The Case for Institutional Repositories:
A SPARC Position Paper

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ABSTRACT

Institutional repositories—digital collections that capture and preserve the intellectual output of university communities—respond to two strategic issues facing academic institutions: 1) they provide a central component in reforming scholarly communication by stimulating innovation in a disaggregated publishing structure; and 2) they serve as tangible indicators of an institution's quality, thus increasing its visibility, prestige, and public value. This paper examines institutional repositories from these complementary perspectives, describing their potential role and exploring their impact on major stakeholders in the scholarly communication process.

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EXECUTIVE SUMMARY

Institutional repositories—used in this paper to mean digital collections capturing and preserving the intellectual output of a single or multi-university community—provide a compelling response to two strategic issues facing academic institutions. Such repositories:

- Provide a critical component in reforming the system of scholarly communication—a component that expands access to research, reasserts control over scholarship by the academy, increases competition and reduces the monopoly power of journals, and brings economic relief and heightened relevance to the institutions and libraries that support them; and

- Have the potential to serve as tangible indicators of a university's quality and to demonstrate the scientific, societal, and economic relevance of its research activities, thus increasing the institution's visibility, status, and public value.

Institutional repositories can provide an immediate and valuable complement to the existing scholarly publishing model, while stimulating innovation in a new disaggregated publishing structure that will evolve and improve over time. Further, they build on a growing grassroots faculty practice of self-posting research online. While institutional repositories necessitate that libraries—as their logical administrative proponents—facilitate development of university intellectual property policies, encourage faculty authors to retain the right to self-archive, and broaden both faculty and administration perspectives on these issues, they can be implemented without radically altering the *status quo*. Moreover, they can be introduced by reallocating existing resources, usually without extensive technical development.

In sum, institutional repositories offer a strategic response to systemic problems in the existing scholarly journal system—and the response can be applied immediately, reaping both short-term and ongoing benefits for universities and their faculty and advancing the positive transformation of scholarly communication over the long term.

This paper examines institutional repositories strategically, from two complementary perspectives: 1) as a natural extension of academic institutions' responsibility as generators of primary research seeking to preserve and leverage their constituents' intellectual assets; and 2) as one potentially major component in the evolving structure of scholarly communication. We describe the roles of institutional repositories in this structure and explore the impact on major stakeholders in the process and outcomes.

INTRODUCTION

As producers of primary research, it is only to be expected that academic institutions would take an interest in capturing and preserving the intellectual output of their faculty, students, and staff. Traditionally, scholarly publishers (as aggregators and distributors) and institutional libraries (as managers and preservers) served complementary roles in facilitating scholarly communication and preserving—albeit in a diffuse and indirect manner—an institution's intellectual legacy. Over the past several decades, however, the economic, market, and technological foundations that sustained this symbiotic publisher-

library market relationship have begun to shift. Several coinciding factors are forcing change in the structure of scholarly journal publishing:

- Technological change, in the form of digital publishing technologies and ubiquitous networking, has driven the demand for broader access to research and for more robust digital presentation.

- Significant increases in the overall volume of research, especially in the sciences, has strained the capacity of the print publishing model and exacerbated user dissatisfaction with the latency inherent in print publication.

- Increasing dissatisfaction, especially on the part of librarians, with traditional print and electronic journal price and market models—models that have become less relevant and more difficult to sustain in a period of rapidly escalating prices and relatively flat library budgets.

- Increasing uncertainty over who will handle the preservation archiving of digital scholarly research material.

All these factors have evolved and combined to create new expectations in the academic community for the production, distribution, and interchange of scholarly communications and to force a rethinking of the relative roles of authors, librarians, and publishers—as well as the possibility of entirely new actors who will emerge as the publishing model evolves. In such an environment, institutional repositories might well act to preserve an institution's intellectual work product while contributing to a fundamental, albeit long-term, change in the structure of scholarly communication.

Researchers, librarians, and publishers have applied considerable thought to the various issues—technical, organizational, cultural, economic, and legal—germane to understanding the impact of digital media on scholarly communications. This SPARC position paper explores the impact that institutional repositories—digital collections that preserve and provide access to the intellectual output of an institutional community—can have on evolving models of scholarly communication, their implications for current stakeholders in the process, and the potential benefit they deliver to the institutions that sponsor them. Specifically, this document:

- Describes the potential roles of institutional digital repositories in the evolving structure of scholarly communication and relative to alternative repository models; and

- Explores the impact of institutional repositories on the major stakeholders in the scholarly communications process—with an emphasis on scholars, academic institutions and their libraries, and publishers.

SPARC intends this paper to facilitate a practical discussion of institutional repository policy and management issues amongst operational decision makers.[1] This discussion will necessarily engage participants from a variety of perspectives— faculty as principal

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[1] Technical and operational details pertaining to the implementation of an institutional repository will be addressed in a forthcoming SPARC companion document.

contributors and stakeholders, librarians as implementers,[2] and provosts and deans as vital administration proponents.[3]

RATIONALE FOR INSTITUTIONAL REPOSITORIES

The rationale for universities and colleges implementing institutional repositories rests on two interrelated propositions: one that supports a broad, pan-institutional effort and another that offers direct and immediate benefits to each institution that implements a repository.

New Scholarly Publishing Paradigm

While institutional repositories centralize, preserve, and make accessible an institution's intellectual capital, at the same time they will form part of a global system of distributed, interoperable repositories that provides the foundation for a new disaggregated model of scholarly publishing. As we will discuss below, this model unbundles the principal functions of scholarly communication, thus presenting the potential to realize market efficiencies previously hidden by the vertically integrated publishing model that now characterizes academic journal publishing.

Altering the structure of the scholarly publishing model will be neither simple nor immediate. The stakes are high for all the well-entrenched participants in the system—faculty, librarians, and publishers—and the inertia of the traditional publishing paradigm is immense. In the near-term, large journal publishers have both the power and the incentive to maintain the *status quo*: the prestigious journals they control appear integral to the very structure of academic professional advancement. However, digital publishing and networking technologies, harnessed by an increasingly dissatisfied library market—as well as by authors themselves—are now driving fundamental changes to this publishing model at an accelerating pace. And new communications paradigms, especially when constructed by the scholars themselves, can eliminate seemingly insurmountable publisher advantages in relatively short order.[4]

Institutional Visibility and Prestige

Institutional repositories, by capturing, preserving, and disseminating a university's collective intellectual capital, serve as meaningful indicators of an institution's academic quality. Under the current system of scholarly communication, much of the intellectual output and value of an institution's intellectual property is diffused through thousands of scholarly journals. While faculty publication in these journals reflects positively on the host university, an institutional repository concentrates the intellectual product created by a university's researchers, making it easier to demonstrate its scientific, social and financial value. Thus, institutional repositories complement existing metrics for gauging institutional productivity and prestige. Where this increased visibility reflects a high quality of scholarship, this demonstration of value can translate into tangible benefits,

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[2] This would include both individual institutions and consortia and pan-institutional initiatives.

[3] Institutional repositories operate in a global context. While some of the specifics of this paper's presentation may be U.S.-centric, the fundamental issues discussed apply globally.

[4] See Evans and Wurster (1997) and Arms (2000).

including the funding—from both public and private sources—that derives in part from an institution's status and reputation.

The current system of scholarly communication limits, rather than expands, the readership and availability of most scholarly research (while also obscuring its institutional origins). Rounds of journal price increases and subsequent subscription cancellations act to reduce the audience further. In this context, the role of alternative scholarly publishing models, such as institutional repositories, in breaking the monopolies of publishers and increasing the awareness of university intellectual output grows increasingly clear.[5] Further, institutional repositories can serve this function whether they are implemented on individual campuses or in collaborative consortial projects.

DECONSTRUCTED SCHOLARLY PUBLISHING MODELS

Scholarly communication has been described as comprising four essential components:

- Registration—establishing the intellectual priority of an idea, concept, or research;

- Certification—certifying the quality of the research and/or the validity of the claimed finding;

- Awareness—ensuring the dissemination and accessibility of research, providing a means by which researchers can become aware of new research; and

- Archiving—preserving the intellectual heritage for future use.[6]

These functions need to be served whatever system(s) of scholarly communication exist.

We have suggested above that institutional repositories can play a meaningful role in an evolutionary restructuring of scholarly communication. We will now explore that evolving publishing model and the potential roles of institutional repositories (and complementary digital repositories) within it. This discussion will provide the context for an examination of the impact institutional repositories might have on various stakeholders, including librarians, faculty, administrators, students, publishers, and research sponsors.

