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Towards a political ecology of the digital economy: Socio-environmental implications of two competing value models

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ABSTRACT

This article explores the socio-environmental implications of two different value models currently competing for dominance in the digital economy: the neo-feudal cognitive capitalism (NFCC) and the hypothetical case of mature peer production (HMPP). Using a systematisation that considers environmental effects of information and communication technologies as direct, indirect and structural, this article discerns the future socio-environmental scenarios indicative of each value model. We argue that the two value models share the same type of direct environmental effects associated with a similar technological infrastructure; however, their indirect effects differ in prospects of consumer behaviour, environmental awareness and product design. Likewise the difference in structural effects is significant as the NFCC is based on profit maximisation and an accumulation of capital, whereas the HMPP is agnostic to growth and oriented towards the commons. Hence, the latter is considered as the socio-environmentally auspicious choice, but comes not without transitional challenges of its own.

1. Introduction

With an escalating environmental crisis and an unprecedented increase in the use of information and communication technologies (ICTs), it is now more crucial than ever to understand the relation between the two and what socio-environmental scenarios we might expect from such a pattern (Edenhofer et al., 2014; McLellan et al., 2014; Internet World Stats, 2014). While no society can arguably be sustained indefinitely if highly dependent on ICTs and the non-renewable resources they necessitate, it is nonetheless important to understand the politically laden socio-environmental scenarios now emerging. This is so for at least two reasons. Firstly, because the digital economy has long since reached a point at which it is more detrimental to overlook it than to seek a creative management in which its true socio-environmental potential can come to the fore. Secondly, different value foundations can largely be said to determine the meaning of ICTs in society (see Rattle, 2010; Fuchs, 2008), implying that an ecologically coherent digital economy might prove to be beneficial for both local and global environments, given current trajectories.

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Kostakis and Bauwens (2014) have previously argued that the current ICT-driven techno-economic paradigm (abbreviated TEP, Perez, 2002, 2009a,b) has made possible three value models now competing for dominance in the digital economy: that is the traditional proprietary capitalism; the mixed model of neo-feudal cognitive capitalism; and the hypothetical case of mature peer production. As the traditional proprietary capitalist model is arguably in decline (Kostakis and Bauwens, 2014), this article will be more focused on the socio-environmental implications of the two latter models. Investigating the prospect for environmental sustainability of these emerging value models, it is important to consider that ICTs are not void of political struggle and that the competing value models offer separate organisational outlooks for society (Benkler, 2006; Kostakis, 2009, 2012). This includes alternative organisations of the economy, alternative forms of governance, and also, as this article will expand upon, alternative organisations of socio-environmental relations. To our knowledge the peer-to-peer (P2P) value models of the digital sphere have not been explicitly explored from the perspective of sustainability. Bridging this gap this article has two aims. First, it provides an overview of the digital sphere's emerging political economies from a socio-environmental perspective and, thus, contributes to further conceptual refinements for future scenarios enabled by the progressive dynamics of P2P infrastructures. This might be of interest for political economists, policy makers, environmentalists, practitioners and future studies scholars in their effort to bring in theoretical and empirical perspectives on the role of ICTs in transitional scenarios.

Section two presents a theoretical framework in which we can begin to understand the political economies of the current TEP. Then, sections three and four analyse the neo-feudal cognitive capitalism and the hypothetical case of mature peer production respectively, and how they form two separate sets of socio-environmental relations. There we follow a systematisation that has been used among scholars in investigating the environmental effects of ICTs (see Berkhout and Hertin, 2001, 2004; Hilty et al., 2006; Fichter, 2003). This systematisation understands environmental effects of ICTs as direct, indirect and structural (i.e. first, second, and third order effects) and is used to make comprehensible a subject that contains multiple layers of complexity. While we are aware that this method is imperfect, we believe that it makes up for its shortcomings by providing concision and comprehension. Last, section five concludes the analysis and reflects again on the future challenges of the digital economy and environmental sustainability.

2. Theoretical framework[1]

2.1. Capitalism as a creative destruction system

Many would argue that no other economic system than capitalism has produced so much wealth. On the other hand, some might claim that no other system has produced so much destruction. Others consider capitalism a creative destruction system. This article uses the theory of techno-economic paradigm shifts—gradually developed by Schumpeter ([1939]1982, [1942]1975), Kondratieff ([1926]1979), Freeman (1974, 1996), and in particular Perez (1983, 1985, 1988, 2002, 2009a,b)—as its point of departure to develop its narrative. This choice arguably helps recognise the dynamic and changing nature of the capitalist system, in order to avoid any particular period extrapolation as "the end of history" in the fashion of Fukuyama (1992). Interestingly, Marxist and neo-Schumpeterian theoretical approaches consider capitalism prone to crises which are basic features of its normal functioning. However, the neo-Marxist critique (see Wolff, 2010; Harvey, 2010) puts emphasis on the inherent unsustainability of capitalism, aiming at a different system—"modern society can do better than capitalism", Wolff (2010) postulates—whereas neo-Schumpeterians, such as Perez (2002) or Freeman (1974, 1996), see crises as a chance to move the capitalist economy forward. This article is an integrative attempt at highlighting the potential of new modes of social production and organisation immanent in capitalism but which, in the long term, might transcend the dominant system.

Perez (2009b) emphasises the special nature of major technological bubbles (MTB), which are endogenous to the process by which society and the economy assimilate each great surge. The MTB tend to take place along the diffusion path of each technological revolution: from the installation period, when the new constellation of technologies is tested and investment is defined by the short term goals of financial capital (so a rift between real values and article values occurs), to the deployment period, when financial capital is brought back to reality, production capital takes the lead and the state is called to make effective "creative destruction management" (Kalvet and Kattel, 2006). Perez (2009b) argues that the MTB of the current TEP, that is the ICT revolution, occurred in two episodes (Fig. 1).

First was the Internet mania, based on technological innovation, which ended in the NASDAQ collapse in 2000. This was followed by the easy liquidity bubble, based on financial innovations accelerated by the new technologies, ending in the financial crisis in 2007–8. The essential implication of is that "what we are facing is not just a financial crisis but rather the end of a period and the need for a structural shift in social and economic context to allow for continued growth under this paradigm". Moreover, Perez's essay (2009b) on the double bubble is used as a point of departure that treats the current situation as not just another passing recession, and sets the ground for tentative proposals concerning the second half of the ICT revolution's wealth-generating potential.

