

Chapter 2

Access to Scientific Knowledge: A Historical Perspective

Abstract The scientific communication system familiar to us today has evolved over several centuries. Journal articles became the conventional means for publishing ideas, theories, and research findings and journals became the formal “dissemination carriers.” Although learned societies played a dominant role in journal publishing at the beginning, toward the end of the twentieth century, both societies and commercial publishers controlled journal publishing, but commercial publishers became dominant players in the twenty-first century. While the subscription-based journal access model persisted overtime, issues related to restrictions imposed upon accessing scientific knowledge which is essential to the progress of science and the sustainability of this system gained attention toward the end of the twentieth century and continued to the twenty-first century. Continuously increasing scientific journal subscription rates, publishers offering package deals reducing journal selection options, and publisher merges increasing oligopolistic control of journal publishing created the “serial crisis” in which university libraries struggle to provide access of scientific journals to their academic communities. These developments, how the university communities and academic libraries reacted to the situation, and how advances in the computer and communication technologies started reshaping the entire scholarly communication landscape, opening up new horizons in the quest for seeking alternative journal publishing models are discussed.

Keywords Electronic journals • Electronic publishing • Scientific scholarly communication • Scientific societies • Commercial journal publishers • Scholarly journals • Subscription-based journal access model

2.1 Introduction

Communication is an essential facet of the pursuit and advancement of science. Scientists communicate to exchange ideas and discuss their findings with other scientists at different stages of the scientific research process; these exchanges

include both formal and informal communications. The dissemination of and access to scientific information are the two main aspects of the scientific scholarly communication process.

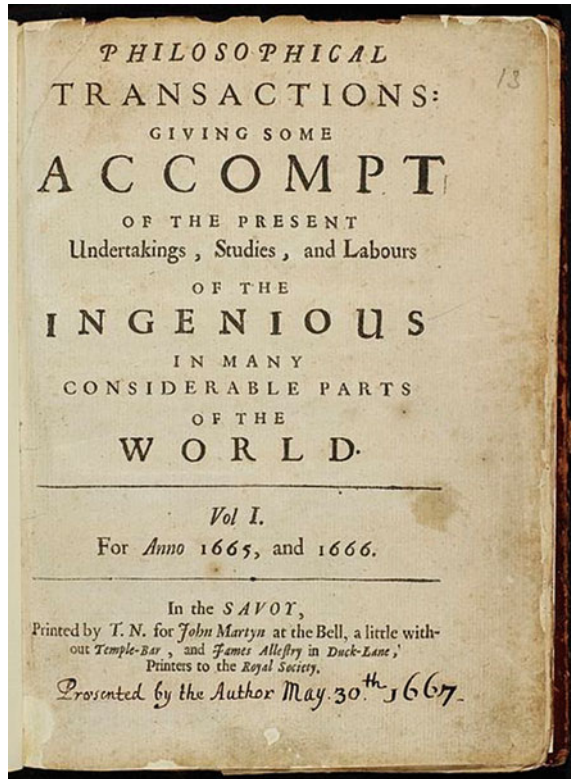
2.2 Scientific Scholarly Information Sharing: 1600–1900

The scientific communication system familiar to us today has evolved over several centuries. Paisley, in his 1972 article, discussed the role played by the informal social relationships among scientists, referred to as the “invisible college,” in transfer of scientific information during the 100 years or so after the formation of “the Royal Society for Promoting Practical Knowledge” in 1668 (Paisley 1972). The formation of scientific societies was the earliest significant juncture in the history of scientific scholarly communication. In the 1660s, the Royal Society of Science and the Paris Academy of Science were being reported as the first scientific societies created. Between 1660 and 1793, nearly 70 official scientific societies or academies were formed; these followed the model of either the Royal Society or the Paris Academy. In addition to these two major types, other societies based on the scientific institutions, such as observatories and botanical gardens thrived during this period (McClellan 1985, p. xix). These societies promoted science through a variety of institutional activities, including conferences to facilitate communication within their respective scientific communities. Over time, scientific conferences became an important channel, not only for sharing but also for reexamining findings of scientific research prior to formal publication.

