Professional experience of the person or group that proposes the idea.
- Articles, papers, or studies published by the person or group that proposes the idea.
- Patents granted to the person or group that proposes the idea.
- Experience of the person or group that proposes the idea in the topic or subject related to the challenge or problem to solve.
- Capability of the organization or group that proposes the idea (regarding number of employees and staff profiles).

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Table 1, continued.

Do you think that having additional information about the person or group that proposes the idea would help you make better informed and more efficient decisions when filtering ideas?

In case you answered "Yes" to the previous question: what information would be useful for you to make the assessment of the ideas from third parties? (Give a value from 0 to 5, when 0 means "no value" and 5 "great value")

- Professional experience of the person or group proposing the idea.
- Articles, papers, and other works published by the person or group that proposes the idea.
- Patents granted to the person or group that proposes the idea.
- Experience of the person or group in the subject or topic related to the challenge or problem to solve.
- The capability (regarding number of employees and staff profiles) of the organization or group that proposes the idea.
- Other (please specify).

Do you think that having detailed information about the academic or professional profile of the person or group that proposes the idea would be useful to make better decisions when evaluating that idea?

The interviews with managers also sought information about the role of knowledge transfer agencies (typically linked to universities) in open innovation platforms. When asked what functions knowledge and technology transfer could develop, the interviewees highlighted:

1. Identifying collaboration programs and projects in which the company can participate. This criterion was valued the same by all interviewees, with a score of 4.
2. Completing comparative studies of technical solutions, methods, and technologies, also rated 4.
3. Identifying partners for the design of products and services. This aspect got 3.6 and was evaluated similarly by all the interviewees.
4. Searching for partners for manufacturing and commercialization received lower scores, 2.3 and 2 respectively. The design of products and services was evaluated differently by the interviewees.

The analysis of the answers suggests that several activities in the innovation process could be executed more efficiently with the support of documented information from external sources. These activities include:

1. Knowing the technical profile of the agent proposing a solution to challenges.
2. Identifying external experts who can help in evaluating ideas and establishing groups of assessors.
3. Checking the availability of explicit knowledge (papers, patents, previous projects, and the like) that discuss the challenge's topic. This information could be used as an input to the idea valuation process.

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Technical Implementation and Feasibility Study

Web-based open innovation platforms could be improved by integrating them with scientific and technical document databases. Today, most open repositories and document databases offer integration capacities through the Web-based protocols REST (representational state transfer) and SOAP (formerly simple object access protocol) and APIs (application programming interfaces). APIs are tools used to share content and data between software applications. With them, a researcher can launch queries to a document database from external applications. For this article, the author performed a technical analysis on the PubMed and PubMed Central databases published by the National Center for Biotechnology Information (NCBI). The databases provide APIs called Entrez Programming Utilities or E-utilities that allow a user to query up to 38 biomedical databases using the REST or SOAP protocols. E-utilities also give access to such NCBI databases as PubMed Central, which has the full text of the documents, the National Library of Medicine (NLM) catalog, and the MeSH (medical subject headings) list of topic descriptions. To use the API, it is necessary to register and get a key to report the source of the queries, with a restriction of three queries per second.

Web-based open innovation platforms could be improved by integrating them with scientific and technical document databases.

All the APIs for E-utilities use the same reference URL. Parameters can be added to that URL to specify the requested action, which database to query, and the search criteria. ESearch accepts complex queries that combine clauses restricted to specific fields of the bibliographic record using the Boolean operators *AND*, *OR*, and *NOT*. For example, to ask the ESearch E-utility to get the PubMed documents about arthroscopy published in the last two years, one would use the URL https://eutils.ncbi.nlm.nih.gov/entrez/eutils/esearch.fcgi?db=pubmed&term=arthroscopy+2018[pdat].

ESearch returns the answer as an XML document with the identifiers of the documents (PubMed ID or PMID) matching the conditions. This list must then be further processed to request specific data about the documents using the eSummary.fcgi or eFetch.fcgi E-utilities. The detailed bibliographic records are also returned in XML format and can be displayed to the users or stored locally. See Figure 2.

This approach shows how a combination of questions gives the capability of searching different databases programmatically. These databases can be integrated with an external, Web-based open innovation platform by a sequence of queries to the E-utilities API, first running a search via ESearch, then collecting the specific documents' data via ESummary and EFetch. Table 2 summarizes the list of functions provided by E-utilities.