[1] The theoretical framework provided is a reworked excerpt from the book Network Society and Future Scenarios for a Collaborative Economy by the authors Vasilis Kostakis and Michel Bauwens (2014, Palgrave Macmillan).

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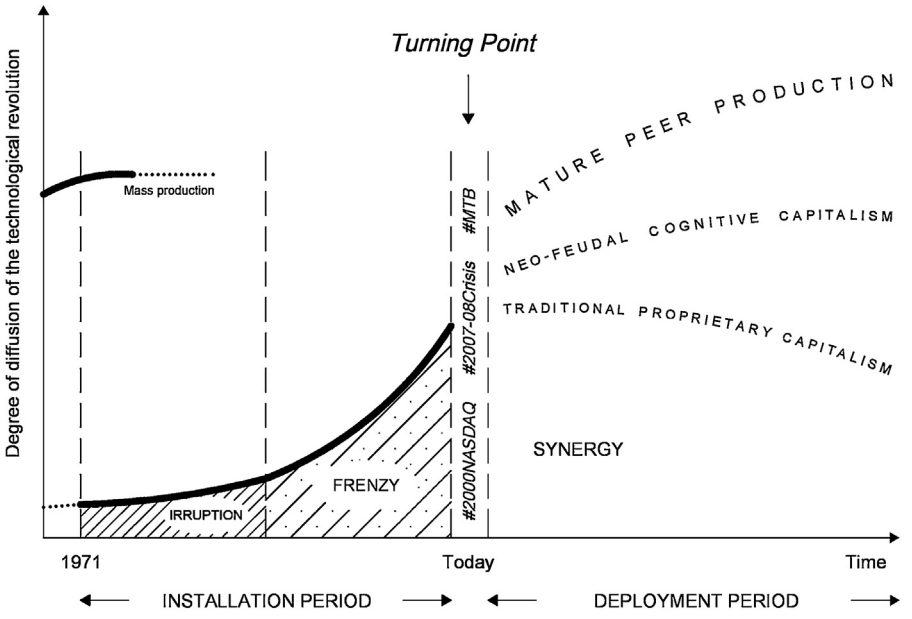

Fig. 1. Three competing value models within the current ICT-driven techno-economic paradigm.

Since the introduction of the microprocessor (California, November, 1971), and after a nearly 30 year-long paroxystic culmination of market experimentation and moments of Galbraithian irrationality (1993), we find ourselves in the aftermath of two major bubbles and, arguably, in the midst of a major capitalist crisis (Fuchs et al., 2014, 193). In other words, we are witnessing the swing of the pendulum from extreme individualism to collective, synergistic well being. The whole system is trying to recompose (Perez, 2002), while political unrest and protests are erupting globally. The world is at a crossroads where the excesses, the fallacies and the unsustainability of the current practices need to be recognised; appropriate regulatory changes have to be made where the usual recipes for confronting tensions fail; and conditions where production capital is put in control, greater social cohesion is achieved, and desperation and anger turn into creation, must be facilitated (Perez 2002, 2009a,b). In other words, this turning point is a time of indeterminate realisation of the full potential of the current ICT-driven paradigm, creating the new fabric of the economy and overcoming the tensions that caused this premature saturation (Perez, 2002).

2.2. Three competing value models

According to Žižek (2010, x), the dominant system is unable to face its internal imbalances and its failures: the ongoing ecological crisis as well as the emergence of new forms of apartheid, walls and slums. Capitalism transforms not because of its failures but because of its successes, neo-Schumpeterians might reply, and now it is high time we created virtuous circles of production that would allow the system to reinvent itself once again. In the meantime, a new type of capitalism, named "cognitive capitalism", arises in which "the object of accumulation consists mainly of knowledge" that is now the basic source of value (Boutang 2012, 57). The industrial mode of production is becoming obsolete and the "network" is the main pattern of organising production and socio-political relations (Castells, 2000, 2003, 2009). P2P infrastructures and renewable energy merge, creating an energy Internet and, thus, inaugurate a third industrial revolution (Rifkin, 2011). Others (see Anderson, 2012) point to emerging desktop manufacturing technologies such as the three dimensional (3D) printing, and consider them the pervasive technological cluster which will trigger a new industrial revolution. Success in taking advantage of these transformations, and, at least in theory, the benefits of new wealth creating potential will spread more widely across society.

Here we argue that, at the current turning point of the ICT-based TEP and within the present political economy, there are three different value models competing for dominance which influence the way institutional recompositions will take place. One form is still dominant, but rapidly declining in importance; a second form is reaching dominance, but carries within itself the seeds of its own destruction; and a third is emerging, but needs vital new policies in order to become dominant (Fig. 1).

The recent crises have brought scholars from various traditions and schools to agree that the global economy is currently at a turning point within the ICT-driven TEP. In this article, we will not deal with traditional proprietary capitalism but with the remaining two competing value models. These are more synchronised with the main characteristics of the current TEP, and seem to introduce less fragile alternative approaches for development in the deployment period. The second form is the neo-feudal cognitive capitalism (NFCC), in which proprietary forms of knowledge are in the process of being displaced by emerging forms of peer production (Benkler, 2006; Bauwens, 2005), but under the dominance of financial capital. We will

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describe how this process is well under way. The third is the hypothetical form of mature peer production (HMPP) under civic dominance, whose stems are already emerging through the interstices of the dominant system.

2.3. The P2P infrastructures: two axes and four quadrants

The P2P technological infrastructures, such as the Internet, are those infrastructures for communication, cooperation and common value creation that allow for permission-less interlinking of human cooperators and their technological aids. We argue that such infrastructures are becoming the general conditions of work, life and society (Bauwens, 2005). Of course, one should be aware of the danger of "Internet-centrism" (Morozov, 2012) and the perception that the Internet is the solution to all of humanity's problems. However, change is unlikely to occur without sufficient ICTs penetration since, as has become evident, various aspects of complex human nature can be amplified and telescoped by the Internet (Mackinnon, 2012). P2P relational dynamics are based on the distribution of the productive forces. First, the means of information production, that is the networked computers, and now the means of physical manufacturing, that is machines that produce physical objects, are being distributed and interconnected. Just as networked computers democratised the means of production of information and communication, the emergent elements of networked micro-factories or what some (see Kostakis et al., 2013; Anderson, 2012) call desktop or distributed manufacturing, such as 3D printing and computer-numerical-control (CNC) machines, are democratising the means of making.

