"Digital Object Identifier: Privatising Knowledge Governance through Infrastructuring"

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Abstract

This chapter uses what has become arguably the most ubiquitous piece of thinking infrastructure, the Digital Object Identifier (DOI), as a point of entry to explore the infrastructuring of hegemonic power in knowledge circulation. The chapter opens with a technical explanation of the DOI, followed by a brief history of the formation of the organizations that undergird the DOI. Along with the other metric devices, emerging "norms" and narratives about the DOI further reinforce its centrality and we spend time debunking these myths. We close by exploring and making visible the relational work that the DOI performs to enable and shape the development of surveillance publishing, a dominant mode of profit and cognitive extraction in the higher education and research market.

Introduction

This chapter contributes to analyses of the geopolitics of global knowledge circulation through an infrastructural lens. We approach this work from a shared interest in growing inequities in knowledge production and the historical structure and contemporary mechanisms by which such deep asymmetries are reproduced and reconfigured, which we have been exploring together over the last decade (Okune et al., 2016; Chan et al., 2019; Albornoz et al., 2020). Knowledge circulation relies on an assemblage of socio-technical practices that are embedded within complex and layered infrastructures. The study of the circulation of academic knowledge would be incomplete without looking at the underlying socio-technical infrastructures that create the "conditions of possibility" for certification, circulation, access and uptake. With the global rush

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for capturing big data for predictive analytics, the complexity of infrastructures continues to grow and new technological elements and a diversity of state and non-state players are continually added to the mix. This expanding infrastructure includes large-scale and longitudinal scientific datasets, research analytics services, apps for research, data dashboards, publishing platforms powered by artificial intelligence and much more.

With these growing complexities, scholars of infrastructures have been refining and rethinking their analytic tools. While the notion of "knowledge infrastructure" as "robust networks of people, artifacts, and institutions that generate, share, and maintain specific knowledge about the human and natural worlds" (Edwards, 2010) has served us well, Kornberger, Bowker and colleagues recently introduced the idea of "thinking infrastructure" to encompass "a broad range of phenomena that structure attention, shape decision-making and guide cognition such as rankings, ratings and algorithms" (Kornberger et al., 2019: 1).

In the case of knowledge infrastructure, Kornberger and colleagues argue, the roles of the producers and consumers of knowledge are relatively clear. But "thinking infrastructures are apparatuses in which distributed agency and cognition are cojoined, held together, reinforced and (re)directed" (ibid.: 6) so that the boundaries and relationship among technologies, social players and knowledge practices have become blurred and comingled.

This formulation is particularly relevant for the analysis of the audit and metric-driven culture of the contemporary academy and the growing influence of "platform capitalism" (Srnicek 2017) and "surveillance publishing" (Pooley, 2022; Lamdan, 2022), both predicated on the massive and incessant extractions of users (researchers), research data and behavioural traces by the platform builders to generate "means of behavioral modification" (Zuboff, 2019: 19). These traces, both behavioural and digital, are linked through massive connections of data points gathered from multiple sources, including scientific data sets, publications, citation metrics, conference participation, grant funding data, researcher profiles, social media and many other unrelated sources. New kinds of data analytics and "research intelligence" products are then derived from the raw data to further increase the valuation of the enriched data and associated products, such as citation metrics and rankings. And the more "value" these products accrue, the more they are

sought after, creating a kind of fictitious value chain and market demand for yet more data to fuel new product development (Roosendaal et al, 2002; Kaplinsky, 2000; Williams, 2017; Wainwright & Bervejillo, 2021).

This chapter contributes to a growing body of work looking at the complex socio-technical assemblage of "thinking infrastructure" that includes monographs and journals, Journal Impact Factors, H-Index, citation metrics, Article Processing Charges and Global University Rankings (Burrows, 2012; Williamson, 2019; Biagioli & Lippman, 2020; Chen & Chan, 2021; Maddi & Sapinho, 2022; Stack, 2021), among others. These components are tightly "cojoined" and mutually reinforcing devices that animate institutional competition and the corresponding compliance with metrics (Barron, 2021). What these devices have in common is that they are mostly instruments owned by multinational corporate entities, which are often a hybrid of private equity firms, information conglomerates, data analytic companies and multinational publishing houses (Lamdan, 2022). Transforming themselves from oligarch publishing houses to "data cartels" through mergers, acquisition and vertical integration (Chen et al., 2019; Chen & Chan, 2021), these extractive entities are busy creating thinking infrastructure across space and, in the process, they are also transforming the missions of higher education to align with the logics of a capitalist market and corporate agendas.

