The Crisis of the Commons: An Inquiry into 'Technologies of the Commons' as Tools for Organizing

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Introduction: commons as organizational technologies

The concept of the 'commons' has gained increasing attention throughout a wide range of disciplines including economics (Ostrom, 1990; Ostrom, et al. 1999; Patel, 2011), computer studies (Berry 2008; Stallman 2002), human ecology (Hardin, 1968), legal theory (Lessig, 2002, 2004), political theory (Hardt and Negri, 2009; Hyde, 2010; Terranova, 2004) and history (Hill, 1972, 1996; Linebaugh, 2008; Neeson, 1996; Thompson, 1991). Berry (2008) has traced a concern for the commons as an organizational problematic to Ancient Roman law with its categorization of *res communes* and *res divini juris* to identify domains of objects that may be legally subject to common ownership and usage. Recently, concerns have been raised that common are now an existential crisis, which threatens the welfare and existence of future generations (Klein, 2014; Fraser, 2022). This article argues that the concept of the commons provides an insightful approach for analysing organizations, which with some exceptions has been largely neglected within the field of organization theory and management studies (de Vaujany et al, 2022; O'Mahony, 2003; O'Mahony and Ferraro, 2007; Von Hippel, 2005).

The idea of the commons appears in diverse domains of activity, including the governance of ecological resources (Barnes, 2006; Hardin, 1968; Ostrom, 1990; Perelman, 2003), the organization of information and knowledge production in a 'creative commons' (Berry, 2008; Hardt and Negri, 2009; Lessig, 2002; Von Hippel and Von Krogh, 2003), and cultural traditions and customs (Hill, 1972; Linebaugh, 2008; Neeson, 1996; Thompson, 1991). The argument of this article will draw upon these different conceptions of the commons in order to outline a framework by means of which the commons can be understood as an organizational phenomenon that bridges different domains of organizational analysis.

This article investigates how 'technologies of the commons' (Berry, 2008) can be created by self-organized communities to govern the distribution and production of collectively owned resources. Broadly speaking 'technologies of the commons' are institutional arrangements for the maintenance of a commons and the sustainable use of its resources. Such communal technologies have been created to exploit the manage the creation and distribution of informational and ecological resources. To begin with, I shall explain why it is that certain resources have been conceived of as commons in the first place.

1. The Reappearance of the Commons

The notion of the commons was a major feature of economic and social life in Europe until the 19th Century, at which time it came under increasingly aggressive attacks by corporate capitalism as a key organizing principle of social life (Hill, 1996; Neeson, 1996; Linebaugh, 2008). Historical studies of the commons have detailed the emergence of 'rights of usage' and 'rights of common' during the Middle Ages which permitted limited access for the poor to forage forests and pastures (Hill, 1972, 1996; Neeson, 1996; Thompson, 1991). Customs such as estovers – the right to take wood from the forest for firewood or to repair one's dwelling - formed an essential element in the livelihood of the poor, and especially poor women (Linebaugh, 2008). Up until the time of the Industrial Revolution, customs regarding access to and the use of the commons were a major feature of the moral economy of European society (Neeson, 1996; Thompson, 1991).

Thompson (1991) has observed that since the publication of Hardin's (1968) influential work on the 'tragedy of the commons', commentators have tended to assume that the 'commons' were destroyed by the commoners themselves through the over usage of the resource system. However, historical studies show that Hardin's view of history is not supported by the evidence, and that the commons were destroyed by the legal measures that favoured the land-owning classes such as the enclosure laws, rather than by over-usage by the commoners (Hill, 1996; Neeson, 1996; Thompson, 1991). In this respect, (Thompson, 1991, p.107) observed that, '…commoners themselves were not without commonsense. Over time and over space the users of the commons have developed a rich variety of institutions and community sanctions which have effected restraints and stints upon use.' Ostrom's (1990) recent research into commons governance maintains a similar view citing historical evidence pertaining to the successful long-term management of common lands. This research clearly supports the view that self-organized user communities can play an active role in the maintenance of common resources.

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The commons provided a widespread alternative to market-based forms of social life, which gave commoners access to important staple resources and left time for recreation that was not available to those engaged in industrial wage labour (Hill, 1996; Neeson, 1996). Historical studies of the commons are replete with examples of rudimentary practices of commoning (Hill, 1996; Neeson, 1996; Thompson, 1991). Hyde's (2010) study of the commons has identified three forms of commoning that were characteristic of the pre-industrial economy, i) right of *piscary* to fish in streams, ii) right of *turbary* to use turf for heating, and iii) right of *estovers* to collect wood from the forest for heating and house repair. These common rights were practices that sustained the peasant economy. These were defined and defended by other practices such as an annual perambulation by commoners to mark out and claim the bounds of a given commons. According to Linebaugh (2008) the idea of the commons was key to one of the founding documents of modern democracy, The *Magna Carta*, which established fundamental rights to subsistence, free movement, access to commons, reparations and *Habeas Corpus*, among other things. I shall now turn to an analysis of the composition of different forms of commons and the governance of organizations based within each commons.