Of course, this process is not without its problems. In a time of extreme polarisation and with no equilibrium reached in regard to global governance of the Internet (Mueller, 2010), we have witnessed conflicts over the control and ownership of distributed infrastructures. For example, the Internet has become a highly contested political space (MacKinnon, 2012). On the one side, peer production signals for some fundamental changes to take place juxtaposing them against an old order that should be cast off (Bauwens, 2005; Benkler, 2006). On the other, the proposed legislations of ACTA/SOPA/PIPA that enforce strict copyright or the attempts at surveillance, public opinion manipulation, censorship and the marginalisation of opposite voices by both authoritarian and liberal countries (MacKinnon, 2012), are only some of the reasons that have made some scholars (see Zittrain, 2008; Mackinnon, 2012) worry that digital systems may be pushed back to the model of centrally controlled information appliances. Hence, there appears to be a battle emerging amongst agents (several governments and corporations), which are trying to turn the Internet into a tightly controlled information medium, and user communities who are trying to keep the medium independent.

This article attempts to simplify possible outcomes by using two axes, or polarities, which give rise to four possible scenarios (and two generic models) on the basis of the turning point of the ICT-driven TEP (Fig. 2). Each quadrant stands for a certain scenario of the deployment phase of the current TEP, i.e. which best practice model for the most effective use of the ICT will prevail. This does not exclude the presence of the rest, however the dominant quadrant arguably defines the kind of TEP and the subsequent political economy which may prevail. As will be described below, the forces at play want to protect their interests through the control of technological and media platforms, which encourage certain behaviours and logics, but discourage others. The powers over technological protocols and value-driven design decisions are used to create technological platforms that match proprietary interests. Even as P2P technologies and networks are becoming ubiquitous, ostensibly similar P2P technologies have very different characteristics which lead to different models of value creation and distribution, and thus to different social and technological behaviours. In networks, human behaviour can be subtly—or not so subtly—influenced by design decisions and invisible protocols created in the interest of the owners or managers of the platforms.

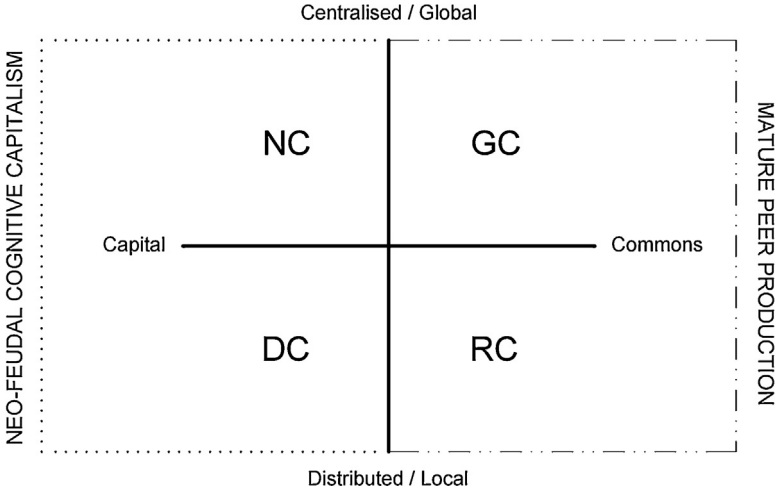

Fig. 2. Two axes and four future scenarios.

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Fig. 2 is organised around two axes, which determine at least four distinct possibilities. The first top-down axis distinguishes centralised technological control (and an orientation towards globality) from distributed technological control (and an orientation towards localisation); the horizontal axis distinguishes a for-profit orientation (where any social good is subsumed to the goal of shareholder profit), from for-benefit orientations (where eventual profits are subsumed to the social goal). Each scenario has a descriptive role and outlines tentative political economies with the aim of sparking the imagination and serving as a route map for the future (Miles, 2004). The first axis presents the polarity of centralised versus distributed control of the productive infrastructure, whereas the second axis relates an orientation towards the accumulation of capital versus an orientation towards the accumulation or circulation of the commons.

Within this context the following four future scenarios for economy and society are introduced: netarchical capitalism (NC), distributed capitalism (DC), resilient communities (RC) and global commons (GC). Netarchical and distributed capitalism differ in the control of the productive infrastructure but both are oriented towards capital accumulation and, thus, are parts of the wider value mode of cognitive capitalism. Here we find the net-giants with centralised governance utilising the P2P infrastructures such as Google and Facebook, but also distributed types of P2P infrastructures with a profit-orientation such as Bitcoin and Kickstarter. Further, this side would include many of the rapidly growing businesses that appeared with the recent explosion of the "sharing economy", whose very definition is still under debate. It is evident, however, that this term is also used to describe activities whose goal is clearly profit maximisation (Schor and Fitzmaurice, 2015). Initiatives like AirBnB, Uber, make huge profits by offering their privately owned P2P infrastructures for individuals to rent out their own resources (Scholz, 2014). Thus, sharing here is no more than a marketing ploy (for more information on the debate on the sharing economy see Baker, 2014; Eskow, 2015; Roose, 2014).

On the other side of Fig. 2, resilient communities and the global commons reside in the, one might say auspicious HMPP under civic dominance (right quadrants). Here, projects such as the free encyclopedia Wikipedia, Free/Libre Open Source Software (FLOSS) and Open Source Ecology (OSE), in the upper right quadrant of GC are conjoined with RC projects and types of organisations of the commons such as the Transition Towns movement and permaculture initiatives as well as true sharing economy projects like time banks and food swaps whose goal is commons-oriented (Schor and Fitzmaurice, 2015).

Thus there are two competing value models which offer different socio-economic outlooks presumably also with different environmental outlooks. We shall now turn to concerns related to the latter.

3. Socio-environmental implications of the neo-feudal cognitive capitalism

3.1. Direct socio-environmental effects

The most evident way in which NFCC platforms can be said to intertwine in local and global ecologies is in their dependency on a material ICT infrastructure. Direct environmental relations of ICTs include the manufacturing process, such as raw material extraction, product assembly and transportation; the usage of the platforms, such as energy demand; and the disposal of obsolete devices, such as e-waste and recycling.