Other databases offer integration capabilities like those of E-utilities. For example, the Scopus database published by Elsevier provides a detailed API through the Scopus Search service: http://api.elsevier.com/content/search/scopus. It also accepts a query in which different parameters can be combined to retrieve documents: *Abs* to search in the documents' abstract, *Affil* to search authors' affiliation, *Auth* to search documents by author, *Conf* to get the documents by conference, and so on.

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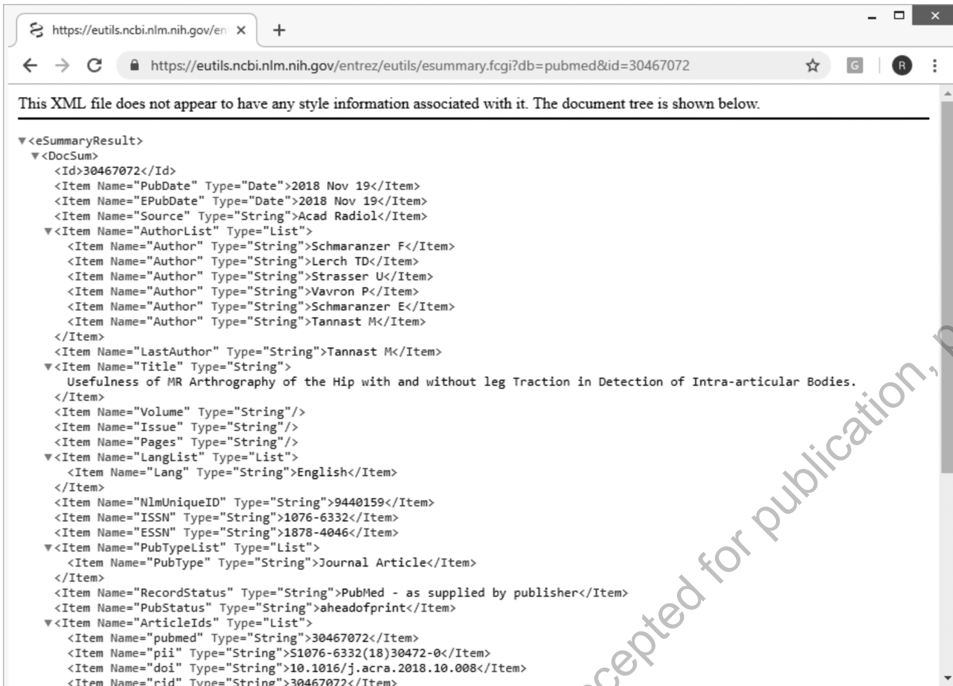

Figure 2. A typical list of search results retrieved by ESearch from the PubMed and PubMed Central databases of the National Center for Biotechnology Information.

The Scopus Search service supports not only the retrieval of documents but also the gathering of data about authors, companies, and research groups. The interviewees stressed the importance of determining the profile and experience of the people who respond to challenges for the analysis of innovations and ideas. Scopus offers the Author Search API, which can be used to filter authors by organization, city or country, name, or expertise area.

These methods establish the basis to automate the retrieval of data about experts once they have been identified through the analysis of their contributions to the literature. Other databases have similar APIs, including open repositories such as OpenAIRE, although their capabilities are more limited than those of E-utilities and Scopus. All these APIs make possible the integration of document databases with open innovation platforms.

Results and Conclusions

To access the E-utilities and Scopus APIs, the author designed a Web-based demonstrator that illustrates the feasibility of the proposed integration of academic databases with open innovation platforms. The demonstrator was built using the PHP programming language and the PostgreSQL database. It provides a basic functionality to record challenges, ideas, and the conclusions of their assessment. The demonstrator enables interaction with the

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Table 2.
E-utilities to access the PubMed and PubMed Central databases

E-utility	Function	Parameters
ESearch	It launches a query against one database and returns a list of the PubMed identifiers of the documents that match the query.	Database, query, and one parameter to keep the results set in the server.
ECitMatch	It retrieves the PubMed identifiers of the documents that cite other documents sent as an argument.	Cited document (journal abbreviated title, publication year, volume, first page and author, separated by the | character).
EPost	It creates an entry in the search history with the documents retrieved by the search, so this set can be reused in subsequent queries.	PubMed identifiers of the documents to keep or reference to a previous query.
ESummary	It retrieves the basic bibliographic data for a set of documents.	PubMed identifiers of the documents, separated by commas, or reference to the result of a query stored at the server.
EFetch	It retrieves the full details of the documents.	PubMed identifiers of the documents, separated by commas, or reference to the result of a query stored at the server.
ELink	It searches items related to another one in different databases.	Source database, target databases, and identifiers of the documents.
EInfo	It displays information about one database (number of records, last update, and links with other databases).	Identifiers of the database.
EGQuery	It runs a global query in all the databases and returns the number of items matching the query in each database.	Query terms.