2. The Peculiarities of 'Common' Resources

The key characteristic underpinning the concept of the commons is that access to it is 'open' in important respects and that this openness is not incidental or a matter of ideological preference but is a material feature of the commons itself. In the language of economics such resources are termed 'imperfectly-excludable'. All commons are composed of imperfectly excludable goods, although the degree of 'openness' of a given commons and access to its resources are regulated by the users of that commons. Historically, the access rights and restrictions to a commons were known as 'stints'[11]. In economic theory, two elementary forms of commons have been identified, those which are composed of non-rivalrous resources and those composed of rivalrous resources (Lessig, 2002). Rivalrous resources are subject to competition over their consumption, since they exist in only limited supply, such as streets and parks. However, non-rivalrous resources such as ideas, knowledge and language are not subject to the same limitations as rivalrous resources. Once produced, a non-rivalrous resource can never be exhausted; your consumption of the resource will not decrease the amount that is available for use by others. These peculiar material characteristics of common resources have significant implications for their management and their systems of governance, a fact that has been highlighted both in the organization of ecological resources (Ostrom, 1990; Patel, 2011) and in the organization of informational resources (Lessig, 2002, 2004; Terranova, 2004) and the open source movement (Demil and Lecocq, 2006; Lessig, 2002; O'Mahony, 2003).

Common resources have material characteristics that impose crucial limitations upon and open up possibilities for forms of governance appropriate for their maintenance and development. The governance structure of different commons is tied to the 'empirical situation' within which a particular organization is located (Ostrom, 1990, p.13). What is of particular interest for our purposes is that the characteristics of both ecological and informational resources have led to the proposition of alternative 'commons' forms of governance (Berry, 2008; Dietz et al., 2003; Lessig, 2002; O'Mahony, 2003; Ostrom, 1990).

We might understand such systems of governance as mechanisms for dealing with what Callon (1998) has characterized as 'overflowing,' which concerns the management of externalities that have escaped the market framing of a given transaction. Indeed, it has been suggested that such systems of self-governance can lower transaction costs of organizations, both in the information commons (Demil and Lecocq, 2006) and in the ecological commons (Ostrom, 1990). The idea of 'commons governance' can be seen to develop both from a negative critique of the limitations of markets and hierarchies in allocating goods and a positive critique based upon the development of 'technologies of the commons' which are institutional arrangements for the maintenance of the commons and for the management of associated externalities. David Berry (2008) originally coined the term 'technologies of the commons' to explain the success of free and open source projects developed on the Internet such as 'wikis', the content management systems of websites, mailing lists that facilitate online debate, and other tools that allow users collaborate together in open source projects. Berry (2008, p.136) also includes legal licences such as GPL and the Creative Commons in his conception of technologies of the commons, which help protect the infrastructure of the commons. We can fruitfully extend this idea of technologies of the commons to practices and techniques that facilitate the maintenance of other types of commons, including both informational, cultural and ecological commons. I shall now turn to an analysis of the composition of two major types of commons: the informational commons and the ecological commons.

[11] There is some disagreement in the literature as to the nature of stinting, for instance Lewis Hyde has (2010: 35) argued that, 'A true commons is a stinted thing…', whereas Neeson's (1996) historical study of commons in England in the 18th century notes the existence of many commons that were unstinted and thus open to anyone.

3. Innovation and the Informational Commons

Professor of Law at Stanford University Lawrence Lessig (2002) has shown that many aspects of everyday life involve the use of common resources, such as public streets, public highways, parks and beaches, writings that are not under a current copyright, and perhaps most importantly, language itself. In his book, *The Future of Ideas: the fate of the commons in a connect world*, Lessig (2002) explains how the Internet evolved from a physical layer of computers, terminals, cables and so on, which was proprietary, but also from a layer of code, the majority of which is available free of charge. This includes the Apache operating system on which about two-thirds of Internet servers run, email routing software, the public domain TCP/IP protocols, the Linux operating system, and the World Wide Web itself. Lessig's (2002, p.57) overview of the key developments of the software on which the Internet runs has led him to observe that, 'The most important space for innovation in our time was built upon a platform that was free.' By making this software free, the costs of innovation are substantially lower than if it were based upon a purely proprietary model. Lessig is not arguing that all software should be free, but that, as a society, we ought not be so quick to grant monopolies on the use of ideas and new inventions. He points out that knowledge is both an input and an output of the creative process. By putting a price on intellectual property and charging for its use we might provide an incentive to produce more inventions, but this will also increase the costs of the production of future inventions thus stifling future innovation.