3.1.1. The manufacturing processes

The manufacturing process of ICTs is a scale-dependent and complex endeavour, utilising global logistics that merges multiple production industries. As such, it is hard to determine the environmental effects of particular ICT products. Nevertheless, most studies on the subject seem to agree that the extraction of the materials needed for ICT components is strongly associated with negative environmental effects (Berkhout and Hertin, 2001, 2004; Plepys, 2002; Dudka and Adriano, 1997). Various case studies have shown how industries associated with the extraction of ICT component materials contribute to the loss of local biodiversity, contamination of water flows, damage to farmland and more (Pöyhönen and Simola, 2007; Alier, 2001). In addition, necessary preconditions for a profitable extractive industry such as cheap labour and the need for an extensive local infrastructure (such as roads and railways) tend to exacerbate negative socio-environmental conditions in local environments ranging from slave-like labour circumstances and declining health conditions to deforestation/habitat loss (Fuchs, 2014b; Reed and Miranda, 2007).

A study on the life-cycle assessment of a personal computer (PC) has shown that the pre-manufacturing, i.e. the manufacturing "of the hundreds of electrical parts within the main board" stands for the larger proportion of the negative environmental impacts (Choi et al., 2006, 126). The transportation of the components to and from the assembly process were in comparison relatively negligible when considering impact per unit, whereas the use and disposal of the PC were shown to have significant environmental impacts (Choi et al., 2006).

3.1.2. Use

The environmental effects associated with the actual use of ICTs have so far largely focused on greenhouse gas emissions of servers and search data. ICT use has been estimated to roughly contribute with 0.6 gt, or 2% of global total CO_2 emissions, with a steadily increasing trend (Fehske et al., 2011; Fettweis and Zimmermann, 2008). Google, as one of the largest online websites is the NFCC platform which have been studied the most with regard to greenhouse gas emissions. A tentative calculation from 2011 estimated that one Google search (depending on the definition of a search) emitted on an average one gram of CO_2 (Gombiner, 2011, 122). At that time, there were approximately one billion searches per day, whereas the total searches per day now rise over three times that figure (Internet Live Stats, 2014a, b). These figures point first and foremost

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at an unsustainable trajectory of CO_2 emissions on behalf of the usage of NFCC platforms. Secondly, and more convincingly, they are indicative of a dependency of a fossil economy in which greenhouse gas emissions continues to be the norm rather than a last resort.

3.1.3. Waste and recycling

With an increasing demand for ICT products, electronic waste (e-waste) is believed to be one of the fastest growing waste fractions among rich nations. The correlation between GDP and e-waste is strong, yet the e-waste sites in question are almost exclusively situated in poor or developing nations where e-waste recycling markets have emerged as a result of illegal transnational trade (Widmer et al., 2005; Robinson, 2009; Schmidt 2006; Nordbrand, 2009). ICTs such as PCs and cell phones make out a considerable portion of global e-waste as new models are quickly becoming obsolete both as an effect of design and fashion (Nordbrand, 2009, 11; Schmidt, 2006, 235). The socio-environmental impacts in the local areas where e-waste is processed for valuable parts is significant as large amounts of toxic components are burned, dissoluted in strong acids and rummaged through by workers with little or no protective equipment (Robinson, 2009; Schmidt, 2006). Still, the recycling of electronic components and materials might pose less of a socio-environmental threat than extracting new materials (Schmidt, 2006, 234; Robinson, 2009, 187). The percentage of e-waste which is recycled, however, estimates to no more than 10%, whereas the remaining 90% of obsolete devices are disposed in household trashes (Ladou and Lovegrove, 2008).

3.2. Indirect socio-environmental effects

Here we first address the link between the NFCC value model and the indirect environmental effects of contemporary consumer culture. We look at Facebook and Google in particular as they form a comprehensive link to consumer culture via the utilisation of advertising. Next we discuss to what extent P2P communication in NFCC platforms can be said to contribute to the forming of environmental awareness.

3.2.1. Consumer culture

NFCC can in many ways be claimed to facilitate and exacerbate a modern consumer culture. This link is most obvious in how Google and Facebook utilise advertisement as a means to accumulate capital (Fuchs, 2014a; Cohen, 2008), but it can also be observed in the IBM/Linux cooperation, Kickstarter, AirBnB and Bitcoin (Fig. 3), as they are all concerned with the matter of developing, circulating, or providing the means for a consumer culture. Through collaborating with advertisement firms these can be said not only to facilitate a consumer culture but also to be the ideal market place for promoting it. Advertising on NFCC platforms such as Google and Facebook is therefore not only creating demand for specific goods and services among a wide range of people, but creating the demand for ubiquitous consumption behaviour (see Baudrillard, 1998).

In the context of socio-environmental issues of over-consumption largely driven by the global wealthy (Witt, 2011; Wackernagel et al., 2002) the debate regarding online consumption has so far largely focused on whether e-commerce is more or less resource efficient with regards to transportation, and whether or not the commodities in question are more or less immaterial and therefore less environmentally harmful. Here, advocates of efficiency are confronted by advocates of sufficiency who argue that rebound effects—in the form of total consumption increase—will likely eradicate efficiencies in online consumption (Fichter, 2003; Rattle, 2003). Arguably, we should not presume that the consumer demand created online will

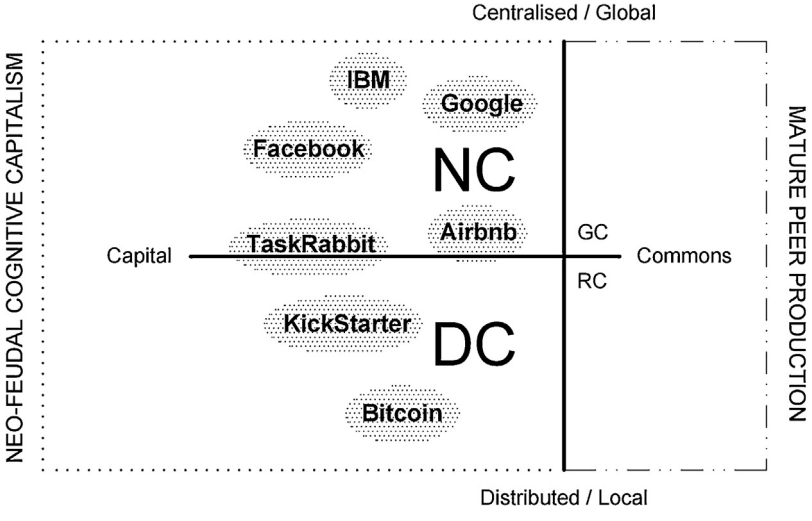

Fig. 3. The mixed model of neo-feudal cognitive capitalism as capital (profit) oriented platforms utilising P2P infrastructures.

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also be saturated online. More than anything, the consumer culture online should principally be understood as an addition and not a substitution in the life of the user. Thus, consumer culture online can be interpreted as yet another step towards universal commodification and thereby a cultural problem of value with significant socio-environmental repercussions (Plumwood, 2002; Rattle, 2014; Chelstowski, 2014).