PubMed, PubMed Central, and Scopus databases to give people assessing ideas the capability of getting documents related to the topic under discussion, and to check the profile of the people answering the challenges. The implementation also provides the capability of saving the retrieved documents in the open innovation platform's internal database, linked to the challenge and opportunity under discussion. See Figure 3.

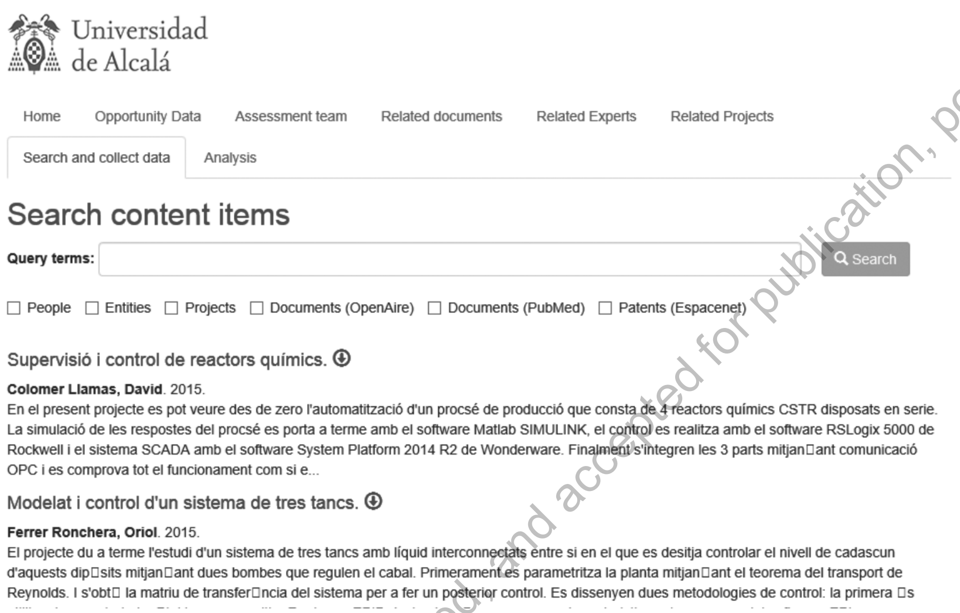

Figure 3. Documents retrieved from academic databases saved in the internal database of an open innovation platform.

The software prototype showing how to connect open innovation platforms with document databases obtained positive feedback, as it opens an interesting line of improvement to Web-based open innovation platforms. Its initial scope can be widened to incorporate access to data about projects, patents, persons, or organizations with APIs provided by other document databases, such as OpenAIRE or Espacenet from the European Patent Office. In all the cases, the technical basis to access these repositories is the same: REST Web services.

This study suggests the following recommendations for the field of knowledge and information management:

1. Offer solutions to access external document databases and repositories from other tools that employees use to complete their daily work.
2. Design tools that act as mediators between various information resources, having a single point of access to all of them.
3. Give greater visibility to the scientific and technical knowledge available in open repositories and databases.
4. Put explicit information and knowledge at the center of the innovation development process.