Traditional print journal publishing—as well as digital publishing models that are, essentially, analogues of print publishing—integrate these four components into one publishing model. Additionally, these components themselves comprise multiple elements of the scholarly publishing value chain.[7] These publishing elements—including production, editorial processing, and distribution—have a significant impact on the costs of scholarly journals under the existing system. This vertical integration has several implications.

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[5] See Wyly (1998) and Crane (2001).

[6] See Roosendaal and Geurts (1998).

[7] A value chain is the collection of activities that combine to design, produce, and deliver a product or service to satisfy a particular market need.

First, this melding tends to disguise the fact that most of the direct labor and much of the indirect cost required for each of the components derives from the academic institutions that ultimately bear the cost of scholarly journal subscription fees. Faculty researchers produce the original research itself; academic editors and peer-reviewers select and validate the quality and priority of the research; academic libraries process, house, and distribute the journals to end users; and library resources support archival preservation—all at little or no direct cost to the journal publishers themselves.[8] (See Table 1.)

A second implication of this integrated publishing model, and particularly germane for the current analysis, is that increased cost efficiencies in any one component of the scholarly publishing value chain do not translate into reduced journal prices. Bundling together individual functions in the publishing chain—each having different economies of production, scale, or scope—compromises the market efficiency of each of them. Deconstructing such a vertically integrated value chain, and fragmenting it into multiple businesses, makes the discrete value added by publishers more apparent and separable and helps eliminate inherent systemic inefficiencies.[9]

Historically, for example, the publisher contribution to the scholarly publishing value chain concentrated on the distribution component: typesetting, printing, marketing, and fulfillment were specialized and expensive tasks that authors and libraries gladly delegated to publishers. With the evolution of digital publishing and networked distribution technologies, the relative value of print production and distribution has declined. Yet most publishers are unwilling to accept the commensurate decline in revenues and profits that their reduced participation in the chain would yield. Therefore, many publishers have responded with real or artificial added-value programs, such as bundled print-and-digital offerings or cross-subject aggregations, to support prices.[10]

Digital publishing technologies and extensive global networking—coupled with an increasing volume of scientific research and decreasing satisfaction with a dysfunctional economic model—change the fundamental structure of scholarly publishing by allowing its various components to be de-linked, both functionally and economically. When the functions are unbundled and begin to operate separately, each can operate more efficiently and competitively. This can yield a structure that integrates a system of cooperating distributed agents, responsible for various aspects of the registration,

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[8] See Van de Sompel (2000) and Arms (2000).

[9] Evans and Wurster (1997) described how the changing economics of information act to undermine established value chains in many sectors of the economy, and John Smith (1999), Herbert Van de Sompel (2000), and Paul Ginsparg (2001) have applied the same logic to scholarly communication, arguing that scholarly publishing needs to move beyond a digital analog of print publishing to a new paradigm of a global interoperable network.

[10] The high profit margins resulting from high prices and franchise leveraging that were enjoyed by some commercial publishers accelerated the decomposition of the scholarly publishing value chain. Without those margins, supported by price increases as much as by improved operational efficiency, there would have been considerably less incentive for academic stakeholders to explore alternatives. Likewise, the opportunity costs and traditional barriers to market entry relative to potential return formerly discouraged other players, both commercial and nonprofit.

certification, awareness, and archiving functions.[11] As we will see, institutional repositories have the potential to play a significant role in the structure envisioned.

Table 1: Scholarly Communication Functions in the Traditional Academic Journal System

Function	Process	Actors	Process Sponsor
Registration	Paper (or electronic) submission to journal	Academic author-researcher	Publisher
Certification	Peer review	Academic referees	Publisher
Awareness	Library journal selection and support	Librarians Publishers	Academic institution Publisher
Archiving	Perpetual access	Librarians	Academic institution

Table 2: Scholarly Communication Functions in a New Disaggregated Model

Function	Process	Actors	Process Sponsor
Registration	Posting electronic paper to repository	Academic author-researcher	Repository sponsor
Certification	Peer review Associative certification Online response	Academic referees Academic referees Academic respondents	Overlay journals Academic departments Repository sponsor
Awareness	Interoperable open repositories and support services	Librarians	Academic institutions Professional Societies Third-party providers
Archiving	Perpetual access	Librarians	Academic institution

INSTITUTIONAL REPOSITORIES IN A DISAGGREGATED PUBLISHING MODEL

Reviewing how this disaggregated publishing model is evolving will help us appreciate more fully both the role that institutional repositories will play in such a structure and the impact changes might have on principal stakeholders. This exercise is not futuristic speculation: many of the functional components described below already exist in practice, and as these components proliferate the model will become richer and more robust. Critical mass in terms of the underlying content repositories that fuel the system represents the single most important element of the new model. Institutional repositories will prove essential to getting the reconstituted scholarly communications structure to a tipping point where the benefits of the new system can be fully realized.

Fundamental to implementing this disaggregated model is the logical separation of the content and service components advocated by Van de Sompel and others.[12] This separation allows for distributed open access content repositories to be maintained independently of value-added services fulfilled discretely by multiple service providers.

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[11] See Harnad (1995), J. Smith (1999), and Van de Sompel (1999). On the decoupling of peer-review certification from the publishing process, see Phelps (1998).

[12] See Van de Sompel (2000).

Once the components of scholarly publishing are logically separated, the registration, certification, and awareness functions, orchestrated by publishers in the current publishing model, can be undertaken by any organization with sufficient intellectual prestige, organizational standing, and market position.

Content Layer

In the content layer, authors, author proxies (departments, user communities, and scholarly societies, for example), and institutions deposit scholarly research and other intellectual product in one or more content repositories. Institutional repositories represent but one type of content archive, forming part of a global system of decentralized, distributed repositories. Such a system offers several benefits:

- Interoperable repositories support the researcher's ability to search seamlessly across repository types, facilitating interdisciplinary research and discovery. This is increasingly valuable as the trend towards such multidisciplinary approaches increases in the sciences, social sciences, and humanities.

- The vast global corpus of heterogeneous data that the repositories represent can be curated by the local content managers best prepared to accommodate each data set's specific detail and particularities (for example with detailed metadata appropriate to the content).

- Institutional repositories, along with other self-archiving repositories, create distributed, interoperable preservation systems. Digital archiving best practice suggests that multiple mirrored and distributed repositories, varying in location and formats, contribute to a sound preservation strategy.

Interoperability comprises persistent naming, standardized metadata formats, and a metadata harvesting protocol. Metadata describes the nature of the digital data stored in repositories (including the content, structure, and access rights administration). The metadata harvesting protocol allows third-party services to gather the metadata from distributed repositories and conduct searches against the assembled metadata to identify and ultimately retrieve documents. These mechanisms can be applied to any type of compliant digital library, creating a global network of digital research materials.[13]

By facilitating interoperability, the Open Archives movement has accelerated the deconstruction of the traditional scholarly publishing model and increased the potential for institutional repositories within a reconstituted publishing scheme. The movement spawned the Open Archives Initiative (OAI), which was established to develop and promote interoperability solutions to facilitate the dissemination of content.[14] These

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[13] Detailed and specific metadata becomes increasingly expensive. To allow a lower level entry, the Open Archives Initiative (OAI) supports a core set of metadata that represent a lowest common denominator. This lowers barriers to participation, and allows ephemera or other material that might not warrant the expense of extensive metadata tagging, while still adding value in terms of information retrieval. See Lagoze and Van de Sompel (2001) and Lynch (2001).

[14] "Open Archives" in this context requires some explanation. While many OAI proponents advocate monetarily free access to scholarly information, the OAI itself uses "open" to indicate machine interoperability, without a connotation of free or unlimited access. Additionally, for OAI, "archive" serves

solutions build on a publishing model that separates data providers (institutional repositories, discipline-specific archives, and the like) from service providers (metadata harvesters, search/retrieval, and other value-added access tools). The OAI established a metadata harvesting protocol that supports the interoperability of digital repositories irrespective of type (institutional, discipline-specific, commercial, etc.) or content.

A variety of these digital repositories have arisen in the past two decades, some as responses to the pressures on the economic model of scholarly publishing and others as a result of the natural evolution of scholarly communication in some disciplines where scholars and scientists have sought to recapture control of their intellectual product. In many instances, these alternative publishing models demonstrate the increasing interest on the part of scholars themselves to apply digital publishing technologies and the Internet as means of disseminating their research. A brief review of two of these complementary initiatives—author "self-archiving" and discipline-specific repositories—will provide further context for our examination of the role of institutional repositories.