Lessig proposes that although inventors should be paid for the product of their labour, they ought not be granted a complete monopoly over the use of their ideas by others because such ideas are a common resource which can enrich us all. Perhaps the most distinctive aspect of the innovation commons is that it is not exhausted when it is consumed. This is true of all kinds of symbolic media whether it be language, music or scientific knowledge. Not only does the consumption of an idea or a piece of music leave the resource fully intact for anyone else to use, but it may stimulate further innovation, and thus increase the resource available for others. Lessig (2002, p.250) argues that it would be absurd to put a price on the use of all intellectual property because, in his own words, 'We refer to plots in movies to tell jokes without the permission of the director. We read books to our children borrowed from a library without any payment of performance rights to the original copyright holder.' Consider for a moment a vision of a world in which all ideas were subject to stringent intellectual property regulations the instant they were created, where one could only talk, think, and use the ideas of others under licence and as such only the wealthy could afford to think freely. He cautions that laws for exploitation of culture for economic gain are increasingly invasive where, 'the content of our culture is controlled by an ever-expanding scope of copyright.' (Lessig, 2002, p.110). Lessig turns to the work of Thomas Jefferson in search of an adequate formulation of the information commons and its peculiar characteristics. Jefferson described this commons with great eloquence in the following manner:

> '[1] If nature has made any one thing less susceptible than all others of exclusive property, it is the action of the thinking power called an idea, which an individual may exclusively possess as long as he keeps it to himself; but the moment it is divulged, it forces itself into the possession of everyone, and the receiver cannot dispossess himself of it. [2] Its peculiar character, too, that no one possesses the less, because every other possesses the whole of it. He who receives an idea from me, receives instruction himself without lessening mine; as he who lites his taper at mine, receives light without darkening me. [3] That ideas should freely spread from one to another over the globe, for the moral and mutual instruction of man, and improvement of his condition, seems to have been peculiarly and benevolently designed by nature, when she made them, like fire, expansible over all space, without lessening their density at any point, and like the air in which we breathe, move, and have our physical being, incapable of confinement, or exclusive appropriation. [4] Inventions then cannot, in nature, be a subject of property.' (Thomas Jefferson, *Letter to Issac Macpherson* 1813, quoted in Lessig, 2002, p.94).

This captures the essential aspects of the information commons, where Lessig breaks this statement down into four key insights. First, information is imperfectly excludable, meaning that once it has been passed on it cannot be taken back subsequently. Second, it is non-rivalrous, meaning that when information is consumed it does not diminish the resource available for others to use. Third, the physical properties of information make it very easy to spread, like air or fire. When considered together we can infer a fourth property from these characteristics - that inventions cannot and should not become private property. Lessig also points out the irony that this analysis came from the pen of Thomas Jefferson who was the first commissioner of the US Patent Office.

Arguments for the protection of the innovation commons as an open resource have emerged from diverse areas of social life and political persuasions, including popular music groups such as Radiohead and Neil Young, business

writers such as Don Tapscott and Andrew Williams (2007) and political theorists such as Hardt and Negri (2009) and Terranova (2004). The immediate reaction of big business to the emergence of the open source communities was to engage in a vicious legal war against the outsiders who were creating new models for producing and sharing intellectual property, especially in the music and software industries. These projects are not just confined to the software industry or the music industry but have gathered momentum across the economic spectrum as diverse as the mining industry, publishing, music, politics, and the human genome project (Berry, 2008; Hardt and Negri, 2004, 2009; Lessig, 2002, 2004; Tapscott and Williams, 2007).

Within the field of organization and management studies, the idea of the information commons has been used to explore the respective successes and failures of the open source community (Demil and Lecocq, 2006; O'Mahony, 2003; O'Mahony and Ferraro, 2007; Von Hippel and Von Krogh, 2003). The information commons is now actively maintained and defended against increasing enclosure through legal measures such as the General Public License (GPL). O'Mahony's (2003, p.1187) research into the open source community has explained the organizational significance of GPL 'copyleft' in the following terms: 'Informants using GPL do not use it to exclude others from using their work, but to codify norms of reciprocity and temperance or, in other words, to prevent code from becoming subtractable in future.' A host of other types of intellectual property licenses have been developed over to facilitate the creation of informational commons, which govern a variety of rights including rights of ownership, rights of use, rights of modification and rights of distribution., such as the Creative Commons License.