Some of the early societies established the first formal scientific journals in the seventeenth century. In 1665, the Royal Society of London published the *Philosophical Transactions for the Royal Society*, the world’s first and longest-running scientific journal (Fig. 2.1) (Oldenburg 1673).

This was followed by various types of scientific and technical publications introduced by other scientific societies. There were mainly two types of scientific society publications: transactions (e.g., the *Philosophical Transactions*), which were published quarterly or trimestrally, and *Mémoires* (e.g., *Histoire et Mémoires* of the Paris Academy), which were published annually (with some lapses) and were generally restricted to members of the society. This trend continued into the eighteenth century, and both of these types of society publications were considered as primary places for the sharing of original scientific research (McClellan 1985, pp. 10–11). Although some journals originated as individual initiatives, scientific societies were the institutional centers that facilitated formal scientific communication and gave rise to scientific journals (Singleton 1981) and journal articles became the conventional means for publishing ideas, theories, and research findings. Ziman (1969) identified this as “a mechanism for the systematic publication of fragments of scientific knowledge” and described this arrangement as the “technique of soliciting many modest contributions to the vast store of human knowledge” (Ziman 1969).

Fig. 2.1 The Philosophical Transactions of The Royal Society, Vol. 1, 1665 and 1666. Story of the formal scientific scholarly communication began with this momentous publication



The prominent role played by the scientific societies in journal publishing diminished as commercial publishers entered the scientific scholarly communication arena during the nineteenth century. The goals and strengths of these two groups in the scholarly communication system may not have always been complementary. For example, commercial publishers may have more resources to promote and expand worldwide sales of journals, thereby enabling efficient dissemination of research findings. However, it can be argued that, since commercial publishers are motivated by financial reasons, they might tend to expand their enterprises regardless of the demands, needs, and affordability of the publications they provide. On the other hand, learned societies might be more interested in maintaining the standard of their publications and promoting their subject disciplines rather than increasing their profit margins. However, since the learned societies promote their specific disciplines, they might not be responsive to the needs of emerging interdisciplinary specializations. In addition, limitations in resources and manpower needed to market their publications can also limit the growth of the scholarly communication system (Singleton 1981).

2.3 Scholarly Communication Developments in the Twentieth and Twenty-First Centuries

As the scholarly communication system was evolving during the eighteenth and nineteenth centuries, a steady journal growth was observed. Based on the scientific journal data from the 1650 to 1950 period, de Solla Price and Page (1961) reported the number of scientific papers published annually doubled every 10–15 years (de Solla Price and Page 1961). The journal growth in the twentieth century was influenced by a variety of external factors. In the first four decades of the century, funding for scientific research was mainly from governments, and the scholarly communication system was controlled by the scientific societies even though there were some commercial players (Mabe and Amin 2001). Due to geopolitical events such as the expansion of nuclear weapon development and the space race, the next few decades saw an increase in research funding for science and technology fields by the governments of many developed countries, resulting in a high rate of growth in scientific research worldwide. There was an upsurge in publication of scientific scholarly articles after World War II. Taking scholarly output of mathematics as an example, Odlyzko (1995) estimated the number of published articles doubled about every 10 years from the end of World War II until 1990 (Odlyzko 1995).

The scholarly communication system at this particular juncture moved to a mixed model controlled by both societies and commercial publishers (Mabe and Amin 2001) (Craig et al. 2007). The rapid growth phase of journal titles was followed by slower growth after the 1970s, especially in general and physical science, and in technology fields (Mabe and Amin 2001) (Archibald and Line 1991). Even under a different geo-social environment in the twentieth century, a compounded annual journal increase of 3.3% was observed (Mabe and Amin 2001). However, according to another study, the number of journal titles as well as the number of articles in each journal declined during the period 1980–1987 (Archibald and Line 1991). Meanwhile, the journal publishing market continued with ownership by both commercial enterprises and scientific societies. Singleton (1981) discussed the perceived and actual roles of societies and others in journal publishing and showed a substantial amount of cooperation between these sectors (Singleton 1981).