3.2.2. Environmental awareness

The proliferation of ICTs has no doubt changed the way in which information is communicated, something which has led some scholars to highlight the potential of ICTs in raising environmental awareness (see Tomlinson, 2010). At the same time, conflicting political (and economic) interests formulate environmental issues differently. The deliberate misinformation concerning environmental sustainability on behalf of some well established corporations has for example, given rise to what some call "green-washing", i.e. false marketing and conceptualisation of environmental sustainability and sustainable consumption in particular (Furlow, 2010). There is, however, another dimension to the communication of environmental issues and environmental awareness which is indicative of NFCC platforms in particular. For example, Fuchs (2008) argues that environmental awareness is reinforced through the communication and social relation aspects that sites such as Facebook makes possible, but that it is mostly a matter of reinforcing and not raising awareness as "internet is mainly a sphere of commerce, sex, and entertainment where ecological information and communication are only minority phenomena" (304). In other words, the communication patterns arranged and managed by Facebook typically bring together people who are already sensitive to environmental issues. While it must be considered a strength that otherwise separate groups of environmentalists are brought together in combating global calamities, these efforts typically become an "insider affair" (Fuchs, 2008, 304).

3.3. Structural socio-environmental effects

Perhaps the most important and the most clear way in which NFCC differ from the HMPP is in its structural relation to local and global environments. Here we discuss the notion of a dematerialising economy, rebound effects and design. We then interpret the environmental effects of an emerging digital managerial class in the global economy of scale.

3.3.1. Design

When designing for profit, planned obsolescence becomes a tool and structural feature rather than a bug, as it provides the means to circulate commodities at a controlled rate (Guiltinan, 2009). Planned obsolescence is in many ways detrimental to environments as it exclusively entails the premature exist of valuable materials and components from the world economy, thereby increasing all the aforementioned direct environmental impacts discussed in Section 3.1 through increased production. For example, Choi et al. (2006) in their environmental life-cycle assessment of PCs claim that design with environment in mind is "recommended for improving the entire environmental performance of electronic equipment" (122).

3.3.2. Wage labour

In NFCC the intersection of labour appropriation and consumer culture can be understood metaphorically as a bench vise closing in on user independence. In NFCC users are not paid for their contribution to the continuation of the platforms, and at the same time, they are expected to consume commodities produced by the market. The outcome is perpetuated structural wage labour dependency that carries with it many implications for the life of the users and the structural inertia of society at large. One (out of many) very important environmental implication of wage labour dependency is that users are to a higher degree dependent on food that is produced by the market, and according to the means of the market. This is the norm rather than the exception in industrialised countries where the dependency on the world food market is too little questioned or discussed. Global food market dependency is, however, indicative of a mode of food production in which customary methods of mono-cropping, land grabbing, deforestation, toxification, commodification and enclosure of food varieties and DNA continues to exhaust the "free gifts of nature" (Moore, 2014; Shiva, 1991; Pretty, 2002; Ho et al., 2008).

3.3.3. Dematerialisation

The observations of increasing consumption of services and digital products have led some scholars to consider the global economy to be in a process of dematerialisation (Quah, 1999; Boer, 1998). These notions have gained little momentum among scholars who point out that dematerialisation is in fact the process of displacing polluting industrial processes to other parts of the world-system, and that global material throughput is increasing in the process and therefore not dematerialising at all (Hornborg, 1998, 2009; Malm, 2012). In line with the latter, we would argue that there has been a confusion in the conceptual distinction between dematerialisation and efficiency, in the argumentations of the former.

Yet it is undeniably so that surplus value is increasingly drawn from what we can call cognitive labour (see Boutang, 2012, 32) and that such a pattern of economic growth must be considered very resource efficient. This is not an oxymoron. In fact, this is in line with the logic of the capitalist mode of production if we recap the understanding of capitalism as in constant search for new markets to reinvest in (Harvey, 2010). Such a system does not substitute markets, resources, or wage systems but adds new ones. NFCC can thus be said to operate with a more traditional proprietary value model rather than being a substitute of it. Marina Fischer-Kowalski et al. invite us to think of IT, and in extent NFCC, as an economic sector that is "relatively decoupled" (Fischer-Kowalski and Haberl, 2007, 249). Hence, what we can call semi-immaterialised growth, or,

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a relatively decoupled economic sector must be considered a part rather than a substitution of the global economic whole. What has been observed as dematerialisation is not a matter of less material throughput so much as a matter of an additional relatively decoupled (very resource efficient) economic sector.

3.3.4. Rebound effects

Internally, the relatively decoupled economic sector brings new potential for economic growth but is still not independent of material—and thus environmental—dynamics. Already in the second great surge of development in the age of steam, William Stanley Jevons observed that increased efficiency in machinery running on coal led not to the decreasing but the increasing usage of coal (Alcott, 2005). In short, efficiency made way for increased production and an absolute increase of coal usage (Alcott, 2005; Foster et al., 2010b). The very efficiency that has led some to believe that ICTs are contributing to a process of dematerialisation of the economy, has led others to point out that rebound effects are likely to counterbalance efficiency, and in a worst case scenario increase expected environmental impacts (Fuchs, 2008; Berghout and Hertin, 2004, 915). This is specific for NFCC as opposed to the HMPP because rebound effects are related to the imperative of profit maximisation (Foster et al., 2010b). Here, following the work of Van den Bergh (2011a), we present two ways in particular through which such a rebound effect is likely to occur in NFCC.

1. The "[c]reation of extra demand for relatively energy-intensive goods" is likely to occur (Van den Bergh, 2011a, 47). As we have seen, design in NFCC is linked to the planned obsolescence of electronically devices. Planned obsolescence is a feature to create artificial demand for increased consumption that inevitably leads to further and higher inputs of labour, energy and land in accordance to expanding markets.
2. An increased accessibility of commodities online as facilitated through NFCC is likely to increase overall household consumption and expenditures. Fischter (2003) has argued that while on-line shopping and home delivery of groceries offers to "reduce the total transportation related to grocery shopping and its associated energy consumption and emissions", rebound effects "might be of greater significance with regard to overall environmental impact" (30). In addition, as "[t]ime savings going along energy efficiency improvements of technical equipment may mean that individuals will have more time available which they then can spend on activities that use energy". Hand-in-hand with consumer behaviour mechanisms (see Section 3.2.1) and stratified awareness of environmental issues (see Section 3.2.2) this is indeed a non-negligible rebound effect indicative of NFCC.