The problem of the occurrence of 'free riders' can be circumvented within the informational commons because information is not exhausted when it is consumed which lends itself to different possibilities for governance. Following the work of the open-source pioneer Eric Raymond (2001), Demil and Lecocq (2006, p.1463) have proposed an alternative system of organizational governance modelled on the bazaar as being 'particularly suitable for industries based on codified information goods'. O'Mahony (2003), Berry (2008) and Lessig (2002) explicitly refer to the commons itself as being a model for the governance of informational resources. These models take advantage of the fact that network externalities are associated with large numbers of users of information, where the existence of free riders may actually be of benefit to other users, for example in generating useful feedback about the existence of software bugs or general user-friendliness.

Research in management and organization studies has highlighted the conditions under which businesses might successfully make alliances with open source communities (Demil and Lecocq, 2006; Fosfuri et al., 2008; O'Mahony and Bechky 2008). Eric von Hippel has been one of the few management scholars to draw upon the idea of an 'innovation commons' in a discussion of Lessig's work in his pioneering study of user-driven innovations. Von Hippel's (2005, p.116) analysis of the potential of the innovation commons concludes that, 'We will learn over time whether and how widely the practice of creating and defending intellectual commons diffuses across fields.' Manuel Castells (2001) has suggested that new kinds of production in the network society are creating a new division of labour, which is based on cooperation in matters of innovation, and competition in the applications and services that are based on these initial innovations. Castells argues that the superiority of the open source model over traditional proprietary business models is clearly demonstrated by the development of the Internet itself, 'In sum, all the key technological developments that led to the Internet were built around government institutions, major universities, and research centers. The Internet did not originate in the business world. It was too daring a technology, too expensive a project, and too risky an initiative to be assumed by profit-oriented organizations.' (Castells, 2001, p.22).

With the development of new forms of communication and forms of post-Fordist production[12], the cultural commons has itself incorporated new social practices, especially with reference to modern information technologies such as the Internet. Political theorists on the left have argued that new forms of productivity associated with modern information networks and the Internet can be explained in terms of the commons drawing upon Marx's notion of the 'general intellect' (Hardt and Negri, 2000; Terranova, 2004; Virno, 2004). The concept of the 'general intellect' derives from Marx's analysis of technological developments during the Industrial Revolution which he described in terms of, 'the general productive forces of the social brain' (Marx 1973, p.694). These political theorists have thus argued that the general intellect has become a productive force within the modern network society, since it provides an intensification of our powers of cooperation and an intellectual, emotional and communicational infrastructure upon which all other networks are built. Under circumstances of rapidly changing technologies

[12] Post-Fordist production is based on the flexible accumulation of wealth co-ordinated through global communication networks. Hardt and Negri (2000) have observed that Post-Fordist regimes of work have emerged in response to mass protests against factory labour, as well as new forms of neoliberal exploitation based on increasing precarious labour, knowledge work and emotional labour.

and their associated skills, the general intellect is described as a general capacity for cooperation which, 'guarantees readiness, adaptability, etc., in reacting to innovation.' (Virno, 2004, p.41). This conception of the commons is by no means without its critics. For example, Ossewaarde and Reijers (2017, p.27) have argued that technologically mediated commoning is a relatively isolated practice which "leads to cynicism that alienates commoners from the very practice of commoning". Dyer-Witheford (2005, p.159) explains the contradictory forces at work in contemporary informational capitalism in the following terms, 'The paradox of insurgent organization today is … that the same communication systems that constitute the general intellect of net-capital can be transformed into a revolutionary 'social brain', but only if such a project is constantly vigilant against replicating the very divisive logic against which it contends.'

In line with these critical analyses of the informational commons, it should be clear that what is at stake is not simply a matter of more or less innovation or lower transaction costs, as strictly economic explanations might suggest. Attacks on the information commons by corporate and state power have been relentless, when genuine alternatives to the information commons gain popularity. No better example of this exists that the case of Aaron Schwartz, who a research student and open source activist who helped develop the Creative Commons license with Lawrence Lessig and other open source projects. Schwarz committed suicide in 2013 after being hounded by MIT and the Justice department and threatened with $1million in legal fines and a 35 prison sentence for his efforts to create on open access depository of academic papers. Another example is the aggressive treatment hostility of the WikiLeaks network in revert years, where Benkler (2011) has explained the numerous attacks against this network by corporate America and the national security state as being "an attack on an important practice in the networked commons." The extent to which high-tech communication networks form a commons remains an open question and some remain skeptical of the emancipatory potential of these networks (Ranciere, 2006). We will now turn to an investigation of a quite different form of commons - the socio-ecological commons.

4. The Social-Ecological Commons

Within the field of organization theory and management studies there has been much debate over the emergence of 'ecocentric' and 'sustainocentric' paradigms of research (Banerjee, 2001, Moog et al, 2015; Purser et al., 1995, Gladwin et al, 1995). There appears to be little evidence concerning the extent to which environmental values are being adopted within corporations in practice. Bobby Banerjee (2001, p.507) has presented evidence that amongst practicing managers, 'there does not appear to be a paradigm shift to concepts like sustainability or econcentrism.'