The "distributed agency" of thinking infrastructure also speaks to its globally diffused, spatial and geopolitical power. "Infrastructural space" is always "doing something," according to Keller Easterling: "Like an operating system, the medium of infrastructure space makes certain things possible and other things impossible. It is not the declared content but rather the content manager dictating the rules of the game" (2014: 14). Thus, the study of knowledge circulation demands that we ask who the "knowledge managers" are, what rules they make, how these rules create compliance for the "users" and to what end. These questions underscore that thinking infrastructures are neither passive nor neutral but rather active agents that perform and direct many tasks, often relational in nature. This is in keeping with the "infrastructuring turn" in Science and Technology Studies (Anand et al., 2018; Singh & Jackson, 2021), where infrastructure is understood as being in a constant state of change and never static. Thus, the study of knowledge circulation must also take into consideration that infrastructural designs are

rather dependent on historical contingency, uncertainties, timing, lucky circumstances and pre-existing advantages.

Our Approach

This chapter uses what has become arguably the most ubiquitous piece of thinking infrastructure, the Digital Object Identifier (DOI), as a point of entry to explore the infrastructuring of hegemonic power in knowledge circulation. We first provide a technical explanation of the DOI, followed by a brief history of the formation of the organisations that undergird it, and then we briefly explore how it grows its influence and distributed agency. To understand the design of a technology, one needs to also understand the organisations that shape them and their rationale for building the technology. It is important to also understand the relational infrastructures that enabled its adoption and dominant usage, how the agent that created the digital object gains and maintains power and how that power serves to further entrench structural inequities in knowledge production. For this reason, we will also be looking at Crossref, an organisation set up by the International DOI Foundation to promote cross-publishers' linking services, built on the DOI system. Along with other tracking and tracing devices, emerging "norms" and "best practices" like the FAIR data principles, which calls for data to be Findable, Accessible, Interoperable and Reusable (Wilkinson et al., 2016) further reinforce the centrality of the DOI and the concentration of control by the already dominant players: legacy multinational publishers. In the remainder of the chapter, we explore and make visible the relational work that the DOI performs to enable and shape the development of surveillance publishing, a dominant mode of profit and cognitive extraction in the higher education and research market.

What Is the Digital Object Identifier (DOI)?

Digital Object Identifier (DOI) is a unique alphanumeric string that provides a specific link to content online. Unlike common web resources located by a Uniform Resource Locator (URL or, in simple terms, web address), which are often unstable due to change of websites or migration, each DOI is uniquely attached to a specific digital object and associated metadata. Hence, the DOI is supposed to be never changing and, therefore, persistent. DOIs are most commonly assigned to journal articles and books by publishers but are also assigned to a variety of online

resources such as data sets and other digital research objects. They are commonly found in journal article reference lists, and most common citation styles such as the APA and MLA now require the inclusion of DOI in citations.

While the widely perceived advantages of DOIs include the ease of locating a particular reference source and long-term permanence, these advantages are not unique to them. In fact, they are one of a handful of persistent identifier schemes which can be cited to retrieve digital objects. Such identifiers enable resources to be accurately identified by reconciling a publicly visible identification to the current address of the metadata or content in a catalogue or digital repository even when its location changes over time. See Figure 22.1 for an example of the structure of such persistent identifiers.

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https://n2t.net/ark:/99999/12345
  https://doi.org/10.99999/12345
https://handle.net/10.99999/12345
    https://purl.org/99999/12345
https://<various>/urn:99999:12345
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1. the protocol (`https://`) plus a hostname,
2. just for ARK and URN, there's also a label ("ark:" or "urn:"),
3. the name assigning authority (99999, 10.99999, or 99999), which is the organization or group that created a particular identifier,
4. and finally, the *name*, or local identifier, that it assigned (12345).

Figure 22.1 Examples of the major persistent identifier types.

Source: Comparing ARKs, DOIs and other identifier systems. *ARK Alliance*.
https://arks.org/about/comparing-arks-and-other-identifiers/

All DOI numbers begin with a 10 and contain a prefix and a suffix separated by a slash. The prefix is a unique number of four or more digits assigned to organisations such as publishers or government agencies; the suffix is assigned by the publisher and was designed to be flexible with publisher identification standards. While linking to an online publication by its DOI provides a more stable link than a regular URL, the publisher must update the metadata for the DOI if the link to the URL changes. Failing to update the DOI database will lead the DOI to a dead link, rendering it useless.