"Author self-archiving" is a broad term often applied to the electronic posting, without publisher mediation, of author-supplied research. In practice, such self-archiving encompasses both the posting of pre-prints and (in many instances) published papers by individual researchers on personal web sites and the inclusion of such research on the discipline-specific e-print servers described below.[15] Policies of traditional publishers concerning author self-archiving of published papers vary, as does the stringency with which the policies are enforced. The response of academic authors themselves to such policies runs the gamut from strict adherence to utter indifference.[16]

Certain academic disciplines with established pre-print traditions developed electronic mechanisms to facilitate the sharing and storage of research pre-prints. Discipline-specific digital repositories for high-energy physics and mathematics (arXiv);[17] economics (RePEc);[18] cognitive science (CogPrints);[19] astronomy, astrophysics, and geophysics (NTRS and ADS);[20] and computer science (NCSTRL)[21] evolved within those specific research communities as digital extensions of existing peer-to-peer research communication practice. As such, these

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as a synonym for repository and does not necessarily indicate a digital preservation archive in the sense professional archivists might use the term. See < http://www.openarchives.org/>.

[15] Licensing and copyright agreements and statements frequently use the term "self-archiving" to indicate whether the author retains the right to make their research available publicly prior to or after publication in a journal.

[16] Stevan Harnad has advocated a system that respects publisher copyright while making all research available via open access. See Harnad (1999) and (2001).

[17] <http://arxiv.org/>

[18] <http://netec.mcc.ac.uk/RePEc>

[19] <http://cogprints.soton.ac.uk>

[20] NASA Technical Reports Server (<techreports.larc.nasa.gov/cgi-bin/NTRS>) and the NASA Astrophysics Data System (<http://adswww.harvard.edu/>).

[21] National Computer Science technical Reference Library. <http://ncstrl.org>

repositories—often termed "e-print servers"—have enjoyed high rates of participation within their respective fields.

While such e-print initiatives are frequently cited as successful examples of author self-archiving, discipline-specific repositories have not enjoyed similar success in academic disciplines without established pre-print traditions.[22] Therefore, while discipline-specific repositories support some research communities, they provide only one component in the evolving structure of scholarly communication.

The content layer can thus comprise institutional, discipline-specific, society sponsored, commercial, or governmental content—any repository that complies with the interoperability and metadata protocols that facilitate the discovery and retrieval of their content. For example, a pre-print might be housed simultaneously on a discipline-specific e-print server or on a discipline's community portal, in the institutional repository of the author's host institution, and on the author's personal web page. Similarly, a research paper in the life sciences might reside in BioMed Central and PubMed Central, in addition to the author's institutional repository. As noted previously, the disaggregated model includes not only pre-prints and research papers, but also extends to research data sets, digital monographs, theses and dissertations, conference papers, listserv archives, and other gray literature. In this scenario, there will never be a monopoly by any model; multiple interoperable repositories will coexist and complement one another.

Archiving
The archiving function may also be discussed in the context of the content layer. Under the print journal system, librarians have traditionally supported the archiving function of scholarly communication by physically maintaining and preserving the printed literature. With the advent of digital distribution, the publishers themselves asserted control over the digital versions of their publications, assuming responsibility—though seldom in clearly defined terms—for the preservation of digital content.

At present, there are no universally-accepted archival standards for ensuring the longevity and preservation of digital formats. Rather, an evolving and fluid set of technical best practices guide most digital preservation planning. The long-term retention of digital objects requires proactive management and considerable resources. Many librarians remain skeptical of the publishers' suitability for this task given their inherently shorter-term perspective. Institutional repositories, in the context of a disaggregated scholarly publishing model, keep responsibility for the preservation of research materials in the hands of librarians, those professionally prepared and committed to handle it.

At any given institution, decisions about the technical format variations accepted for the repository and provisions for their portability, coupled with the institution's commitment to funding long-term data migration and storage, will determine the extent to which the repository serves the archive function.[23] Still, the distributed network of interoperable

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[22] Additionally, since discipline-specific servers are often maintained by an individual or a small group of volunteers, they may not have the stability that an institutional sponsor contributes.

[23] For a concise summary of the issues pertaining to digital access and preservation, see Teper and Kraemer (2002) and Conway (1996).

repositories and mirror sites now developing offers a sounder digital preservation framework than fragmented and proprietary publisher interests. Obviously, as the proportion of digital-only material continues to increase, the issue will become even more pressing.

Service Layer
The service layer comprises the various value-added services that provide practical mechanisms for the registration, certification, and awareness functions. These services supplement or replace those provided by the current journal publishing system. Again, these services facilitate the use of the content in institutional and complementary open online repositories, but remain logically separate from the repositories themselves.

Registration
The accelerating rate of research output, at least in the sciences, requires alternative registration and certification mechanisms to support the increased volume. In the absence of new models, the bandwidth of the existing journal certification system constrains, rather than advances, scientific/scholarly communication. Published peer reviewed research included in an institutional repository will have already cleared the original publisher's registration and certification processes. Preprints and other unpublished material, however, will initially be registered by an institutional repository's content accession process. Subsequent certification, which in effect ratifies the registration, can be effected either via the traditional publishing process or through new mechanisms that achieve the same end, but without the monopolistic implications of the current journal publishing system.

Certification
Most of the institutional repository initiatives currently being developed rely on user (including author) communities to control the input of content. These can include academic departments, research centers and labs, administrative groups, and other sub-groups. Faculty and others determine what content merits inclusion and act as arbiters for their own research communities. Any certification at the initial repository submission stage thus comes from the sponsoring community within the institution, and the rigor of qualitative review and certification will vary. In some instances, the certification will be implicit and associative, deriving from the reputation of the author's host department. In others, it might involve more active review and vetting of the research by the author's departmental peers. While more formal than an associative certification, this certification would typically be less compelling than rigorous external peer review. Still, in addition to the primary level certification, this process helps ensure the relevance of the repository's content for the institution's authors and provides a peer-driven process that encourages faculty participation. It should be noted that to serve the primary registration and certification functions, a repository must have some official or formal standing within the institution. Informal, grassroots projects—however well-intentioned—would not serve this function until they receive official sanction.

Overlay journals—third-party online journals that point to articles and research hosted by one or more repositories—provide another mechanism for peer review certification in a disaggregated model. While some of the content for overlay journals might have been previously published in refereed journals, other research may have only existed as a pre-

print or work-in-progress.[24] As a paper could appear in more than one journal and be evaluated by more than one refereeing body, these overlays would allow the aggregation and combination of research articles by multiple logical approaches—for example, on a particular theme or topic (becoming the functional equivalent of anthology volumes in the humanities and social sciences);[25] across disciplines; or by affiliation (faculty departmental bulletins that aggregate the research of their members). Such journals exist today—for example, the *Annals of Mathematics* overlay to arXiv[26] and *Perspectives in Electronic Publishing*,[27] to name just two—and they will proliferate as the volume of distributed open access content increases. Besides overlay journals pointing to distributed content, high-value information portals—centered around large, sophisticated data sets specific to a particular research community—will spawn new types of digital overlay publications based on the shared data.[28] Regardless of journal type, the basis for assessing the quality of the certification that overlay journals provide differs little from the current journal system: eminent editors, qualified reviewers, rigorous standards, and demonstrated quality.

In addition to these analogues to the current journal certification system, a disaggregated model also enables new types of certification models. Roosendaal and Guerts have noted the implications of internal and external certification systems.[29] Certification may pertain at the level of internal, methodological considerations, pertinent to the research itself— the standard basis for most scholarly peer review. Alternatively, the work may be gauged or certified by criteria external to the research itself—for example, by its economic implications or practical applicability. Such internal and external certification systems would typically operate in different contexts and apply different criteria. In a disaggregated model, these multiple certification levels can co-exist.

To support both new and existing certification mechanisms, quality certification metadata could be standardized to allow OAI-compliant harvesting of that information. This would allow a reader to determine whether there is any certification information about an article, regardless of where the article originated or where it is discovered.[30]

Awareness
A variety of mechanisms contribute to fulfilling the awareness function, the function which, ideally, facilitates the frictionless communication and dissemination of research. Most of these service-level awareness tools are enabled by the interoperability (and the standards and protocols that support it) of the content repositories. For example, search

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[24] The concept of overlay journals is explored most extensively by J. Smith (1999), who calls them "Subject Focal Points," and Ginsparg (2001).