Externally—in the view of NFCC as part of an economic whole—there are similar reasons to believe that the global economy is dematerialising as a result of strategic uses of ICTs, for example, in climate monitoring and trade logistics (Farounbi, 2013; Sarkis, 2004). Conversely, the ecological crisis, epitomised by climate change and the increasing global material throughput, points towards a steadily increasing materialisation (Krausmann et al., 2009). Further analysis on claimed efficiencies and how emancipated time, money, resources or other factors of it can "grow again" through online organisation must be made with focus on the matter of rebound effects (Van den Bergh et al., 2011, 4). Here it is also crucial to discern who is profiting from ICTs in the world economy and who is left out.

3.3.5. NFCC in the world economy

It is important to briefly discuss what a digital divide—a separated world-system with regard to digital literacy and Internet access—means for the global socio-environmental arrangements in NFCC. In the framework of TEP we can understand a digital divide to be the outcome of a lag in technological diffusion (Perez, 2002, 64–65). Dependency theorists and environmental historians who consider the world economy to be a "zero-sum game" stress the view that such technological lag is a structural feature for the perpetuation of unequal exchange of land and labour that drives capital accumulation and continued socio-environmental injustices (Hornborg 1998, 2001). Therefore, instead of framing the digital divide as a problem of underdevelopment, it can be framed as a precondition for a continued supply of cheap labour and easily accessible raw materials for the global wealthy through the promise of development and progress to the global poor (Bryant and Bailey, 1997; Bunker, 2005; Escobar, 2006).

4. Socio-environmental implications of the hypothetical case of mature peer production

4.1. Direct socio-environmental effects

Based on the mutual utilisation of ICTs, NFCC and the HMPP share the same type of direct socio-environmental effects, only with slight variation. A variation would primarily come through an alternated process of manufacturing that is made possible in the HMPP; something we here choose to call *design global—manufacture local.* Design global—manufacture local captures an interesting dynamic of distributed production made possible in the reconciliation of global commons and resilient communities (Kostakis and Bauwens, 2014). It is illustrative of how design and manufacturing could be combined in commons-based efforts in such a way that design would be developed, shared and improved globally in the knowledge commons, whereas the actual manufacturing would take place locally with the natural commons and specific local biophysical conditions in mind. The physical manufacturing arrangement for such a productive model could include micro-factories which in essence are small-scale community manufacturing facilities providing appropriate technologies ranging from basic farming tools

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to desktop manufacturing technologies such as 3D printers and CNC milling machines, all open hardware (Tanaka, 2014; Okazaki et al., 2004). Such micro-factories are intended to displace the process of assembly to the home or community of the users and thus usher in a productive model characterised by the distributed means of making and open design. The direct environmental effects of such an arrangement would likely be a decrease in transportation related to the manufacturing process of necessary hardware related to ICTs, and thus the possible downscaling of the modern assembly process which has been very much criticised (Fuchs 2014b, 117–121). Granted, the extraction and processing of the raw material needed for the hardware in question would still bring the previously discussed direct environmental impacts (Section 3.1), as well as maintaining certain fundamentally problematic aspects of dependency.

4.2. Indirect socio-environmental effects

With an alternative manufacturing process in the HMPP comes in turn indirect environmental effects of consequence. Potential environmental effects of such a transition can already be observed in how resilient communities are oriented towards more localised food systems and relative food autonomy with less harmful relations to global and local environments (UNCTAD, 2013; Ho et al., 2008). There are, however, also important indirect environmental aspects of open source hardware, desktop manufacturing and a do-it-yourself (DIY) culture developed mainly around the global commons that in the combination with resilient communities carries promising post-capitalist dynamics.

4.2.1. Dealienation

Depending on the level of reconciliation between the digital commons and resilient communities the HMPP bring important prospects of dealienation, i.e. the re-forming of the worker relation to the means of production, and in turn, to the signs of local landscapes and interconnections (see Pretty, 2002). In Marxist terms the separation of the worker and the means of production—and thus the product of labour—gives rise both to a division of labour as well as the dispossession of the worker's means to "work on nature"; an essential aspect of the human nature, or what Marx called the "species being" (Cox, 2015). The detachment from actively experiencing and engaging in immediate environments is a vital part of the process of alienation as the interconnection between human and the rest of the environment is obfuscated (Foster et al., 2010a, 135–142; for a critical reflection see Hailwood, 2012). Indicatively, in capitalism, workers, consumers and users are kept from experiencing how their labouring is in fact a work on nature, something which in turn limits the successful adaption and conceptualisation of the human relation to biophysical realities and limits.

A productive model that reconciles the means of production and the worker does therefore not simply emancipate parts of the species being but challenges also the omnipresent Cartesian conception of human as separated from nature (Descola and Pálsson, 1996), with positive repercussions in sustainable behaviour (Kim et al., 2010). Of course, one should be aware that the potential dealienating effects of design global—manufacture local is limited in cases where the raw material needed for the manufacturing comes at low cost from somewhere else. Such a scenario must be considered likely during an initial deployment phase of the current TEP as the majority of open source technologies still relies on low cost transactions rather than DIY in the pre-manufacturing and extraction process, even though this is not unheard of (Lipson and Kurman, 2013, 190). This means that the global unequal exchange of land and labour will likely proceed and retain certain levels of techno-fetishism that make many unwittingly equate machines with magic (Hornborg, 2001). The HMPP is, however, not symptomatic of advanced technology dependency in the same fashion as in NFCC where it remains as a central cornerstone of the economy of scale and the preservation of status quo.

4.2.2. Design

In mutualising efforts of global commons and resilient communities the HMPP can thus be said to form a dealienating basis upon which environmental awareness reaches beyond the digital. In the HMPP the digital economy becomes not a sphere independent of ecology, biodiversity, climate change or food, but ideally a vital tool for the understanding of these matters in their local socio-environmental context. As such, the HMPP encourages the diffusion of local knowledge and therefore the incentive to design with what is best for long lasting supportive environments (Bauwens, 2005). Such design can be improved and modulated globally and has the potential to diffuse resilient means of production in both urban and rural context (Kostakis and Papachristou, 2014). Furthermore, design in for-benefit and commons-oriented economies largely contradict planned obsolescence and other means of creating artificial scarcity (Buitenhuis et al., 2010; Pearce, 2012; Pearce and Mushtaq, 2009), thus offering significantly higher resource efficiency than NFCC.