The scholarly communication system evolved to become a more formalized journal publishing structure by adding complementary abstracting and indexing tools, as well as other services. This system was accepted as the fastest, convenient, and trusted way to disseminate and access scientific research findings. The scholarly communication system based on journal access by subscription-based model progressed and persisted. However, concerns about the restrictions imposed on the sharing and access to scientific knowledge and the sustainability of this system started gaining attention towards the end of the twentieth century and the debate continued into the twenty-first century. Meanwhile, revolutions in information

technology, developments in higher education and scientific research communities, and the growth, modifications, and challenges in the publishing sector continued to shape the scholarly communication landscape in the first decade of the twenty-first century.

2.4 Journal Subscription Debates

In the 1970s and 1980s, as the cost of journal subscriptions was rising, the economics of journal publishing became an important topic of discussion. According to Cummings et al. (1992), scientific and technical journal subscription prices increased at an average rate of 13.5% per year from 1970 to 1990, exceeding the rate of inflation. The factors for this increase, according to the authors, were the high production cost of scientific journals; the higher subscription rates charged by commercial publishers; the increase in new specialized journal titles which tend to have smaller subscription bases at the inception; and the concentration of science journals within a few publishers (Cummings et al. 1992). According to the annual Periodicals Price Survey in 1997, 13 scientific, technical and medical (STM) fields (physics, chemistry, astronomy, biology, math and computer science, engineering, technology, geology, botany, zoology, health science, food science) had the highest subscription prices. These same 13 disciplines, with minor changes, topped the subscription pricing ladder for the eight years of data available (Ketcham and Born 1997). A subscription price increase of more than 40% was observed in these fields (except astronomy) during 1993–1994. Because of increasing science journal subscription prices, the dwindling budgets of research libraries were not able to retain their purchasing power: they were forced to allocate larger portions of their acquisitions budgets into science journal subscriptions, resulting in cancelation of some journal titles and reduction in monograph purchasing.

The scholarly communication system underwent an unprecedented transformation during the last decade of the twentieth century. One of the major factors in this transformation was the developments in information technologies, resulting in the emergence of electronic journals (e-journals) in the mid-1990s. In 1995, the Association of Research Libraries' Directory of Electronic Journals listed 139 peer-reviewed e-journals, but only 9% charged a subscription fee, with the highest rates in the scientific and medical fields (Van Orsdel and Born 1996). The percentage of e-journals in the Science Citation Index was 24% by 1997 (Van Orsdel and Born 1997) and, persuaded by authors, the larger STM journal publishers began to invest heavily in technology. Some publishers, including Blackwell Science, MCB University Press, and Taylor and Francis (T&F) experimented with different access models, such as providing user gateways for their journal products instead of using the traditional system. Meanwhile, publisher mergers continued to reduce competition, which was not encouraging news for libraries faced with shrinking budget situations and increasing demands to provide access to scholarly information to their academic and research communities.

To exert pressure on commercial publishers and shape the scholarly communication marketplace, libraries, universities, and learned societies experimented with alternative measures. The Scholarly Publishing and Academic Resources Coalition (SPARC), founded by the Association of Research Libraries, created a fund to support nonprofit scholarly publishing and initiated several scientific e-journals (Van Orsdel and Born 1999). The HighWire Press, started by Stanford University Library in the mid-1990s, introduced an e-publishing platform to help societies with electronic journal publishing; they had early success with publishing high-quality STM journals and expanding the market within and outside the United States (Van Orsdel and Born 1999). Another attempt by learned societies, universities, and government research organizations was to start creating databases with features appreciated by scholars (such as linking journals and scholarly papers) and offer them at a much lower price than commercial publishers. These competitive efforts by the nonprofit players and the demand for better deals forced successful STM publishers to provide more value-added products. In late 1999, 12 STM publishers—John Wiley and Academic Press, American Association for the Advancement of Science, American Institute of Physics, Association for Computing Machinery, Blackwell Science, Elsevier, IEEE, Kluwer, *Nature*, Oxford University Press, and Springer-Verlag—collaborated with each other to link citations to full-text articles across their collections (Van Orsdel and Born 2000).