[25] For example, publishers might provide such a service for anthologies that they are publishing—or contemplating publishing—in print. Anecdotal evidence continues to mount that making such books available for free in electronic formats increases, rather than substitutes for, print sales.

[26] The *Annals of Mathematics* is published bimonthly with the cooperation of Princeton University and the Institute for Advanced Study. See <http://www.math.princeton.edu/~annals/>

[27] See Hitchcock and Hall (2001) and <http://aims.ecs.soton.ac.uk/pep.nsf>.

[28] See < http://www.nature.com/nature/debates/e-access/introduction.html>.

[29] Roosendaal and Guerts (1998).

[30] See Van de Sompel (2001).

and retrieval engines will search the metadata harvested from federated repositories. Access to disparate content types will drive retrieval interfaces to evolve from text search models to search engines capable of handling complex data types (for example, biological information, cell structures, and genome structures). In addition to the overlay journals described above, other types of content filters would speed research and improve teaching. For example, personalized alert services, analogous to those now available on proprietary information retrieval services, would operate across distributed open access repositories, notifying a user when new research on a particular user-specified topic is found.[31]

Citation linking, in the context of distributed open access repositories, improves user research access, reveals historical and conceptual trends between articles, and facilitates new methods by which to gauge research quality and measure researcher productivity.[32] New benchmarks and evaluation techniques will also evolve to allow further analysis of the entire open access research corpus. Additionally, extensive open citation linking and sophisticated retrospective analysis would permit the creation of literature summaries that could identify the most efficient path through the literature on a particular concept or research subject or map the trajectories of new research generated by a research article. Again, competing versions of these functional enhancements could be developed and offered by both commercial and non-commercial entities without creating a monopolistic constraint on access to the content itself, as data providers and service providers remain logically separate.[33]

Summary
The reform of the scholarly communication process via the disaggregation outlined above presupposes a large body of open access research. Institutional repositories, perhaps more than any other type of content source, can contribute significantly to achieving the critical mass of open access content necessary to enable the collateral information and knowledge components of the disaggregated communication system. At the same time, it should be emphasized that the new structure accommodates, rather than displaces, traditional scholarly publishers. The purpose of a disaggregated scholarly publishing model is not to destroy the current journal system, but to weaken the monopolistic impact of that system on academic institutions and their libraries. While institutional repositories and other open access initiatives will increase competition and apply pressure to bring prices in line with the value publishers add distinct from the academically-produced content, traditional scholarly publishers will continue to form part of the competitive landscape.

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[31] These alert services could also point to both open access and/or fee-based published content, depending on user-specified parameters.

[32] See Van de Sompel and Hochstenbach (1999); Van de Sompel and Beit-Arie. (2001); Lawrence, Giles, and Bollacker (1999), pp.67-71; and Cameron (1997).

[33] See Hitchcock et al. (2000).

ESSENTIAL ELEMENTS OF AN INSTITUTIONAL REPOSITORY

We have outlined the principal functions of scholarly communication, described the market implications of their integration in the current journal publishing system, and outlined the potential benefits to the communication process and to academic institutions of separating the functions in a disaggregated model. Before proceeding further, it makes sense to apply the discussion above to a working definition of an "institutional repository."

Stated broadly, a digital institutional repository could be any collection of digital material hosted, owned or controlled, or disseminated by a college or university, irrespective of purpose or provenance. Here, however, we will narrow our definition to focus on a particular type of institutional repository—one capable of supporting two complementary purposes: as a component in a restructured scholarly publishing model, and as a tangible embodiment of institutional quality.

Defined for our purposes then, an institutional repository is a digital archive of the intellectual product created by the faculty, research staff, and students of an institution and accessible to end users both within and outside of the institution, with few if any barriers to access. In other words, the content of an institutional repository is:

- Institutionally defined;
- Scholarly;
- Cumulative and perpetual; and
- Open and interoperable.

We will amplify and qualify each of this definition's elements below. However, our purpose in doing so is not to prescribe the precise requirements necessary to qualify as an institutional repository. As we will see, institutional repositories can assume many forms and serve a variety of purposes. Indeed, the technical and administrative infrastructures developed by academic institutions for existing digital library initiatives might often be modified or repurposed to serve the requirements of an institutional repository. Similarly, our more narrowly defined institutional repository might form a component of a more comprehensive institutional initiative, one encompassing virtually all of an institution's digital assets.[34] Rather, we need to identify essential defining elements to bound a meaningful discussion of the organizational, technical, financial, and cultural issues relevant to implementing an institutional repository.

Institutionally Defined
In contrast to discipline-specific repositories and subject-oriented or thematic digital libraries, institutional repositories capture the original research and other intellectual property generated by an institution's constituent population active in many fields. Defined in this way, institutional repositories represent an historical and tangible embodiment of the intellectual life and output of an institution. And, to the extent that

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[34] For example, Ohio State University's proposed Knowledge Bank. See <http://www.lib.ohio-state.edu/Lib_Info/scholarcom/KBproposal.html>.

institutional affiliation itself serves as the primary qualitative filter, this repository becomes a significant indicator of the institution's academic quality.

Depending on the university, an institutional repository may complement or compete with the role served by the university archives. University archives often serve two purposes: 1) to manage administrative records to satisfy legally mandated retention requirements, and 2) to preserve materials pertaining to the institution's history and to the activities and achievements of its officers, faculty, staff, students, and alumni. Compared to institutional repositories, which aim to preserve the entire intellectual output of the institution, university archivists exercise broad discretion in determining which papers and other digital objects to collect and store. Still, the potential overlap of roles of the two repository types merits consideration at institutions that support both.

Developing institutional repositories does not require that each institution act entirely on its own. For many colleges and universities, existing state or regional institutional or library consortia will provide a logical infrastructure for implementing institutional repositories via collective development. Such cooperation could deliver economies of scale and help institutions avoid the needless replication of technical systems. Indeed, consortia might well prove the fastest path to proliferating institutional repositories and attaining a critical mass of open access content.

While much of the discussion that follows focuses on repositories that serve the needs of academic institutions, other types of institutions that generate substantial bodies of research or other intellectual property could establish repositories as well. These might include government departments or agencies, NGOs and IGOs, museums, independent research organizations, federations of societies, and (theoretically at least) commercial entities—any organization that wishes to capture and openly disseminate its intellectual product, thus contributing to scientific/scholarly discourse and benefiting from the resulting organizational visibility.

Scholarly Content
Depending on the goals established by each institution, an institutional repository could contain any work product generated by the institution's students, faculty, non-faculty researchers, and staff. This material might include student electronic portfolios, classroom teaching materials, the institution's annual reports, video recordings, computer programs, data sets, photographs, and art works—virtually any digital material that the institution wishes to preserve.[35] However, given SPARC's focus on scholarly communication and on changing the structure of the scholarly publishing model, we will define institutional repositories here—whatever else they might contain—as collecting, preserving, and disseminating scholarly content. This content may include pre-prints and other works-in-progress, peer-reviewed articles, monographs, enduring teaching

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[35] Indeed, if an institution so chose, it could define its repository to include intellectual property assets that the institution holds, for example digital assets donated or bequeathed to an institution, even when the content was not actually created at the institution. Such digital intellectual property conservancies (IPCs) fall beyond the scope of this paper. On IPCs, see Bearman (2000).

materials, data sets and other ancillary research material, conference papers, electronic theses and dissertations,[36] and gray literature.

To control and manage the accession of this content requires appropriate policies and mechanisms, including content management and document version control systems. The repository policy framework and technical infrastructure must provide institutional managers the flexibility to control who can contribute, approve, access, and update the digital content coming from a variety of institutional communities and interest groups (including academic departments, libraries, research centers and labs, and individual authors). Several of the institutional repository infrastructure systems currently being developed have the technical capacity to embargo or sequester access to submissions until the content has been approved by a designated reviewer. The nature and extent of this review will reflect the policies and needs of each individual institution, possibly of each participating institutional community. As noted above, sometimes this review will simply validate the author's institutional affiliation and/or authorization to post materials in the repository; in other instances, the review will be more qualitative and extensive, serving as a primary certification.

Cumulative and Perpetual
Essential to the institutional repository's role both within the university and within the larger structure of scholarly communication is that the content collected is both cumulative and maintained in perpetuity. This has two implications.