The limitations of the market mechanism have been recognized in economic theory under the umbrella term of 'externality' (Marglin, 2008). An externality can be defined as the effect of a transaction on a third party who has not consented to that transaction, such as environmental pollution or workplace accidents. With externalities the social costs or benefits of a transaction are not fully represented by the market price and are thus not borne directly by the organizations or persons that produced them (Coase, 1960; Perelman, 2003). Marglin (2008, p.284) explains that, 'Once upon a time when the world was sparsely inhabited, once upon a time when we used relatively few resources, it might have been acceptable to relegate externalities to the realm of occasional nuisance and anomaly. But now that we live and work at close quarters to one another, our non-market interactions are much more part of the fabric of our lives, and externalities are of central concern.' Nowhere is the problem of externality more evident than in the (mis)management of ecological resources.

This year the Secretary General of the United Nations, António Guterres , observed that the destruction of the natural world has progressed unabated over recent decades, even in the full knowledge of the catastrophe that is unfolding (United Nations, 2022). In 2009, the International Union for Conservation of Nature estimated that approximately 48,000 species were at risk of extinction in the near future. Scientific research estimates that about 11% of bird species are threatened, endangered or extinct, 18% of mammal species, 5% of fish species and 8% of plant species (Heywood, 1995; Sutherland, 2003). These disappearing species may well possess unique properties, but since many are largely unknown to us or are not sold on the markets, they have no monetary exchange value. In economic terms, these extinctions register as nothing more than an externality. According to economist Michael Perelman (2003), the complexity and fragility of the ecosystem make it essentially impossible to determine the eventual consequences of destroying the next unit of natural habitat or the next species, and thus it is impossible to measure the genuine cost of economic activities that have such effects. Perelman has noted that the economic concept of scarcity works on the assumption that all qualitative distinctions and variables can be reduced to and accounted for in terms of one general form of equivalence in which, '… complex conditions are artificially collapsed down to a single monetary

measure.' (Perelman, 2003, p.41). However, given that the ecosystem provides us with our basic human needs, its value to us is beyond measure.

An example of the complexities involved in the rationing of the ecosystem in economic terms can be illustrated with the example of bee 'pollination services' (Berenbaum, 2007; Benjamin and McCallum, 2008). At present there is a looming crisis facing the agriculture industry in Europe and the U.S. as a result of a massive decline in the number of bee colonies available to pollinate the annual agricultural crops. Crops that rely on bees for their pollination and reproduction include those which are a vital part of our everyday diet such as fruits, vegetables and nut crops (Berenbaum, 2007). The number of honey-bee colonies has declined by 40 percent in the U.S. over the past 60 years. The causes of the decline are believed to be a combination of the action of pesticides and bee parasites, which has resulted in widespread 'Colony Collapse Disorder.' This decline is not confined to the US alone and similar trends exist across four different continents. In testimony to the U.S. Congress one insect expert explained that if the current trend continues the managed honey-bee will cease to exist by 2035, where 'markets will respond, but may do so in ways that are detrimental to the economy as a whole' (Berenbaum, 2007). A collapse in bee numbers and their 'pollination services' would quickly lead to a collapse in important crops that are a vital part of our food chain. Many other ecological services have been similarly afflicted by harmful externalities including pollination, water filtration, soil fertility, and the regulation of water and climate systems (Patel, 2011).

The complexity of the eco-system and problems concerning the measurement of its value maybe one reason why its consumption may not be effectively rationed by the market mechanism (Callon, 2009; Perelman, 2003), but another reason is that there are actually positive incentives to destroy it. Bakan's (2004) critical review of corporate governance describes business corporations as 'externalizing machines', where economic incentives exist to externalise some the costs of production onto third parties, such as intentional pollution or industrial accidents which cause severe damage to our health and environment. His analysis draws on numerous cases where corporations have systematically broken the law because infringement is cheaper than compliance. Bakan observed that abuses of environmental protection legislation and health and safety laws are seldom detected or reported to regulatory agencies, and the prosecution of infractions are rare. He goes through a list of fines levied on large corporations to illustrate the fact that breaches of the law appear to be endemic in corporations. According to Bakan, breaking the law has become just another cost of doing business, where the corporation acts as a free rider in its exploitation and pollution of the ecological commons. Patel (2011) has developed Bakan's argument further in the context of relations between the rich Western World and so called third-world countries, where Western economies are acting as free riders on the eco-systems of their poorer neighbours. Patel (2011), Fraser (2022) and Klein (2014) argue that corporations have externalized massive environmental costs onto poorer countries, exporting their most polluting and damaging activities to the Global South. Klein (2014) observes that in the past is was possible for the global North to treat poorer countries as "sacrifice zones", whose natural resources, wealth and health were simply plundered or destroyed, today the entire world is becoming a sacrifice zone, with the destruction of the global ecological commons.