Amidst these developments, the high-cost of journal subscriptions continued (Fig. 2.2), compelling libraries to cancel print journal subscriptions and divert that money to accessing e-journals and related products (Van Orsdel and Born 1999). In addition, journal publishers started offering package deals. The continued concentration of scientific publishing among a limited number of publishers was a concern for consumers of scientific information. The dominating

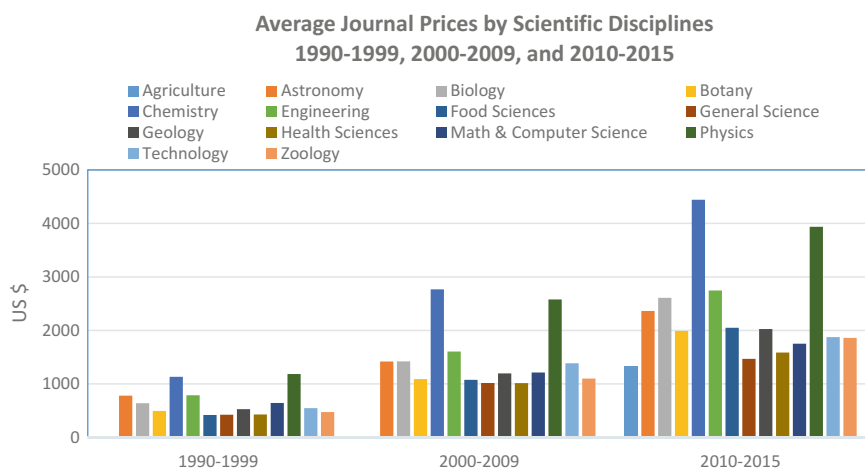


Fig. 2.2 The rise of average journal prices by Scientific Discipline from 1990–2015. Data source “Periodicals price surveys” from 1990–2015 published by the *Library Journal*

commercial STM journal publishers in 2006 were Elsevier, Wiley, Springer, T&F, Kluwer Medical, Thomson, and Blackwell (Van Orsdel and Born 2007). By 2011, half of the journal titles were from five major commercial publishers—Elsevier, Wiley, Springer, T&F, and SAGE—and all of them offered “Big Deal” journal packages in which cost increases were dictated by contracts (Bosch and Henderson 2012). Dissatisfied with the journal package deals offered by commercial publishers, high-profile university libraries spoke on behalf of many institutions about their intention to reject package deals and instead to choose journals, title by title, the way it was done traditionally, meeting the needs of their academic communities in a cost effective manner (Mayor 2004).

With the introduction of e-journals, the article acquisition system appeared to change to article-by-article acquisition or “Pay-Per-View” (PPV) as an alternative to subscribing to an entire journal (Bosch and Henderson 2012). However, the oligopoly of the commercial publishers continued even in the e-journal environment. By examining nearly 4.5 million of all document types published by various journals between 1973–2013 period, Larivière et al. (2015) reported that, in natural and medical sciences, Reed-Elsevier, Wiley-Blackwell, Springer, and T&F together with the American Chemical Society were the top five publishers with the highest number of scientific documents in 2013. A striking drop was observed in the percentage of articles and number of journal titles published by publishers *other* than the major ones (Larivière et al. 2015).

2.5 Concluding Remarks

Even though the traditional journal subscription model was a convenient method to deliver content in the print environment, its economic sustainability was being questioned. More importantly restrictions imposed by high subscription rates of scientific journals and other practices used by journal publishers for accessing research findings have become major concerns. The technological advances and entry of e-journals offered the potential to rethink the entire scholarly communication system. Against this backdrop, the exploration for alternative journal publishing models that promote unrestricted access to scientific knowledge began.

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