The DOI and Organisations behind It

A key node in the digital infrastructure for academic publishing and research object management, the DOI is assumed by many to provide a neutral service for scholarly communications, a stable and Persistent Identifier (PID) for ensuring the permanence of scholarship and the ease of citation linking. And yet, this global standard, certified by the International Organization for Standardization (ISO) in 2012, is in fact controlled by some of the most powerful legacy publishers and has helped them continue to remain in control and expand their influence in the production and circulation of academic knowledge. In this section, we sketch a brief history of the emergence of the DOI and shed light on the invisibilised organisations behind it.

Around the same time as the early open knowledge movements were gaining momentum, in the late 1990s, the Euro-American publishing industry articulated a need to uniquely and unambiguously identify content on the newly emerging web. According to a rather candid pamphlet published by Crossref on the early history of the organisation, the International Association of Scientific, Technical and Medical (STM) Publishers was alarmed by a new proposal by Harold Varmus of the National Institute of Health in 1999 for an open repository of all published biomedical articles called E-Biomed, which later became PubMedCentral. The original proposal calls for scientists to submit both preprints and published articles from journals into an open access repository that also provides reference linking. To pre-emptively take control and ownership of reference linking, the STM Association quickly announced the formation of a new linking initiative, later called Crossref. According to the document, at the time "it was, of course, a strategic move only, since we had neither plan nor prototype," (Crossref, 2009: 8).

The DOI was thus established by the leading commercial publishers of the time to better identify the rights holder of an object, especially in a context of exponential digital networks growth and increased digital sharing of online content (Paskin, 2015). As one of the Association of American Publishers (AAP) committee members Rosenblatt wrote in 1997 in *The Journal of Electronic Publishing*:

> At a minimum, the DOI helps ensure that publishers will dance to the same rhythm. […] Adopting electronic-publishing solutions based on common open

standards increases the likelihood that publishers' capital investments will pay off. It helps ensure that publishers will be able to extend their franchises into cyberspace, where much of the world of information is surely going.

In 1998, the International DOI Foundation was formally incorporated to develop and govern the new system. The lead of the organisation was recruited from his position as director of IT at Elsevier and the board of the foundation included representatives from major tech companies and publishers such as Microsoft, Elsevier and John Wiley and Sons (Davidson & Douglas, 1998).

The most widely known application of the DOI system is the Crossref cross-publisher citation linking service which allows a researcher to link from a reference citation directly to the cited content on another publisher's platform, subject to the target publisher's access control practices. Crossref, registered in New York in 2000, is a key part of the DOI success story. With a mission to make research outputs easy to find, cite, link, assess and reuse, it has been influential in increasing and promoting the widespread adoption and assignment of DOIs (as opposed to other PIDs). It has provided an important cover of "community" that has been vocal in advocating and promoting particular practices (such as FAIR) and technologies (like the DOI). A closer look at the composition of leaders reveals that despite the new rhetoric, founders and key actors in Crossref have or have had ties to the same dominant publishers.

Emphasising the backing of the major dominant publishers that enabled the successful growth of Crossref, a pamphlet quoted Karen Hunter of Elsevier, a founding member of the International DOI Foundation Board: "There really wasn't any question about it working, because all the big players were in at the start" (CrossRef, 2009: 15).

DOI as de Facto Standard

Thanks in part to the momentum and promotion by groups like Crossref, in 2012, the DOI system was adopted as International Standard ISO 26324 and gained power as an international standard to govern the identification and management of content (physical, digital or abstract entities) on digital networks. The uptake of the DOI as an international standard was not necessarily due to its technical advantages over other similar permanent identifiers systems.

Rather, it attests to the market power and political resources available to the publishing conglomerate in lobbying for endorsement of their technical object at the international level. Almost as soon as the DOI was introduced, some DOI users were already critiquing that the whole system was redundant:

> if the publishers could just figure out how to use URIs properly, we wouldn't have to deal with this whole separate DOI thing. Some people complain that URLs change, but the existence of the DOI system is proof that people are willing to commit to stable identifiers. So just use those stable identifiers in your URIs – problem solved. (surrealize, 2010)

Here, key to a critical understanding of the function of a DOI in maintaining publisher control is that the DOI is designed to point to the publisher's version of the article as it appeared in final published form, generally referred to as the "Version of Record" (VoR). The VoR is an organising concept in scholarly publishing and creates an object of financial models, policies and recognition and reward systems (Hinchliffe, 2022). A major advantage of the DOI for publishers then is that it makes the tracking of citations easy, particularly for counting and for quantification of usage. To track citations, publishers must be able to maintain control over the scholarly record by specifying what counts and how what counts can accrue value for authors. The DOI, therefore, leverages and reinforces the deep dependence of researchers on citation as a key currency in the academic reward and exchange system, promising reliability and trust in pointing readers to the VoR, while at the same time reinforcing the VoR as the version to be cited.