First, whatever the content submission criteria for a repository, items once submitted cannot be withdrawn—except in presumably rare cases involving allegations of libel, plagiarism, copyright infringement, or "bad science." This removal would be the functional equivalent of revoking the registration initially granted to the contribution on accession into the repository.[37] This does not necessarily mean that all content will be universally accessible in perpetuity. Institutions must develop criteria and policies—and implement rights management systems—for allowing access to a repository's content, both inside the institution and from outside, that balance the goal of the broadest available access with the reality of encouraging faculty participation. The cumulative nature of institutional repositories also implies that the repository's infrastructure is scaleable. While initial processing and storage requirements might prove modest, institutional repository systems must be able to accommodate thousands of submissions per year, and eventually must be able to preserve millions of digital objects and many terabytes of data.[38]

Second, institutional repositories aim to preserve and make accessible digital content on a long-term basis. Digital preservation and long-term access are inextricably linked: each

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[36] Some governments require that electronic theses and dissertations (ETDs) be retained as a permanent record of the student's academic accomplishments and, therefore, ETDs are classed as permanent records in the governments' retention schedules. Institutional repositories can thus support compliance with these schedules. See Teper and Kraemer (2002), p. 65.

[37] In the existing journal system, which bundles registration and certification, registration is most commonly revoked by rejecting the paper for publication (that is, by denying certification).

[38] See, for example, <http://web.mit.edu/dspace/www/implementation/challenges.html>.

being largely meaningless without the other.[39] Providing long-term access to digital objects in the repository requires considerable planning and resource commitments. The institution needs to balance the desire to accept the farrago of file formats popular with various disciplines, in order to simplify content submission and encourage faculty participation, with the complications that migrating some of those formats or media might present as new standards evolve. While it is possible for an institution to dictate digital formatting standards for students—in the submission of electronic theses and dissertations, for example—prescribing such formats for faculty, for both attitudinal and practical reasons, proves far more problematic.

Interoperability and Open Access

Providing no- or low-barrier access to the intellectual product generated by the institution increases awareness of research contributions. The goals motivating an institution to create and maintain a digital repository—whether pan-institutional, as a component in the changing structure of scholarly communication, or institution-centric—require that users beyond the institution's community gain access to the content.

For the repository to provide access to the broader research community, users outside the university must be able to find and retrieve information from the repository. Therefore, institutional repository systems must be able to support interoperability in order to provide access via multiple search engines and other discovery tools. An institution does not necessarily need to implement searching and indexing functionality to satisfy this demand: it could simply maintain and expose metadata, allowing other services to harvest and search the content. This simplicity lowers the barrier to repository operation for many institutions, as it only requires a file system to hold the content and the ability to create and share metadata with external systems.[40]

Given the disparate publishing practices amongst academic disciplines, an institution's content accession and access policies need to accommodate legitimate researcher concerns about access to pre-publication material deposited in the repository. Institutional repositories typically do not permit content to be removed once submitted. However, a variety of legitimate circumstances might require an institution to limit access to particular content to a specific set of users. These circumstances might include copyright restrictions, policies established by a particular research community (limiting access to departmental working papers to members of that department, for example), embargoes that an institution's Sponsored Programs Office might require to keep the institution in compliance with the terms of sponsor contracts, and even monetary access fees for certain data. Implementing these policy-based restrictions requires robust access and rights management mechanisms to allow or restrict access to content—and, conceivably, to parts of digital objects—by a variety of criteria, including user type, institutional affiliation, user community, and others.[41]

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[39] See Teper and Kraemer (2002), p. 64.

[40] Personal communication, Herbert Van de Sompel, June 21, 2002.

[41] The Shibboleth Project (see < http://middleware.internet2.edu/shibboleth/> is addressing this cross-organizational sharing of web resources subject to access controls by developing architectures, policy structures, and practical technologies.

IMPACT OF INSTITUTIONAL REPOSITORIES ON PRINCIPAL STAKEHOLDERS

As digital publishing technologies continue to evolve, forcing a fundamental change in the structure of scholarly communication, everyone connected with the process will be affected: librarians, faculty, students and practitioners, research funding agencies, and commercial and non-commercial publishers. The nature and extent to which institutional repositories impact the major stakeholders suggest where resistance might be encountered and the manner in which such obstacles might be mitigated or overcome. Similarly, the clarity with which proponents communicate the benefits of institutional repositories to key participants will have a direct impact on the success of individual implementations.[42]

Libraries

The potential impact of institutional repositories on academic libraries occurs on both the strategic and tactical levels. Establishing an institutional repository program indicates that a library seeks to move beyond a custodial role to contribute actively to the evolution of scholarly communication. As long as traditional scholarly publishers remain part of the competitive landscape—likely for the foreseeable future—academic libraries will retain responsibility for managing and archiving traditionally-published print materials. However, as the volume of high-quality, web-based open access research expands, the role and value of the library's journal collections will decline proportionately. Library programs and budgets will have to shift to support faculty open access publishing activities in order for the library to remain relevant to this significant constituency. For libraries with an organizational imperative to invest in the future, institutional repositories offer a compelling response.

While some faculty members currently dedicate considerable time and energy to the technical aspects of delivering scholarly information, the faculty's primary role will remain as information contributors, end users, and change agents. In the long-term, organizing and maintaining digital content—as well as supporting faculty as information contributors and end users—should remain the responsibility of the library. Libraries are best-suited to provide much of the document preparation expertise (document format control, archival standards, etc.) to help authors contribute their research to the institution's repository. Similarly, libraries can most effectively provide much of the expertise in terms of metadata tagging, authority controls, and the other content management requirements that increase access to, and the usability of, the data itself.

Assuming the document management tasks that attend an institutional repository often translates into new roles for librarians—roles, one suspects, that in practice will frequently prove incremental to existing staff duties. Still, anecdotal evidence suggests that librarians may welcome these additional responsibilities, as they enhance the quality and frequency of their contact with the faculty, which in turn informs and improves their collection development decisions.[43]

If the library takes the lead in establishing and operating an institutional repository, it will also assume the critical faculty and administration outreach and education functions

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[42] For examples of how an academic community might use an institutional repository, see the use studies developed by MIT's DSpace project: <http://www.dspace.org/live/implementation/usecase.html>.

[43] E-mail communication from Eric Van de Velde of CalTech, March 22, 2002.

noted above. The leaders of virtually all current institutional repository initiatives, despite the differences between their various institutions and implementations, agree in emphasizing the importance of working closely with faculty, administrators, and other stakeholders in establishing and communicating shared goals and policies.[44]

Beyond these tactical implications, institutional repository programs promise libraries an extraordinary level of visibility within the university. As libraries move to support faculty digital publishing activities, the library's relevance to the faculty—and, consequently, the institution overall—will increase.

Faculty and Researchers
The greatest obstacle to any change in the fundamental structure of scholarly communication lies in the inertia of the traditional publishing paradigm. And nowhere is that inertia more profound—and understandable, given the professional stakes—than amongst academic faculty. Unlike trade publishing, academic authors rarely receive direct compensation for the research articles they publish. Rather, they publish for professional recognition and career advancement, as well as to contribute to scholarship in their discipline. Accommodating these faculty needs and perceptions—and demonstrating the relevance of an institutional repository in achieving them—must be central to content policies, implementation plans, and internal marketing.

Faculty perceptions—and their reactions to the changes implied by institutional repositories—will vary depending on academic discipline. At most institutions, faculty submissions will have to be voluntary or risk encountering resistance, even from faculty members who might otherwise prove supportive.[45] Understandably then, the direct benefits of participating in an institutional repository will have to be articulated clearly, emphatically, and often to engender faculty support. Additionally, institution-specific participation incentives—especially if tied to professional evaluation and advancement—will further boost faculty participation.

A key element of the faculty publishing process concerns the retention of copyright and the granting of non-exclusive licenses. Author retention of the right to self-archive, including the posting of research on open access institutional repositories, is an essential element of a reformed scholarly publishing system. Publisher resistance to authors retaining the rights to provide open access to their research is understandable—from the publisher perspective—as it challenges the publishers' monopoly. Given the importance to professional advancement of publication in prestigious journals, academic authors might think—if they consider the issue at all—that they have no choice but to capitulate to a publisher's requirements. Awareness of the copyright and self-archiving issue, and challenges to tradition, are increasing in some disciplines, but continued education on the issues will be a necessary component to any institutional repository communications program.

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[44] See Pinfield, Gardner, and MacColl (2002) and the descriptions of the DSpace (<http://web.mit.edu/dspace/www/home.html>) and ARNO (<http://cf.uba.uva.nl/en/projects/arno/>) projects.
[45] See Pinfield, Gardner, and MacColl (2002).