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Notes

1. Organisation for Economic Co-operation and Development (OECD), "Oslo Manual 2018: Guidelines for Collecting, Reporting, and Using Data on Innovation," 4th ed., 2018, https://www.oecd.org/science/oslo-manual-2018-9789264304604-en.htm.
2. Frank van Harmelen, George Kampis, Katy Borner, Peter van den Besselaar, Erik Schultes, Carole Goble, Paul Groth, et al., "Theoretical and Technological Building Blocks for an Innovation Accelerator," *European Physical Journal. Special Topics* 214 (2012): 183–214.
3. Maria Busse, Alexandra Doernberg, Rosemarie Siebert, Anett Kuntosch, William Schwerdtner, Bettina König, and Wolfgang Bokelmann, "Innovation Mechanisms in German Precision Farming," *Precision Agriculture* 15, 4 (2014): 403–26.
4. Eric von Hippel, *The Sources of Innovation* (New York: Oxford University Press, 1988).
5. Christopher Freeman, A. B. Robertson, P. J. Whittaker, R. C. Curnow, and J. K. Fuller, "Chemical Process Plant: Innovation and the World Market," *National Institute Economic Review* 45, 1 (1968): 29–51; Nathan Rosenberg, *Perspectives on Technology* (Cambridge, UK: Cambridge University Press, 1976).
6. Eric von Hippel, "Open Source Projects as Horizontal Innovation Networks—By and for Users," 2003, http://hdl.handle.net/1721.1/1827.
7. Franz Tödtling and Alexander Kaufmann, "SMEs [small and medium-sized enterprises] in Regional Innovation Systems and the Role of Innovation Support—The Case of Upper Austria," *Journal of Technology Transfer* 27, 1 (2002): 15–26; Maia Iordatii, Alain Venot, and Catherine Duclos, "Designing Concept Maps for a Precise and Objective Description of Pharmaceutical Innovations," *BMC* [BioMed Central] *Medical Informatics and Decision Making* 13, 10 (2013): 1–8.
8. Martin L. Weitzman, "Recombinant Growth," *Quarterly Journal of Economics* 113, 2, (1998): 331–60.
9. Henry Chesbrough, "Open Innovation: How Companies Actually Do It," *Harvard Business Review* 81, 7 (2003): 12–14.
10. Oliver Gassmann and Ellen Enkel, "Towards a Theory of Open Innovation: Three Core Process Archetypes," paper presented at R&D Management Conference, Lisbon, Portugal, June 21–24, 2004, https://www.alexandria.unisg.ch/274/.
11. Blandine Laperche, "Knowledge-Capital and Innovation in Multinational Corporations," *Journal of Technology and Globalisation* 3, 1 (2007): 4–41.
12. Van Harmelen, Kampis, Borner, Van den Besselaar, Schultes, Goble, Groth, et al., "Theoretical and Technological Building Blocks for an Innovation Accelerator."
13. Vinit Parida, Mats Westerberg, and Johan Frishammar, "Inbound Open Innovation Activities in High-Tech SMEs: The Impact on Innovation Performance," *Journal of Small Business Management* 50, 2 (2012): 283–309.
14. Wesley M. Cohen and Daniel A. Levinthal, "Absorptive Capacity: A New Perspective on Learning and Innovation," *Administrative Science Quarterly* 35, 1 (1990): 128–52.
15. Robert G. Cooper, "A Process Model for Industrial New Product Development," *IEEE* [Institute of Electrical and Electronics Engineers] *Transactions on Engineering Management* 30, 1 (1983): 2–11.
16. Robert G. Cooper, "Stage-Gate Systems: A New Tool for Managing New Products," *Business Horizons* 33, 3 (1990): 44–54; Robert G. Cooper, Scott J. Edgett, and Elko J. Kleinschmidt, "Optimizing the Stage-Gate Process: What Best-Practice Companies Do—I," *Research Technology Management* 45, 5 (2002): 21–27; Robert G. Cooper and Scott J. Edgett, "Developing a Product Innovation and Technology Strategy for Your Business," *Research Technology Management* 53, 3 (2010): 33–40; Robert G. Cooper and Anita F. Sommer, "Agile-

This mss. is peer reviewed, copy edited, and accepted for publication, portal 22.2.

