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Editorial: Technology-dependent commons: the radio spectrum

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Things owned in common – or jointly – as the case may be, abound. They abound today as they did in earlier times, in urban as well as in rural settings, and in high tech artefacts like Wikipedia as well as in traditional symbols. Usually such commonly held goods do not create any noteworthy problems for those who share an interest in them. But in some cases they do represent an intrinsically difficult situation for stakeholders: their governance and the distribution of benefits begin to pose a social dilemma. Unless the stakeholders find ways of overcoming the problems, the resource will stop yielding benefits. Such dilemmas appear in cases where the resource is subtractable (one appropriator's benefits diminish the benefits available for other appropriators), and where it is difficult or impossible to exclude any particular appropriator. Elinor Ostrom used traditional commons in irrigation water, pasture, and forestry to study how communities were able to overcome such dilemmas, in part through the creation of appropriate institutions for resource management. She suggested eight design principles that could assist in constructing such management institutions (Ostrom 1990, 2005).

Technology did not enter into Ostrom's principles. Yet it is clear today that technological developments often alter the conditions of exploitation of resources, necessitating changes in management strategies, even though it is not always clear which strategies offer the best solution. Technology has, for example, changed fishing practices to such an extent that a dilemma of global depletion of fish stocks, not present a century ago, has now become a pressing concern. Moreover, technology creates new resources, or allows existing resources to be used in quite

new ways. In many cases, technology-based resources also exhibit the properties of subtractability and accessibility that can lead to social dilemmas.

Commons scholars thus need to focus more attention on technology-dependent commons. It is important to understand how, in many cases, enduring use of technology-based resources has been achieved on an ever-larger geographical scale, with a growing number and variety of appropriators, and growing intensity of use. Does the governance of such resources follow models that have been observed in more traditional commons? And have the challenges of managing them – with their continual, rapid evolution and international or global reach – offered lessons that might be applied in other contexts?

In the current mini-feature, we present two articles that trace the evolution of transnational management institutions for the use of radio frequencies in Europe for broadcasting. The radio frequency spectrum is a classic example of a technology-dependent commons, and together, these articles lay foundations for a broader, more theoretically and historically informed understanding of this resource, its peculiarities, and its shifting systems of technology and governance. The articles span the period from the origins of radio, around 1900 to about 1970.

Our two authors both identify the radio frequency spectrum as a common pool resource (Ostrom and Ostrom 1977), in the sense that Europe's division into many small countries made public control of radio transmitters difficult beyond the jurisdiction of individual states. As long as there were no restrictions on the establishment of transmitters, the ether was an open access communication resource subject to overcrowding, a phenomenon that came to be known as "chaos in the ether." Chaos ensued when two or more transmitters operating on the same frequency (wavelength), close enough together in space, created interference, making communication impossible. And since interference ignored borders, the only way to manage this problem in the European context was through international agreements. Yet how were these agreements achieved and structured? And who regulated the system on an international level, and with what degree of success?

In the first study, Nina Wormbs analyzes the initial shift of the radio spectrum in Europe from a strictly open-access resource (lacking rules and restrictions) to a managed commons based on an international system that allocated frequencies to nations. Wormbs demonstrates that this international governance system conformed to Ostrom's eight design principles. Wormbs also explores the important ways in which technology figured in this management system. The second article, by Christian Henrik-Franke, focuses on European radio spectrum governance in the Cold War era, between 1950 and 1970. His major aim is to show how this voluntary system, which linked European states on both sides of the Iron Curtain, managed to survive in the face of profound, enduring political tensions. His analysis gives particular attention to the mix of property rights it implemented, the system's flexibility, and how these features helped to contain the political tensions that accompanied broadcasting across the Iron Curtain.

Several common themes and conclusions emerge from the two articles. Both find evidence that social networks and cultures of professional, technical cooperation helped maintain the viability of international radio spectrum management even though the governance systems included no power to impose penalties on violators, beyond moral suasion. Both also show that technologies played important roles in overcoming resource management problems. Wormbs shows, for example, that development of more stable transmitters helped minimize interference and permitted more intensive exploitation of the spectrum. Technology also performed surveillance functions, in particular for monitoring users' compliance with frequency allocation rules. Henrich-Franke's study shows that the use of directional transmitters made it possible for a broadcaster in one country to use a frequency that was nominally the property of another country, while avoiding interference with the latter, thereby allowing greater overall use of the resource. With respect to governance paradigms, the studies show that European spectrum management in the decades up to 1970 was not predicated on a belief in marketization as the most efficient or beneficial model for allocating access to a valuable, shared resource. As Wormbs notes, a "market solution" for radio spectrum management in Europe was "not standard practice during most of the 20th century." And finally, both studies show that European spectrum governance worked because it allowed for adaptability and flexibility through technology, through hybrid, somewhat flexible property rights, and through a degree of self-organization that was permitted within the framework of basic rules and protocols.

Comparing these studies to present trends in spectrum management reveals several interesting parallels and continuities. Today, with technological change leading to rapid increase in global use of the radio spectrum, engineers and economists are discussing how to manage this resource in smarter ways. The idea is to enable transmitters and receivers to use frequency bands that are immediately available, shifting these as conditions warrant, thereby optimizing overall use of the spectrum and allowing for broader and more intensive use. Cognitive radio, adaptive radio, and software-defined radio are some of the systems currently under development (Faulhaber and Farber 2003; Lehr and Crowcroft 2005). The solutions envisioned place greater emphasis on use rights, as opposed to private property rights. Further, the new paradigm of "Dynamic Spectrum Access" depends on self-organization from below, functioning, however, within global constraints set by international standards, for example as developed by IEEE SCC41 (The Institute of Electrical and Electronics Engineers' Standards Coordinating Committee for Dynamic Spectrum Access Networks). At the broadest level, these changes involve an interactive use of technology and management strategies to enhance access to the resource (geographically and in relation to intensity of use, and numbers and types of users), thereby augmenting its effective size.