4.3. Structural socio-environmental effects

Since the digital commons is essentially based upon the natural commons it cannot be sustained in the long dureé without an effective management of the natural commons. Conversely, the mismanagement of the digital commons might produce very undesirable socio-environmental consequences (see Rattle 2010, 15–18). From this mutual dependency relation we must ask to what extent the circulation of commons in the HMPP means an increased or decreased displacement of the natural commons already under enormous pressure (see Rockström et al., 2009). As an initial effort to understand this we will herein discuss how the circulation of the commons relates to the concept of growth, the ecological crisis, rebound effects and the matter of transition.

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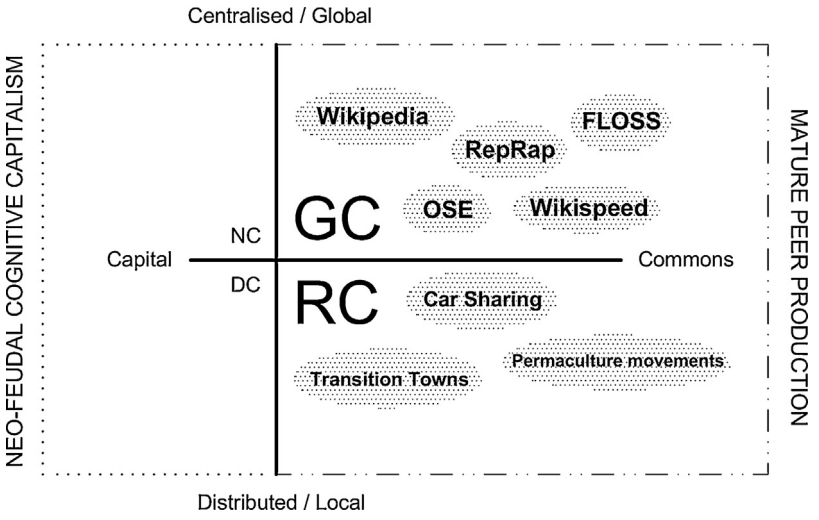

Fig. 4. Commons oriented platforms and initiatives associated with the hypothetical case of peer production.

4.3.1. The role of growth in the circulation of commons

While the HMPP would not be oriented with a growth imperative it would neither be necessarily oriented with a degrowth imperative. Instead, it would predominantly be oriented towards the circulation of commons and agnostic about growth in every aspect. The concept "a-growth" (Van den Bergh, 2011b) could possibly be a suitable description for the underpinning economic logic of a social arrangement around the commons. But, one might ask: what does the circulation of a common mean if not the growth of a commons? To equate the circulation of commons with the growth of commons would be illustratively correct, but it would also mean to overlook the diversity and flexibility that makes the circulation of the commons in many ways superior to the circulation of capital. The circulation of commons must instead be considered as contextual to the notion of growth because the association around a common could imply either an increasing or decreasing of scale. For instance, both the adding and revising/deleting of knowledge in digital commons (such as Wikipedia) can both be an outcome of the successful creation of value in that commons. As such, it is primarily the reciprocal relation of nurture and benefit that characterises the circulation of a commons, as opposed to the increasing scale- and markets as in proprietary models (see Harvey, 2010). Thus we see that "growth" in commons is of a different kind.

To illustrate this we can look at the Open Source Ecology (OSE) project, an open hardware project aiming at making available a set of fifty agricultural- and manufacturing machines (the so-called "Global Village Construction Set") required for a small, sustainable and local-based society (Fig. 4). The design of the machines in question is modular and openly managed by a globally networked group of participants/creators, and every revision of the design is intended for the final product to increase in performance in relation to a given local context. Designers thus design for sustainability, transparency and local needs. What we call 'growth' can here be seen as an improved benefit, or a strengthened socio-environmental relation mediated by communities in need. Of course, it is notoriously difficult to decouple technology and machinery from the material they necessitate, or rather, the social relations they necessitate (Hornborg, 2001; see Section 3.1) which is why the *mature* case of peer production is by definition a reconciliation between projects like the OSE and resilient communities such as permaculture movements which seeks to nurture a long lasting and non-harmful relation to the living biosphere from which materials are extracted (Mollison et al., 1991, see Fig. 4).

4.3.2. Commons in crisis

As the HMPP rise in a historically unequalled context of ecological destruction it is questionable to what extent it will be sufficient to remain agnostic to growth in the management of the commons. If the point of departure would be that of ecological balance then the indifference towards growth could be easily justified, but seeing as this is not the case—with metabolic rifts having left some bioregions drastically overburdened and others considerably scarce (Foster et al., 2010a; Moore, 2011)—the indifference towards growth, and thus degrowth, might indeed turn out to be a barrier for environmental sustainability. Thus the circulation of the commons would need some form of (at the very least initial) balancing mechanism that does not simply support the circulation of a common but the simultaneous balancing of that common, especially so in the management of the natural commons in crisis. If an inbuilt balancing mechanism is in any way improbable then short term techno-fixes might contribute to re-establishing balances. Such interventions—associated with e.g. geo engineering—are often considered controversial though (Barrett, 2008; Robock, 2008) which is why the degrowth approaches or "doing more with less" should also be seriously considered in the HMPP.

With this in mind the HMPP rises not only in the midst of ecological destruction but also in an unparalleled circumstance of unequal distribution of power, that with a digital divide is not only a matter of national but also international concern for

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environmentally sustainable policy making. This must also be considered, specifically at the synergy phase if the HMPP is to realise its full potential and (possibly) outpace NFCC in environmental sustainability.

4.3.3. Rebound effects in the circulation of the commons

While rebound effects are typically associated with the increasing of scale indicative of the capitalist mode of production there are still a few concerns with regards to this issue also in HMPP. After all, as we have pointed out, HMPP is rising *within* capitalism. Van den Bergh (2011b) has previously pointed out that certain aspects of the degrowth movement could trigger mechanisms that increases overall energy expenditures. Moreover, rebound effects indicative of a global installation of distributed production infrastructure as suggested in HMPP raises also some questions of socio-environmental concern. For clarification we turn to one of the more famous open source 3D printing projects, the RepRap project.