Stage-Gate: New Idea-to-Launch Method for Manufactured New Products Is Faster, More Responsive," *Industrial Marketing Management* 59 (2016): 167–80.
17. Rachel Phillips, Kevin Neailey, and Trevor Broughton, "A Comparative Study of Six Stage-Gate Approaches to Product Development," *Integrated Manufacturing Systems* 10, 5 (1999): 289–97.
18. Don Reinertsen, "Streamlining the Fuzzy Front-End," *World Class Design to Manufacture* 1, 5 (1994): 4–8; Rudy K. Moenaert, Arnoud de Meyer, William E. Souder, and Dirk Deschoolmeester, "R&D/Marketing Communication during the Fuzzy Front-End," *IEEE Transactions on Engineering Management* 42, 3 (1995): 243–58.
19. Stefan H. Hallerstede and Angelika Bullinger-Hoffmann, "Managing the Lifecycle of Online Innovation Contests—A Case Study on an Innovation Intermediary's Approach," *International Journal of Technology Marketing* 9, 2 (2014): 125–42; Johan Frishammar, Emmy Dahlskog, Charlotte Krumlinde, and Kerem Yazgan, "The Front End of Radical Innovation: A Case Study of Idea and Concept Development at Prime Group," *Creativity and Innovation Management* 25, 2 (2016): 179–98.
20. Nelson Daishiro Yoshida, "Bibliometric Analysis: A Study Applied to Technological Forecasting," *Future Studies Research Journal* 2, 1 (2010): 52–84; Ming-Yeu Wang, Dong-Shang Chang, and Chih-Hsi Kao, "Identifying Technology Trends for R&D Planning Using TRIZ [theory of inventive problem solving] and Text Mining," *R&D Management* 40, 5 (2010): 491–509; Christine Moser, Julie M. Birkholz, Dirk Deichmann, Iina Hellsten, and Shenghui Wang, "Exploring Ideation: Knowledge Development in Science through the Lens of Semantic and Social Networks," *Proceedings of the 2013 46th Hawaii International Conference on System Sciences (HICSS '13)* (Washington, DC: IEEE, 2013), 235–43.
21. Eric Zimmerling, Patrick J. Höflinger, Philipp Sandner, and Isabell M. Welpe, "Increasing the Creative Output at the Fuzzy Front End of Innovation—A Concept for a Gamified Internal Enterprise Ideation Platform," *HICSS '16: Proceedings of the 2016 49th Hawaii International Conference on System Sciences* (Washington, DC: IEEE Computer Society, 2016), 837–46, https://doi.org/10.1109/HICSS.2016.108
22. Fiona Schweitzer, Oliver Gassmann, and Christiane Rau, "Lessons from Ideation: Where Does User Involvement Lead Us?" *Creativity and Innovation Management* 23, 2 (2014): 155–67; Alexander Brem and Volker Bilgram, "The Search for Innovative Partners in Co-Creation: Identifying Lead Users in Social Media through Netnography and Crowdsourcing," *Journal of Engineering and Technology Management* 37 (2015): 40–51.
23. Namgyoo K. Park, John M. Mezias, and Juju Lee, "Reverse Knowledge Diffusion: Competitive Dynamics and the Knowledge Seeking Behavior of Korean High-Tech Firms," *Asia Pacific Journal of Management* 31, 2 (2014): 355–75.
24. Thomas Lackner, "Open Innovation at Siemens AG," chap. 2 in *Leading Open Innovation*, Anne Sigismund Huff, Kathrin M. Möslein, and Ralf Reichwald, eds. (Cambridge, MA: MIT Press, 2013), 19–34.
25. Kathrin M. Möslein, "Open Innovation: Actors, Tools, and Tensions," chap. 5 in Huff, Möslein, and Reichwald, *Leading Open Innovation*, 69–86.
26. Mohanbir Sawhney, Gianmario Verona, and Emanuela Prandelli, "Collaborating to Create: The Internet as a Platform for Customer Engagement in Product Innovation," *Journal of Interactive Marketing* 19, 4 (2005): 4–17; Bernhard Katzy, Ebru Turgut, Thomas Holzmann, and Klaus Sailer, "Innovation Intermediaries: A Process View on Open Innovation Coordination," *Technology Analysis & Strategic Management* 25, 3 (2013): 295–309.
27. Gordon Müller-Seitz and Guido Reger, "Is Open Source Software Living Up to Its Promises? Insights for Open Innovation Management from Two Open Source Software-Inspired Projects," *R&D Management* 39, 4 (2009): 372–81.
28. Eric von Hippel and Ralph Katz, "Shifting Innovation to Users via Toolkits," *Management Science* 48, 7 (2002): 821–33.
29. Frank Piller and Christoph Ihl, "Co-Creation with Customers," chap. 9 in Huff, Möslein, and Reichwald, *Leading Open Innovation*, 139–54.
30. Karim R. Lakhani, "Contributions by Developers," chap. 10 in Huff, Möslein, and Reichwald, *Leading Open Innovation*, 155–70.

This mss. is peer reviewed, copy edited, and accepted for publication, portal 22.2.