If the technology is designed to reproduce the centralised power of dominant commercial publishers, the organisational relational infrastructure that has enabled its dominance is also important to bring to light. To assign a DOI to academic work requires going through a "registration agency" which uses the policies and common infrastructure provided by the International DOI Foundation, which continues to control the system itself. To become a registration agency, one must meet the contractual obligations of the DOI system and be willing and able to pay a sizable annual fee to become a member of the system (Davidson & Douglas, 1998). Not surprisingly therefore, many of the DOI Foundation members are some of the largest power brokers of the publishing world. The first general member listed on the DOI website for example, is R.R. Bowker, which has been in publishing since 1872 (Bowker History &

Milestones, 2022) and is the official source for International Standard Book Numbers (ISBNs) in the USA, which uniquely identify books and facilitate the sale of books. As mentioned earlier, the most widely known registration agency is Crossref. Despite its corporate origin, Crossref has become so deeply embedded as a non-profit service within the open scholarship space that it has come to be regarded as a core player in the digital publishing infrastructure and was awarded the Association of Learned and Professional Society Publishers (ALPSP) Award for Contribution to Scholarly Publishing in 2012.

The strong and concerted push by the DOI Foundation for the DOI to serve as the de facto permanent identifying standard for digital scholarly objects and for citation linking is paying significant dividends. Far from being disrupted, the legacy publishers – using the infrastructure they have built around their products to maintain their copyright and intellectual property – are reporting record profits (Buranyi, 2017; Pooley, 2022), benefiting from both "closed" and "open" publishing. By nimbly morphing their businesses towards building or acquiring thinking infrastructures to take advantage of the big data bonanza, these publishers have been able to co-opt the rhetoric of "openness" to further their market control, massive profit extraction (Butler et al., 2022; Zhang et al., 2022) and, above all, the governance of knowledge production and academic labour. By promoting and leveraging the purported citational advantage of open access (Langham-Putrow et al., 2021) and the ethos of open science of sharing data as openly as possible as eschewed by the FAIR data principles (Koers et al., 2020), these same organisations have benefited enormously from the volume and diversity of data from the research production of individuals and institutions from around the world. On the one hand, these companies have the resources to build tools and infrastructures to take advantage of all the open data. At the same time, they are completely opaque about how they in turn use this open information to control and govern researchers and drive their behaviour. It is indeed a highly asymmetrical system but researchers are often willing to enter into the bargain because they are not aware of the many hidden costs.

Common Misconceptions and the Real Costs of DOIs

As the case of the DOI reveals, "openness" has empowered the already powerful in the surveillance economy. Our chapter is a case study of this mostly unseen process. The chapter opened by describing how the technical design of the DOI helps to further a quantification of citations and academic outputs, for example, by linking to a publisher-controlled VoR. Along with the other metric devices based on citation counts, emerging "norms" and narratives about the DOI further reinforce its centrality. In this section, we debunk three commonly held assumptions heard from academic colleagues about what a DOI is to better reveal the hidden social costs associated with the implementation of the DOI.

Misconceptions

There is an assumption that if a scholarly object has a DOI assigned, then it is a proxy of quality or at least a valid scholarly object. This assumes some sort of scholarly review mechanism for a piece of work to be assigned a DOI, which is not necessarily true. As many so-called predatory journals are able to assign DOIs as long as they are able to pay for them. Another common assumption about a DOI is that unless an object has a DOI, it is not truly open access. This, too, is incorrect since DOIs can be assigned to both paywalled work as well as work that is freely and openly accessible. Finally, a third assumption is that DOIs are reliable and stable. This is not only an assumption but a marketed core functionality of the product. The value addition of a unique identifier is that even if servers change, the same link should continue to take you to the targeted material. This, unfortunately, does not always hold up. Sometimes there is a coding or an editing error. Or sometimes, one has failed to pay the necessary fees to stay active.