Institutional repository policies, practices, and expectations must also accommodate the differences in publishing practices between academic disciplines. The early adopter disciplines that developed discipline-specific digital servers were those with an established pre-publication tradition.[46] Obviously, a discipline's existing peer-to-peer communication patterns and research practices need to be considered when developing institutional repository content policies and faculty outreach programs. Scholars in disciplines with no prepublication tradition will have to be persuaded to provide a prepublication version; they might fear plagiarism or anticipate copyright or other acceptance problems in the event they were to submit the work for formal publication.[47] They might also fear the potential for criticism of work not yet benefiting from peer review and editing. For these non-preprint disciplines, a focus on capturing faculty post-publication contributions may prove a more practical initial strategy.[48] Including published material in the repository will also help overcome concerns, especially from scholars in non-preprint disciplines, that repository working papers might give a partial view of an author's research. Therefore, including published material, while raising copyright issues that need to be addressed, should lower the barrier to gaining non-preprint traditions to participate. Where authors meet traditional publisher resistance to the self-archiving rights necessary for repository posting, institutions can negotiate with those publishers to allow embargoed access to published research.[49]

While gaining the participation of faculty authors is essential to effecting an evolutionary change in the structure of scholarly publishing, early experience suggests better success when positioning the repository as a complement to, rather than as a replacement for, traditional print journals.[50] This course partially obviates the most problematic objection to open access digital publishing: that it lacks the quality and prestige of established journals. This also allows repository proponents to build a case for faculty participation based on the primary benefits that repositories deliver directly to participants, rather than relying on secondary benefits and on altruistic faculty commitment to reforming a scholarly communications model that has served them well on an individual level.

The principal author benefits of online open access publishing pertain to enhanced professional visibility. This visibility and awareness is driven by both broader dissemination and increased use. No library can afford a subscription to every possible journal—regardless of publication quality—rendering much of the research literature inaccessible to many researchers. As described above, the OAI protocols create the potential for a global network of cross-searchable research information. By design, networked open access repositories lower access barriers and offer the widest possible

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[46] For a detailed description of one such discipline, see Pinfield (2001).

[47] We will discuss below the need to be able to restrict access to some repository submissions. Even with such mechanisms in place, however, faculty resistance to such a change might be significant.

[48] See Pinfield, Gardner, and MacColl (2002). This article, reflecting the experiences of the University of Nottingham and the University of Edinburgh e-print archives, provides practical advice for motivating faculty participation. For more on faculty attitudes towards institutional repositories and self-archiving, see Bentum, Brandsma, Place, and Roes (2001).

[49] This is predicated on the assumption that the commercial value of a research article drops precipitously at some point after publication.

[50] See Pinfield, Gardner, and MacColl (2002).

dissemination of a scholar's work. Further, departmental overlay bulletins and journals can increase the visibility and status of an entire academic department, in addition to the status of its constituent faculty. Another related author benefit derives from the increased article impact that open access articles experience compared to their offline counterparts. Research has demonstrated that, with appropriate indexing and search mechanisms in place, open access online articles have appreciably higher citation rates than traditionally published articles.[51] This type of visibility and awareness bodes well for both the individual author and for the author's host institution.[52]

Additionally, value-added services such as enhanced citation indexing and name authority control will allow a more robust qualitative analysis of faculty performance where impact on one's field is a measurement. The aggregating mechanisms that enable the overall assessment of the qualitative impact of a scholar's body of work will make it easier for academic institutions to emphasize the quality, and de-emphasize the quantity, of an author's work.[53] This will weaken the quantity-driven rationale for the superfluous splintering of research into multiple publication submissions. The ability to gauge a faculty member's publishing performance on qualitative rather than quantitative terms should benefit both faculty and their host institutions.

As discussed above, institutional repositories can serve another function currently served by print journals: that of registering the priority of ideas and intellectual property. By removing the physical page constraints that pertain in print, digital publishing expands the amount of worthy research that can be made available for review. In this way, institutional repositories provide a venue for a greater proportion of researchers to register their work in a recognized forum. Another implication of removing page constraints affects faculty as readers-consumers: progress in most academic disciplines relies largely on the amount of available information. All things being equal, more prior research translates into more and better scholarship. Thus the ability to locate and retrieve more relevant research more quickly and easily online will improve scholarly communication and advance scholarly research.

Besides the benefits for faculty as authors, institutional repositories also deliver benefits to teaching faculty. By including non-ephemeral faculty-produced teaching material, the repository serves as a resource supporting classroom teaching. These materials might

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[51] See Lawrence (2001), p.521. In the case of computer science articles that Lawrence studied, online articles were cited 4.5 times more than offline articles. See also Steve Lawrence. "Free online availability substantially increases a paper's impact." *Nature: Web Debates*. Available from <http://www.nature.com/nature/debates/e-access/Articles/lawrence.html>

[52] CDL's *eScholarship* faculty repository has demonstrated this increased visibility, with citations to posted research proliferating soon after the introduction of the repository. (Roy Tennant, presentation at the SPARC-ACRL Forum, June 16, 2002.) Open access will increase awareness of research not only amongst other scholars within a discipline, but also with the media and hence a broader, public audience. Whatever one's opinion of the dangers of scientific research in the hands of the popular media, it seems clear that such media attention will increase the general popular awareness of scientific discovery and research. Further, increased media interest typically increases the public image and prestige of the contributing researchers.

[53] Developing services such as the Open Citation Project aim to provide enhanced reference linking and give authors citation and impact analysis of their work. See Hitchcock *et al.* (2000) and <http://opcit.eprints.org/>. See also Ginsparg (2001).

include concept illustrations, visualizations, models, course videos, and the like—much of the material often found on course web sites. This benefit should help extend the appeal of institutional repositories across a broader audience of research and teaching faculty.

Students
Student electronic theses and dissertations also provide logical content to be captured by institutional repositories, and to that extent, students are also author stakeholders in such repositories. However, while institutions may anticipate difficulties mandating document formats and copyright policies for their faculties, one suspects they will have no such difficulties regarding student submissions. Universities typically prescribe rigid document format requirements for graduate dissertations, and students are accustomed to adhering to them. Further, one might anticipate students to adapt to digital publishing opportunities faster and with fewer reservations than their faculty.[54]

Publishers
The open access aspect of institutional repositories threatens the existing subscription-based business models—and the attendant revenue streams—of many scholarly publishers. Both commercial publishers, trying to build shareholder value, and nonprofit scholarly societies, depending on journal revenue to help subsidize their operations, rely on subscription-based revenue streams. Understandably, such publishers feel threatened by the demand for business models that eliminate user-side fees.[55]

Commercial Publishers
As discussed above, the integrated value chain of the traditional publishing model allows publishers to maintain price levels that would be impossible to sustain in a disaggregated, less monopolistic environment. As some have noted, the nature of scholarly content renders each article and each journal a virtual monopoly, further securing the publisher's price position. Opening access to the content itself, and translating the content into a free commodity via a network of interoperable digital repositories, radically disrupts this business model. While the value-added information services outlined above—peer review, citation linking, controlled vocabularies, and the like—provide publishers with revenue generating opportunities, the competition for each disaggregated component, in the absence of a virtual content monopoly, will preclude the profit margins to which the large commercial journal publishers have become accustomed. Further, it will be difficult—strategically, financially, and psychologically—for publishers to withdraw from the current activities so central to their corporate identities, especially when a significant portion of their academic customers still prefer the traditional business model until alternatives are proven effective. The future of the commercial scholarly journals industry will depend on how publishers respond to the loss of content and channel exclusivity forced by open access repositories and to a market environment that weighs every component of the publishing value chain against analogous free services.[56]

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[54] See McMillan, Fox, and Eaton (1999) and the Networked Digital Library of These and Dissertations: < http://www.ndltd.org/ >.

[55] See Tenopir and King (2000); Evan and Wurster (1997); and Arms (2000a).

[56] See Evans and Wurster (1997) and Hitchcock *et al*. (2000).

In the early stages, it may at first appear that self-archiving—including participation in institutional repositories—will be sporadic and inconsistent, lowering the perceived threat to traditional publishers. However, for those with high fixed costs, the loss of even a small percentage of subscribers can have a dramatic impact on prices and margins.[57] It would be disingenuous to suggest that such publisher concerns are not real. Still, however disruptive the effect to existing business models, the responsibility of universities lies in generating original scholarship and disseminating knowledge, not in maintaining the market *status quo* or protecting the financial security of publishing company shareholders. In any event, the systemic inertia inherent in the traditional scholarly publishing paradigm suggests that one need not fear the precipitous collapse of commercial academic publishers. The best of them will adapt and survive under new models and will continue to perform a valuable albeit changed role in scholarly communications.