In the face of the limitations of the market economy Ostrom's (1990, 2007) research has explored a broad range of possible solutions that go beyond the usual dichotomy of market rationing or state control. Based upon detailed empirical analysis, her work reveals that locally managed self-organized communities are capable of devising forms of governance that can maintain communal resources and that can avert the tragedy of the commons.

Ostrom's (1990, p.30) research focuses on the management of what she terms 'common pool resources' which she defines as 'a natural or man-made resource system that is sufficiently large as to make it costly (but not impossible) to exclude potential beneficiaries from obtaining benefits from its use.' This includes a huge range of both natural and man-made resources including forests, rivers, lakes, oceans, groundwater basins, irrigation canals, bridges, parking spaces and mainframe computers. The fact that common pool resources, such as fisheries and forests, are non-excludable leaves them liable to over exploitation and eventual destruction. Ostrom has proposed that both the state and the market have severe limitations as systems of governance for these kinds of resource. She observes that the success of state regulation is based upon the assumption of its possession of perfect information about the resources it manages and the assumption that the costs of administration and enforcement will be low, but that neither of these assumptions may hold true in practice. Ostrom is equally critical as regards the efficacy of the market mechanism. One key limitation of the market mechanism identified in Ostrom's work is that common pool resources cannot be easily privatized. The imposition of fences and the enforcement of property rights may be costly and they may face resistance in the context of indigenous cultures or local traditions. The difficulties of fencing a common pool resource are especially apparent in the case of 'nonstationary resources'

such as fisheries or clean air and water. Ostrom (1990, p.13) has observed that, 'even when particular rights are unitized, quantified, and salable, the resource system is still likely to be owned in common rather than individually.' Under such circumstances rationing by means of the market mechanism may cease to function efficiently.

In response to these apparently intractable problems, Ostrom provides a third alternative organizational form (dismissed in Hardin's (1968) earlier formulation of the tragedy of the commons), which is constituted by the self-governance of the community of users themselves. Ostrom shows how in practice, the users of a resource can meet to negotiate rights of common usage amongst themselves and build mechanisms for self-enforcement where their own stake in monitoring the commons themselves is made clear. Whilst the resource system may be collectively owned, the system can be self-managed by means of a negotiated contract which establishes commons rights of usage and clear sanctions for any infractions of these rights. These local systems of self-governance can themselves exist within a wider network of markets and state regulations (Dietz et al., 2003).

Ostrom's research has identified 'design principles' under which self-organized user communities tend to work well, including: i) where face-to-face interaction is the norm, ii) where the use of community resources can be monitored relatively cheaply, iii) where the rates of change in these resources tend to be moderate, iv) where outsiders can be easily excluded at a relatively low cost to create a 'stinted' commons, and v) where the users themselves support effective enforcement and rule following (Ostrom, 1990; Dietz et al., 2003). These design principles are institutional technologies of the commons for the self-governance of socio-ecological resources. She proposes that effective systems for self-governance on a small scale can lead to positive benefits for the wider system, an outcome that she describes in terms of 'nested externalities' (Ostrom, 2010). Ostrom and her co-authors note that few real-world situations correspond to this idealized situation, although they say relatively little about the 'struggle' to create such institutional arrangements (Dietz et al., 2003). In situations where such suitable contextual factors are not in place Ostrom's research proposes the use of other measures of governance such as privatization and state regulation. Now that the different forms of commons have been explained, along with the 'technologies' that have been developed for their maintenance, I shall discuss the implications of these alternative systems of governance for management and organization studies.

5. Discussion: Technologies of the Commons and the Crisis of the Commons

The commons is as yet an under-researched phenomenon within the field of management and organization studies despite having received recognition as an important domain of analysis in other human sciences. Although this article has focused on the informational commons and the ecological commons, many other characterisations of the commons exist, for instance, Negri (2003) elaborates on a collective 'temporal commons' and Ranciere (2009) defines the commons in terms of 'the distribution of the sensible.' Different commons present distinctive challenges for their governance arising from their history and their material characteristics. In the case of the informational commons, the non-rivalrous and inexhaustible nature of information presents opportunities for its exploitation that are not open to other kinds of resource (Note, Hardt and Negri (2009, p.283) include all these commons under the umbrella term of 'biopolitical production' and then state that this 'puts bios to work without consuming it,' which is not strictly true for forms of the commons which involve rivalrous resources). The problem of 'free riders' is mitigated in this commons by the fact that the resource is not itself exhausted by their existence. Because it is not exhausted in the act of consuming it, this has allowed for the development of technologies of the commons to foster network externalities including modular open source projects to facilitate the greater use of the information. The peculiarities of the informational commons have also led to the development of new forms of intellectual property rights in order to help organize and govern the use of this commons.