Consequences

It is assumed that scholarly objects with a DOI are of higher quality, open access and more stable than those without it. But in fact, the DOI as the de facto persistent identifier standard has led to many small organisations located in historically marginalised sites being prevented from contributing or/and having their work circulate widely. Given the fees associated with the assignment of DOIs and their subsequent tracking, many small independent publishers, particularly those based in the Global South, are prohibited from assigning DOIs to their publications because of the associated cost. But without a DOI, their work is then often bypassed

by indexing services because many of the most popular scholarly indices only index objects with a DOI. A large body of scholarship from many parts of the world, whether open access or not, is then made invisible as the result of the prioritisation of DOI as the de facto persistent identifier standard.

Establishing the DOI as the de facto standard for permanently identifying scholarly objects has led to growing network effects, resulting in lock-ins for researchers, pushing out independent alternatives and creating new forms of exclusion by adding a layer of enclosure on top of the open web. Permanent digital identifiers are important for the sharing and circulation of scholarly digital objects. However, the positioning of the DOI as the de facto standard for digital scholarly objects is worrying in its centralisation rather than decentralising of scholarly infrastructure. Such centralisation of power is particularly important to pay attention to when led by well-established dominant players in the publishing and now digital publishing sector.

Concluding Thoughts

In this chapter, we have sought to shed light on the case of the DOI as one part of a complex socio-technical assemblage of "thinking infrastructure". The DOI is but one of many important cases to study among a host of other new technical objects, such as Open Researcher and Contributor ID (ORCID), which is a digital ID for researchers, and new scholarly impact factor metrics ("altmetrics"), which form a socio-technical assemblage that shapes how scholarship is practiced within a so-called open environment. We are concerned that, unbeknownst to many scholars, many of these instruments are owned by multinational corporate entities, which are often a hybrid of private equity firms, information conglomerates, data analytic companies and multinational publishing houses (Lamdan, 2022).

The Open Access movement was founded on the understanding that with the advent of network technologies, there was a real opportunity to disrupt the status quo of scientific knowledge production and share and produce knowledge differently. Many alternatives have emerged in the decades that have followed, including preprint repositories and open peer review as well as post-prints and post-publication reviews.

We are encouraged by ongoing developments in open infrastructure that are reaching for alternatives. As a start, many organisations are committing to the Principles of Open Scholarly Infrastructure (POSI) (Bilder at al., 2020) and assessing their organisations and infrastructural design against the Next Generation Library Publishing's FOREST Framework (Lippincott & Skinner, 2022). More groups are explicitly articulating design logics that undergird their projects, communities and infrastructures, such as the Design Justice principles (2018), Feminist Data principles (Cifor et al., 2019) and the CARE Principles for Indigenous Data Governance (2019). We are especially eager to see new scholar-led infrastructuring projects that are actively working to build alternatives to corporate-led systems. The *Engaging Science, Technology, and Society* journal (Khandekar et al., 2022), for example, has begun experimenting with open ethnographic data publishing infrastructure on the Platform for Experimental Collaborative Ethnography (Khandekar et al., 2021) and there are important, long-standing efforts by the Humanities Commons community (Humanities Commons, 2022; U of T Digital Humanities Network, 2022) and Mukurtu (Mukurtu, n.d.; Christen, 2011), among others.

As we have explored in this chapter, by linking to a publisher-controlled VoR, the technical design of the DOI helps to consolidate the control of dominant publishing organisations and extend the growing quantification of citations and academic outputs. Along with other metric devices, emerging norms and narratives about the DOI further reinforce its centrality while consolidating the power of the surveillance economy. If multiple versions of scholarly outputs proliferate, publishers will lose control of their authority. But, if scholars develop systems to keep instead a "Record of Versions" (Bosman, 2016; Bosman & Kramer, 2016), preserving the genealogy of discussion and layering of new ideas being developed, such multiplicity of versions can deepen scholarly dialogue and encourage new collaborative knowledge-making. Instead of centring technical development around the DOI, we see productive lines of inquiry and development around developing new systems that allow for a dynamic versioning of scholarly outputs in a distributed way.

There is much work to be done to build and test out what constitutes community-led and open thinking infrastructure. When looking at knowledge circulation, we suggest that it is critical to turn our gaze on all components of our infrastructure including the standards, organisations and

social norms which shape and are shaped by the technology layers. There is an urgent need for actions to be coordinated across organisations with shared struggles and shared values. And, above all, the governance of these technologies needs to be interrogated to ensure alignment with the values of the community.

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