Society Publishers
Learned society publishers are for the most part far less aggressive in exploiting their monopolies than their for-profit counterparts. Even so, most society publishing programs, even in a not-for-profit context, often contribute significantly to covering an organization's operating expenses and member services. It is not surprising, then, that proposals advocating institutional repositories and other open access dissemination of scholarly research generate anxiety, if not outright resistance, amongst society publishers. While one hopes that societies adopt the broadest perspective possible in serving the needs of their members—including the broadest possible access to the scholarly research in the field—it is unlikely that societies will trade their organizations' solvency for the greater good of scholarship.[58] It is important, therefore, to review how society publishers can continue to operate in an environment of institutional repositories and other open access systems.

Some suggest that institutional repositories, pre-print servers, and electronic aggregations of individual articles will undermine the importance of the journal as a packager of articles.[59] However, institutional repositories and other open access mechanisms will only threaten the survival of scholarly journals if they defeat the brand positions of the established society journals and if individual article impact metrics replace journal impact factors in academic advancement decisions. On the first point, journal brand reputation will, for the foreseeable future, continue to be integral to the assessment of article and author quality. Market-aware journals with prominent editorial boards and well-established publishing histories should be able to maintain their prestige, even with a proliferation of article-based aggregations. As to the second point, while new metrics will evolve that demonstrate the quantitative impact of individual articles, rigorous peer review will continue to provide value. Even after individual article impact analysis

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[57] Tenopir and King maintain that, due to high fixed costs, the cost and price per academic journal subscription increases almost geometrically once a subscriber base falls below 2,500. Tenopir & King (2000), p. 36.

[58] To help non-profit publishers adapt to open access publishing, an Open Society Institute initiative is underway to fashion business plans that address the practical financial concerns of society publishers of academic journals. See <http://www.soros.org/openaccess/commitment.shtml>.

[59] See, for example, Berin (2002).

becomes widespread and accepted by academic tenure committees, stringent refereeing standards will continue to play a central role in indicating quality.[60]

Indeed, a disaggregated scholarly communications structure broadens the scope for society participation in peer review and other forms of certification. Removing the page constraints imposed by print publishing, and basing the include/exclude publishing decision on qualitative (rather than physical space) considerations, increases the amount of publishable research available overall. This larger body of publishable research that digital publishing allows requires greater system capacity to assign scholarly worth and prestige, and this potentially expands rather than eliminates the society's role in peer review. New metrics that gauge the quality and impact of an author's work will need to gain credence in tenure and other professional advancement decisions, and learned societies could prove instrumental in achieving the cultural and political change necessary for such new systems to gain acceptance.

Societies could also collaborate with libraries to develop and maintain a pan-repository author and document authority control. This personal name and corporate name authority control will be necessary to identify specific authors, irrespective of where their content might be housed. While authority control itself would logically remain with libraries, aspects of this authority control might best be served by professional societies, which could maintain supplemental author information, including current professional affiliation(s) and other relevant author data.

Learned societies have long-standing relationships with their members and they should be able to act as focal points for the research communities they represent. While society dues typically include a journal subscription, society members also enjoy other benefits of membership—and, presumably, additional value—beyond the journal subscription itself. Societies, therefore, provide community-supporting services to justify their members' dues besides the value allocated to the journal subscription. While a commercial publisher would find it difficult to charge a subscription fee for a journal freely available online, society publishers—by repositioning the benefits of membership—might well prove able to allow journal article availability via open access repositories without experiencing substantial membership cancellations or revenue attrition.

While most of our discussion has centered on publishers of academic journals, similar arguments can be made for digital publication of scholarly monographs, whether published by commercial or non-commercial publishers. The National Academy Press[61] and others have demonstrated that offering free access to a digital version of a monograph can actually help generate sales for the printed version. Other university presses might find the same to be true by allowing electronic versions of press

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[60] For example, in high-energy physics, the discipline where a pre-print archive plays the most prominent role, society journal publishers appear to have experienced no deleterious financial impact from the availability of electronic pre-prints. Indeed, the opposite seems to be the case, at least for one prominent journal. See A. Smith (1999) reporting on the experience of the American Physical Society's high-energy physics journal. One might anticipate that open access would pose even less of a threat to journals in disciplines without integral pre-publication traditions.

[61] See < http://www.nap.edu/ >.

monographs to be made available through the authors' institutional repositories. Indeed, the director of one university press has endorsed institutional repositories as a logical component in the shift from a commercial market to an open access "market of ideas" model.[62] This model recognizes that not all university presses would necessarily survive the proliferation of institutional repositories, as universities might logically consider the repositories a more efficient investment in scholarly communications than the universities' presses have traditionally been.

Government Agencies and Other Funding Sources

Given the extent of government and private philanthropic foundation funding for academic research, especially in the sciences, such funding agencies have a vested interest in broadening the dissemination of scientific research.[63] There are several mechanisms by which government and private funding agencies could help to achieve this broadened dissemination.

It has been suggested that government and foundation research grants could be written to include subsidies for author page charges and other input-side fees to support open access business models. Such stipulations would help effect change in those disciplines, primarily in the sciences, where author page charges are the norm. Obviously, such subsidies would be less effective in disciplines where input-side models bear the stigma of vanity publishing; still, over time, this resistance could be overcome.

More importantly, government agencies and foundations might be persuaded to include in their grant stipulations language requiring that funded researchers make their research results available in an open access venue to achieve the broadest possible dissemination.[64] Such a stipulation would, in effect, prevent authors from ceding copyright or granting exclusive content licenses to publishers or others. On an individual basis, faculty researchers wishing to publish their research in a prestigious scholarly journal frequently have little choice but to cede copyright and/or to accept the restrictive publication terms dictated by the publisher. However, given the volume of scientific research funded by government and private foundations, funder-mandated open access could force publishers to accept the inevitability of self-archiving and modify their standard agreements with authors to accommodate that reality.

COSTS OF INSTITUTIONAL REPOSITORIES

Institutional repository implementation projects to-date have been diverse in scope and varied in their technical execution.[65] Such disparate experiences make it difficult to formulate a universal economic model and project either development or operating budgets for new institutional repositories. Both development and operating costs can vary

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[62] See Litchfield (2002).

[63] Recent government security concerns regarding some areas of research notwithstanding.

[64] David Shulenburger, Provost of the University of Kansas, made this suggestion when proposing a national electronic article repository (NEAR) in 1998. See <http://www.arl.org/arl/proceedings/133/shulenburger.html>. Obviously, the political hurdles to such stipulations in government funding would be immense.

[65] See the Appendix: Current Institutional Repository Initiatives.

tremendously, depending on the nature and extent of the repository implementation and the budget practices of the institution. Development costs depend on the nature of the technical infrastructure implemented, the extent of in-house development assumed, and other variables. The impact on an institution's operating budget also depends on a host of ancillary technical support decisions, as well as on the institution's internal resource and cost allocation practices. Practically speaking, both development and operating costs can range from virtually no incremental costs (for institutions that reallocate resources) to hundreds of thousands of dollars (for institutions recognizing incremental systems and staff resources).

Irrespective of scope, all the institutional repository projects so far have observed that the effort and organizational costs required to address repository policy, content management, and faculty marketing issues dwarf the technical implementation effort. These tasks include:

- developing content accession policies;

- deciding on what metadata to store and present;

- creating digital document identifiers (DOIs);

- crafting author permission and licensing agreements to disseminate work indefinitely;

- developing document creation and input guidelines suitable to long term archiving and proper presentation;

- training staff and authors in using the software to submit content;

- creating document submission instructions; and

- marketing the repository concept to prospective depositors.[66]

Given relatively modest development and operating costs, many institutions will choose to self-fund a repository, covering any incremental expenses out of the library's operating budget. Libraries at larger institutions, with more ambitious implementation and operating plans, may seek additional funding from the institution or from outside sources.

Archiving Costs
The cost of preservation archiving, for any digital collection, has yet to be definitively determined. Institutions implementing repositories might decide to treat the future costs of media and format conversion and/or migration as an escrowed expense. Alternatively, they might choose to outsource the archiving/digital preservation function to a third party.[67] While it is difficult to set a cost target for such an escrow fund or reserve account in the absence of established standards and metrics, it is important to build such an estimate into a institutional repository budget, if only as a placeholder.