The governance of ecological commons presents rather different technologies and limitations. These resources are imperfectly excludable 'open' resources but they are exhausted when they are consumed. The issue of the 'free rider' is a far greater concern for the governance of this commons and this is reflected in the organizational design principles for commons governance that one finds in the works of Ostrom (1990) and others (Barnes, 2006; Dietz et al, 2003; Patel, 2011). A major issue for the governance of this commons is the issue of its immeasurable economic and social value. As we have discussed earlier the market price for ecological resources may be a very poor indicator of their significance in the ecosystem as a whole (Berenbaum, 2007; Perelman, 2003). Technologies of the ecological commons thus tend to be orientated around concerns for resource depletion and pollution rather than on issues of free distribution and modification that one finds in the informational commons.

Reframing Market Externalities and Overflows

Berry's (2008) analysis of this community has observed that the Free Software Foundation has been more radical in its ambitions to create an open informational commons, whereas the broader open source community has shown greater interest in building and exploiting links with commercial partners. In this respect O'Mahony and Bechky (2008) have observed the emergence of 'boundary organizations' that have been created in order to manage collaborations between organizations that use these different forms of governance mechanisms. The aim of such boundary organizations is to preserve the integrity of each form of organization (market and commons), but promote limited collaboration where they have a mutual interest to do so. They note that all of the open source projects that they studied for their research had developed such boundary organizations for maintaining links with commercial organizations. The existence of boundary organizations does not dissolve the conflicting interests between the market based organizations and commons based organizations, but permits them to delineate areas of common ground and collaboration.

Mike Power (2009) has suggested that the commons can provide a useful conceptual resource for better understanding the management of market externalities, with particular concern for understanding 'systemic risks' and the development of institutional tools for their mitigation. Power (2009) confines his analysis to the externalities and systemic risks of the financial system, which can be viewed as a commons, but his insight is applicable across a range of different commons. Callon's (1998) analysis of the market externalities has described them as 'overflowings' that must become identifiable, measurable and calculable so that they can be made manageable. Callon thus observed that overflows can become re-framed within the market once they have become subject to some system of measurement. In this way, he proposed that it might be possible for organizations to internalize the social costs of overflows. A key limitation of taking such a market based approach is that it is premised on the existence of easy to quantify variables which can be used as a basis for the pricing of relevant overflowings. In practice there is good reason to dispute Callon's basic premise. This has been abundantly clear in the case of the international system of carbon trading, which has been demonstrably inadequate as a system for reducing the production and release of carbon dioxide into the atmosphere and has been subject to severe academic and civic criticism (Böhm and Dabhi, 2009; Böhm et al, 2012; Lohmann, 2009).

Callon's analysis has already been criticized for its tendency to conceive of overflowing primarily with respect to the frame of the market system. Miller (2002, p.223) has argued that Callon's theory of the market needs to be 'turned the right way up' where the moral economy is not seen as an externality that overflows the market frame but is the focus of the framing itself. Hardt and Nergi (2009, p.283) have commented upon the limitations of the concept of externalities for framing social transactions explaining that, 'Rather than seeing the common in the form of externalities as "missing markets"... we should instead see private property in terms of the "missing common" and "common failures".' Technologies of the commons function by pre-empting the production of unsustainable overflows, rather than by retroactively identifying and measuring such flows after their production as is advocated by Callon's (1998) approach.

The Crisis of the Commons

Ostrom's work regards self-organization within the commons as a part of a 'nested' approach that also includes a role for state regulation and for the market mechanism. Ostrom's conception of the commons situates itself explicitly within the tradition of conservative liberal philosophy developing from thinkers such as Hobbes, Smith, Hamilton and Tocqueville (Ostrom, 1990, p.216). Whilst recognizing an important role for self-organized user groups, its emphasis is on dealing with a limited set of circumstances that cannot be easily solved by the market or the state. Numerous authors have drawn on the idea of the commons to explain the significance of harmful externalities of the prevailing capitalist system and have exploited the democratic and emancipatory potential of forms of commons governance (Federici, 2008; Fraser, 2022; Hardt and Negri 2004, 2009; Linebaugh, 2008; Patel, 2011; Perelman, 2003).