Founded by Adrian Bowyer in 2005 but rapidly grown to a world-wide effort for distributed manufacturing, the RepRap project offers a family of small-scale 3D printers capable of re-producing their own parts as well as producing a range of useful household products (Jones et al., 2011). The costs to produce a RepRap 3D printer is cheap, only around €500–1000 (Ibid.), thus making it easily accessible for most any household in the wealthier parts of the world. One central concern from a socio-environmental perspective with regards to the RepRap 3D project is whether raw material and energy demand will increase or decrease if near every household acquired a printer. Herein lies also, we believe, the highest risks for undesired rebound effects. If every household acquired a 3D printer total energy demands and material consumption might indeed increase. Conversely, what is repeatedly encouraged in the HMPP value model is the collective nature of ownership and distribution, i.e. not a "one printer per person" doctrine. A good way to tackle this concern, nonetheless, is to promote not only distributed production, but also further understandings of what we may call distributed extraction. Raw material extraction, as we have pointed out, is often an overlooked environmental issue in DIY solutions, which at once reflects the problem and need of a reconciliation between the global commons and resilient communities in the realisation of a HMPP. This could help mitigate rebound effects by internalising, rather than externalising, material and labour costs.

4.3.4. Transition

Finally, the matter of a techno-economic transition phase can provide some important environmental perspectives. While the HMPP has post-capitalist features it is initially in need of support in order to be a pragmatic option for users. From this standpoint, the flow of capital from traditional proprietary businesses to the commons might be introduced through a commons-based reciprocity license (for example, in the vein of the Peer Production License) that would operate as a mechanism allowing anyone to benefit from the commons if they also contributed to the commons. This would introduce reciprocity in commercial exploitation of the commons with the aim of strengthening the "commoners" (Bauwens and Kostakis, 2014). What exact forms of value a commons-based reciprocity license should contain would ideally be discussed and decided by the communities and peer clusters themselves, in order to ensure appropriate costs. An alternative that might be auspicious from a socio-ecological perspective is to measure reciprocity not in terms of value but in "net flows of energy and materials" (Hornborg 1998). With commons-based reciprocity licenses we could, however, expect not only a strengthening of the commoners but also a strengthening of profit-oriented businesses, as they too would benefit from the cost-effective advantage of the commons, albeit not with impunity. Hence, there is a risk that a continued co-existence of the circulation of capital and the circulation of commons will lead to a mild form of what Kostakis and Stavroulakis, (2013) call "a parody of the commons" in which profit-driven relations of production parasite on the circulation of the commons. This would mean a temporary proliferation of the means for capital accumulation and thereby an inertia in the societal transition from business-as-usual that would arguably fail to address the acuteness of the ecological crisis (see Anderson and Bows, 2011). Therefore the HMPP must, once again, be considered as a long term solution rather than an immediate fix.

5. Conclusion

This article has provided a tentative analysis of the direct, indirect, and structural socio-environmental implications of the neo-feudal cognitive capitalism (NFCC) and the hypothetical case of mature peer production (HMPP); two competing value models in the digital economy. Of course, we do not claim to make all inclusive conclusions as there are numerous effects which have not been addressed. The socio-environmental effects that have been taken into consideration can nonetheless be argued to point to non-negligible tendencies that evidently separate NFCC from the HMPP in terms of socio-environmental sustainability. Table 1 provides a synthetic overview of the two competing value models.

Firstly, it is important to note that both of the two value models share the same direct environmental effects as they are mutually utilising ICTs, and are thus offering futures dependent on a steady influx of non-renewable raw material and energy associated with a range of socio-environmental complications. HMPP will, however, likely distinguish itself in this regard as it supports novel productive models such as distributed manufacturing with good chances of alternating global chains of production to the benefit of future socio-environmental dynamics.

Secondly, the indirect environmental effects specific of NFCC platforms largely come through associations with proprietary informal (and formal) institutions such as a consumer culture that reinforces patterns of universal commodification and the continuation of environmentally unsustainable behaviour. We should, however, not forget that NFCC platforms do offer dynamics that are widely supporting communication and knowledge. But to whom, and to what end? The HMPP in its association with progressive dynamics of open source technologies, distributed manufacturing and the emerging small

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Table 1
The political, economic and socio-environmental ortientation of NFCC and HMPP; two value models competing for supremacy in the digital economy.

	Political orientation	Economic orientation	Direct socio-environmental effects (material)	Indirect socio-environmental effects (cultural, behavioural)	Socio-environmental orientation (structural)
NFCC	Under control/influence of financial capital	Accumulation of capital	Unequal distribution of infrastructural burdens	Commercialisation of nature and human alienation	Internet and ICTs as an instrument to capitalise on the decline of life
HMPP	Under control of civil society	Circulation of commons	Equal distribution of infrastructural burdens	A likelihood of proliferated environmental awareness and celebration of human collaboration	Internet and ICTs as an instrument to harmonise and connect local and global commons

scale farming paradigm offer a digital sphere that is reciprocally linked to the means of production in the hands of the users and thus a tool for the creation of social value, sustainable design and possible reconnection to landscapes.

Thirdly, as opposed to some beliefs, we have argued that the global economy is not becoming dematerialised but rather that a new economic sector associated with NFCC is rising, one that can be described as relatively decoupled. While efficiencies provide promising outlooks for the continuation of infinite growth, rebound effects inherent in the profit motive are continually counteracting expected environmental mitigations. In line with its inherited economic logic, NFCC can largely be said to maintain proprietary structures that preserves current trajectories pointing at continued socio-environmental calamities and inequalities, and in the end, provide no alternative to the increase of environmentally unsound consumption and production associated with the destruction of the natural world.

In contrast, the HMPP offers a digital sphere active in the innovation and creation of alternative modes of production that could transform and democratise the means of making, with promising environmental consequences, though not without transitional challenges and repercussions. We have argued that the HMPP currently lacks an internal mechanism to combat already existing social and ecological imbalances intrinsically linked to power relations. This in particular is a matter in need of further research and development. Meanwhile, commons-oriented communities produce use value and products that are designed to last as long as possible, providing us with a foretaste of the HMPP and a more ecologically coherent digital economy.

In the broadest sense, uncovering ICTs and their socio-environmental implications can be seen as a vital part in uncovering what it today means to be human. A non-thorough scrutiny of the social pervasion of ICTs and the Internet has arguably contributed to a generic oversight of its socio-environmental impacts. In our attempt to fill this gap of knowledge we have argued that an understanding of the socio-environmental impacts of ICTs is incomplete without a consideration of political economies. The Internet should be considered as a locus of struggle between different values, usages and types of exchange determined by the techno-social design of the systems. This means for policy makers, citizens and researchers that systematic evaluations aimed at understanding what values underscores online platforms and organisations are crucial in realising a responsible and harmonious coexistence.

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