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[66] Email communications from Cal Tech's Eric Van de Velde, March 22, 2002 and personal communication from MIT's MacKenzie Smith, June 16, 2002.

[67] See RLG (2002).

CONCLUSION

We have set forth above the contribution that institutional repositories can make to an evolving, disaggregated scholarly publishing structure capable of addressing many of the current model's dysfunctions, as well as their potential role in enhancing recognition of work carried out at host institutions. We have also explored the change that institutional repositories will visit on key scholarly communication stakeholders, outlining the benefits that will justify those changes. We have seen that institutional repositories can provide an immediate complement to the existing scholarly publishing model, while stimulating the emergence of a new disaggregated publishing model that will evolve over time. This outcome will advance the individual and collective interests of faculty researchers, academic librarians, and institutional administrators.

Institutional repositories represent the logical convergence of faculty-driven self-archiving initiatives, library dissatisfaction with the monopolistic effects of the traditional and still-pervasive journal publishing system, and availability of digital networks and publishing technologies. The current opportunity is manifested in several ways:

- Attitudinally—Institutional repositories build on a growing grassroots faculty practice of posting research online, most often on personal web sites, but also on departmental sites or in disciplinary repositories. This demonstrates a desire for expanded exposure of, and access to, their work. Whatever the practical limitations to-date of broad faculty-driven open access publishing initiatives, faculty awareness of scholarly publishing and intellectual property issues is undeniably growing. Academic libraries can play a critical role in building this awareness through outreach programs and repository initiatives that demonstrate the practical impact of such change. While the fundamental attitudinal shift has to come from faculty themselves, libraries provide the logical institutional catalyst to effect the change.

- Economically—The burden of scholarly journal costs on academic libraries has been well documented. While the variety of institutional contexts and potential implementations make it difficult to project institutional repository development and operational costs with any precision, the evidence so far suggests that the resources required would represent but a fraction of the journal costs that libraries now incur and over which they have little control.

- Technically—Digital publishing technologies, ever-expanding global networking, and enabling interoperability protocols and metadata standards are coalescing to provide practical technical solutions that can be implemented now. Such technologies and standards will continue to evolve—possibly forever—but they are already sufficiently established to make immediate action possible.

The convergence of these interrelated strands indicates that institutional repositories merit serious and immediate consideration from academic institutions and their constituent faculty, librarians, and administrators.

Institutional repositories offer a strategic response to systemic problems in the existing scholarly journal system—and the response can be applied immediately, reaping both short-term and on-going benefits for universities and their faculty and advancing the transformation of scholarly communication over the long term. Perhaps most importantly,

they provide the academy with a powerful means with which to address the manifest problems of the current journal publishing system, without depending on journal publishers to effect fundamental changes they perceive as being inimical to their own interests.

APPENDIX: CURRENT INSTITUTIONAL REPOSITORY INITIATIVES

While many universities are pondering whether or how to implement an institutional repository, a growing number of institutions and consortia are actively engaged in setting up and running repositories. The practical experiences gained by these initiatives—organizational, technical, and legal—should prove instructive to other institutions, and the technical infrastructures that several of the projects are developing might provide turnkey systems that speed repository implementation by others. Therefore, we provide a brief overview of several of these projects below.[68]

ARNO

The Academic Research in the Netherlands Online (ARNO) project, initiated in September 2000, seeks to design and implement university digital archive servers to preserve the academic output (including research reports, pre-prints, theses and dissertations, and articles published in regular scholarly journals) of member institutions. The project's ultimate goal is to make the repository freely accessible via OAI interoperability standards. The project is being implemented by the library staffs of the University of Twente, the University of Amsterdam, and Tilburg University.

Specific project goals include:

- Connecting the document servers to international distributed digital archives and to the Dutch national information infrastructure;

- Developing an infrastructure that will couple with the production processes of scientific publishers and offer a good basis for handling peer review.

- Connecting seamlessly to digital learning environments.

The ARNO software, when finished, will be available via Open Source licensing.[69]

California Digital Library eScholarship Repository

The California Digital Library (CDL) eScholarship Repository, announced in April 2002, illustrates the continuum between digital libraries broadly conceived and institutional repositories. The CDL launched the eScholarship repository, a web site and a suite of digital support services, to distribute academic research and working papers of University of California faculty. The CDL service adopted the OAI metadata harvesting protocol in order to participate in the global network of shared repository contents.

The CDL initiative includes a suite of digital services to store and disseminate faculty research in digital formats. The CDL system uses the web-based bepress (vendor) system to manage paper submission, processing, and dissemination. Additionally, the system

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[68] We treat here initiatives that seek to implement working repositories and, therefore, do not cover other relevant digital library infrastructure initiatives that might ultimately support them. Such initiatives, including the University of Virginia-Cornell University FEDORA project, the National Library of New Zealand's Greenstone digital library software, the Dutch Roquade digital publishing support project (http://www.roquade.nl/), and the Figaro project will be covered in the forthcoming *SPARC Guide to Institutional Repositories*.

[69] See Bentum, Brandsma, Place, and Roes (2001).

also supports a topical alerting service that alerts users to new content in their specified areas of interest.[70]

DSpace
DSpace, a collaborative project of the MIT Libraries and the Hewlett-Packard Company, is creating a stable, long-term digital repository to preserve the significant body of articles and other research materials generated by MIT researchers each year. Significantly, it also seeks to build a repository system that can support a federation of institutional repositories that adopt the system. To support this goal, the DSpace project is exploring related issues including access control, rights management, versioning, retrieval, faculty receptivity, community feedback, and flexible publishing capabilities. Because of its focus on the specific requirements of the institutional repository, DSpace design and functionality is paying particular attention to the content input side of the process, which should ease and encourage author participation. The system will also be designed to integrate with third-party software, allowing it to be coupled with other components (for example, editorial workflow systems) to render a turnkey publishing system. When completed, the DSpace code will be released as Open Source.[71]

Institutional Repository E-print Implementations
Several institutions have applied the e-prints self-archiving software to implement institutional repositories. Developed at the University of Southampton, the free eprints.org self-archiving software now comes configured to run an institutional pre-prints archive. The generic version of e-prints is fully interoperable with all the OAI Metadata Harvesting Protocol.[72]

Universities that have implemented e-prints solutions include Cal Tech, the University of Nottingham,[73] University of Glasgow,[74] and the Australian National University.[75] The participants in all these programs have described their experiences, providing practical insights that should benefit others contemplating an OAI-compliant e-prints implementation.[76]

Ohio State University's Knowledge Bank
Ohio State University's Knowledge Bank provides another example of a project that addresses the objectives of an institutional repository while serving broader digital resource goals. Growing out of the University's Distance Learning/Continuing Education Committee, Knowledge Bank plans to include all of the digital assets and information services available to the OSU community, whether created by OSU constituents or not.

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[70] See <http://repositories.cdlib.org/>.

[71] See <http://www.dspace.org/live/home.html>.

[72] See <http://www.eprints.org/>.

[73] See <http://www.nottingham.ac.uk/library/eprints/>.

[74] See <http://eprints.lib.gla.ac.uk:333/>.

[75] See <http://eprints.anu.edu.au>.

[76] See Pinfield, Gardner, and MacColl (2002); Rusbridge and Nixon (2001).

The project remains in the early stages of development, but should provide a useful example for institutions interested in a comprehensive digital library program.[77]

Utrecht University
Dispute (http://dispute.library.uu.nl/), the institutional repository of Utrecht University, is slated for release by the end of 2002. An operational demonstration site is now available that describes the project's various components that will be integrated into the repository. These include a small (approximately 800 full-text articles) but fully operational repository containing a subset of all types of Utrecht publications, a sample repository from one of the university's research institutes, and a sample repository of online dissertations. The project also includes a faculty personal home page project, which the library hopes will encourage faculty participation in online posting of their research. The Utrecht repository is OAI compliant.

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[77] See <http://www.lib.ohio-state.edu/Lib_Info/scholarcom/KBproposal.html>.

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ABOUT SPARC

SPARC and SPARC Europe are coalitions of research universities and libraries supporting increased competition in scholarly publishing. Memberships currently numbers approximately 240 institutions and library consortia in North America, the U.K., Europe, Australia, New Zealand and Asia. SPARC is also affiliated with major library organizations in Canada, the U.K. and Ireland, Denmark, Australia and the USA. SPARC is located on the web at http://www.arl.org/sparc; SPARC Europe is located on the web at http://www.sparceurope.org.

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