Several parallels with the histories outlined by Wormbs and Henrich-Franke are evident. In the period covered by their studies, like today, technological change lay at the heart of both the need and possibility for new spectrum governance

regimes. We see a further point of continuity between past and present in parallel attempts to develop flexible system architectures that could accommodate changing user needs and technological possibilities. In the European context, this flexibility was expressed perhaps most clearly in the decision to allow countries to use frequencies formally allocated to other countries, as long as their use did not produce interference with existing radio services. Then, too, the present interest in new property rights regimes – encompassing usage rights and hybrid systems of property rights – also has parallels with earlier decades. Henrich-Franke notes that the system for sharing frequencies among nations represented "a very special property regime, which was a mixture between group property (frequency bands), private property, and open access." That is, a given frequency could function simultaneously as private property within a nation's frontiers, and as an open access resource on an international level. Finally, the self-organizing dimension of current spectrum management paradigms also finds a parallel in the earlier period. Both articles present examples of change from below that led to self-(re)organization of the system. In particular, users expanded and gradually reorganized the system, either by exploiting technology to utilize unallocated frequencies, or by cooperating with other users to find ways to share frequencies without harmful interference. Self-organization helped keep the system responsive and sustainable.

It is worthwhile to reflect also on the broader lessons for commons scholarship that emerge from the case histories of radio spectrum governance. Significantly, these articles reveal important continuities with more traditional commons. Wormbs's demonstration that European radio spectrum governance embodied design principles analogous to those identified by Ostrom for management of traditional commons is a case in point. Indeed it is gratifying to learn that a modern technology-based resource can, and probably has to, be managed by the same principles as ancient commons in forestry, pasture, and water for irrigation. This finding strengthens our belief that these design principles are valid in general for common pool goods. Further, the studies of Wormbs and Henrich-Franke show that Ostrom's design principles can accommodate features that have become central in many contemporary commons: self-organization, constant technological change, and continual shift of users (who enter or exit the system), rules, and sometimes changes in how the resource is used.

The case studies presented here connect with two further themes that have general relevance for commons theory. First, the studies point to the important roles played by social networks in effectively managing commons. The management of the spectrum commons was ultimately based on voluntary adhesion to joint rules and protocols, and its functioning and management relied on professional networks of technical experts from member countries (generally employed within national PTT administrations). Their growing contacts and interactions fostered a sense of community and solidarity in a common cause, which helped keep the commons functioning despite political rifts, while making its governance more flexible and responsive. These professionals were guided by reputational concerns

rather than by profit motives (since they were salaried employees). Keeping the system working was a validation of their competence, and both Wormbs and Henrich-Franke show that, in this kind of context, the threat of social shaming worked effectively to deter rule breaking. Moreover, the shared perspectives that grew as these professionals tackled common problems helped establish informal methods of problem solving that overcame political roadblocks and system rigidities. It should be noted, however, that the community of broadcasters and national administrations in Europe in the first half of the 20th century was small enough to maintain personal communication and trust. The unsolved problem is how to build effective social networks at the level of global commons, and in the face of deeply conflicting interests and new political divides.

The second theme concerns the role of markets in commons. Hardin (1968) proposed privatization of threatened resources and regulation of their use by market forces as one solution for the "Tragedy of the Commons" he envisioned. This approach to commons governance gained widespread political acceptance and application through its affinity with the neo-liberal paradigm that increasingly took hold from the 1970s onward. Neo-liberalism assumed that market systems rooted in private property rights could regulate society more effectively than any other system of governance. It also incorporated the idea that market systems are permanently self-regulating, obviating the need for much conscious governance at all. Set up the markets, enforce private property, and market forces would take care of the rest. However, during this same period, and in contrast to mainstream political sentiments, scholarly study of markets based on the neo-classical model increasingly questioned the validity of its assumptions. The list of "market imperfections" due to information costs, transaction costs, measurement costs, cognitive incapacities, too few suppliers, or too few customers became increasingly longer, even as understanding grew as to why market mechanisms worked well in certain specified contexts. Such insights have been slow to permeate the political world, yet the recent mushrooming of interest in commons may signal a shift. Moreover, armed with new insights into the complexities of large scale governance and the limits of regulation by market forces, researchers have been going back to the drawing board to reconsider earlier modes of social, economic, and political regulation in a new light (e.g. Powell 1990; Plateau 1994a,b; Woolcock 1998; Bodin and Crona 2009; Moss and Cisternino 2009).

The historical view of radio spectrum governance provided by Wormbs and Henrich-Franke thus comes at an opportune time, and we should not miss the chance to consider their findings in relation to this new agenda. Their studies provide strong evidence that effective, sustainable governance can occur and has occurred without introducing markets as usually conceived. They show that European radio spectrum governance survived and grew for nearly a century without any market for transactions in the resource, relying on a hybrid mixture of (state) property and spectrum use rights. They show that regulatory power came from cooperation, from basic agreement on common rules (amenable to alteration as circumstances warranted), and from a set of institutions and social networks that

built commitment to the system, negotiated its further development, and handled monitoring, troubleshooting, and conflict resolution functions. Their studies show that, overall, the system worked benignly and flexibly. Their studies suggest that it is time to take a renewed, longer look at cooperative, hybrid solutions to commons management.

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