Federici (2008, p.95) has argued that, "Commons are constituted on the basis of social cooperation, relations of reciprocity, and responsibility for the reproduction of the shared wealth, natural or produced". In a similar vein, Hardt and Negri (2009) have developed a conception of the commons which is radically democratic in its organization arguing that participation is itself a form of pedagogy that expands both our productive forces and our capacity for self-rule. They maintain that, 'any attempt at external organization only disrupts and corrupts the process of self-organization already functioning within the multitude' (Hardt and Negri, 2009, p.302). In relation to the knowledge commons, Moten and Harney (2004) have argued that an "undercommons" can be created on the margins of formal institutions, where "maroon communities" can self-organize against the corrupting influence of neoliberal regimes of management and measurement.

The critical economist Stephen Marglin (2008) has pointed out that privatization is frequently rejected as a solution to the allocation of common resources because such a solution destroys many of the social bonds and community values around which the community's life had been traditionally organized. Federici (2018) and Linebaugh (2012) have both shown that historically liberal capitalist strategies have enclosed the commons at home and abroad by means of violent expropriation of wealth and land from women and indigenous populations. Feminist writers including Federici (2018) and Fraser (2022) have observed that the commons is closely linked to care work and social reproduction more generally. Federeci (2018) explains that, "a feminist perspective on the commons is important because it begins with the realization that, as the primary subjects of reproductive work, historically and in our time, women have depended on access to communal natural resources more than men and have been most penalized by their privatization and most committed to their defense." Fraser (2022) argues that the current crises afflicting many commons are interlinked - ecological, knowledge and education, and health and social care. Fraser (2022) explains how commons provide the conditions of possibility for modern capitalist relations of production, and that corporate capitalism is parasitic upon these commons and "global care chains", at the same time that it depletes and destroys the very conditions upon which it is reliant.

A general feature of all the forms of commons analyzed here is that each can be understood historically as a site of struggle and that they are often associated with local conflicts or broader social struggles (Berry 2008; Federici, 2018; Fraser, 2022; Linebaugh, 2008; Thompson, 1991). A second general feature of the commons concerns the development of alternative forms of governance that move beyond the market mechanism or the state, where the potential of self-organized user communities has been highlighted across a diverse range of domains, including law (Benkler, 2011; Lessig, 2002), computer studies (Berry 2008), political theory (Fraser, 2002; Hardt and Negri, 2009), history (Hill, 2972; Linebaugh, 2008; Thompson, 1991) and environmental studies (Ostrom, 1990; Patel, 2011). A third general characteristic of these diverse forms of commons is that the commons must be actively maintained through the development of 'technologies of the commons,' which vary depending upon the nature of the commons itself.

In summary, this article has attempted to synthesize diverse strands of research into the commons to show how different 'technologies of the commons can be created for the development of alternative non-market institutions of governance. The article has shown how different technologies of the commons can develop grounded - at least in part - on their specific material conditions. This article also argues that we are now facing a crisis of the commons across of range of domains - informational, social and environmental This crisis emerges from intensifying forms of exclusion, exploitation and expropriation of common resources upon which contemporary global capitalism is reliant for its functioning, which is increasingly unsustainable.

The study of technologies of the commons opens up new research questions for organization theory, particularly concerning the ways in which different social movement organizations become organized around such technologies or the extent to which they give birth to new technologies of the commons (Davis et al., 2005; Spicer and Böhm, 2007). Commons based organizations resemble social movement organizations more than they do commercial enterprises (O'Mahony and Bechky, 2008). Lewis Hyde's (2010, p.12) account of the commons has suggested that, 'a number of social movements… have turned to the old idea of "the commons" as a way to approach the collective side to ownership.' Social movement organizations are organized primarily around a collective identity which in many cases is associated with a collectively owned good, as is the case for environmental SMOs, open source communities and health care SMOs. We might thus turn to social movement organizations to better understand where and how technologies of the commons emerge. A promising avenue in this respect has been developed by De Angelis (2012), who has observed that social movements, such as the environmental movement, Via Campesina and the Zapatistas, have emerged to protect various commons, and are also reliant on those commons for their success. De Angelis (2012, p.17) explains that, "Social movements cannot be conceived without a commons basis for the reproduction of the lives of the subjects participating in them as well as the form of their sociality.", and we could add that these movements also create new technologies of the commons to sustain them. Another related avenue of research is to investigate the success of self-organized user groups and the extent to which this success is linked to their creation and exploitation of specific technologies of the commons. Finally, another potential avenue of research opened up by this line of inquiry is to investigate whether technologies of the commons can provide viable non-market alternatives to exploit the benefits or mitigate the harms associated with externalities and present a way of addressing the emerging crisis of the commons. The potential of these kinds of 'technologies of the commons' and their respective limitations is still an open question and could be a fruitful subject of analysis for future research in the field of organization theory and management studies.

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