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At the Turning Point of the Current Techno-Economic Paradigm: Commons-Based Peer Production, Desktop Manufacturing and the Role of Civil Society in the Perezian Framework

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Abstract: Following the theory of techno-economic paradigm shifts (TEPS), this paper calls attention to the phenomenon of Commons-based peer production (CBPP). In the context of the current paradigm, it argues that civil society can play an important role in creating favourable conditions for a more sustainable global knowledge society. Approaching tentatively the ways in which 3D printing and other desktop manufacturing technologies can be used in CBPP, it also explores the ways in which the partnership with the state may provide a supportive innovative institutional basis for taking the maximum advantage of the emerging synergies in the vein of TEPS theory.

Keywords: Peer Production, 3D Printing, Techno-Economic Paradigm Shifts, Civil society, Commons, Heterodox Economics, Collaboration

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This paper uses the theory of techno-economic paradigm shifts (TEPS) theory – gradually developed by Kondratieff (1979), Schumpeter (1982/1939; 1975/1942), Freeman (1974; 1996), and in particular Carlota Perez (1983; 1985; 1988; 2002; 2009a; 2009b) – as its framework to develop its narrative. This choice arguably helps recognise the dynamic and changing nature of the capitalist system in order to avoid any particular’s period extrapolation as “the end of history” in the fashion of Francis Fukuyama (1992). The Perezian framework, as discussed later in more detail, can be considered as a neo-Schumpeterianist approach influenced by (neo-)Keynesiasm policies, that understands capitalism as a creative destruction system. Therefore, the aim is not to make capitalism crisis-free but to manage crises and soften blows or, in other words, to make a successful “creative destruction management” (Kalvet and Kattel 2006). One should be aware of many other theoretical alternatives, such as the Marxist ones, in understanding and acting within certain social, technological and economic processes. It would be interesting to mention that both Marxist and neo-Schumpeterianist theoretical approaches consider capitalism prone to crises which are basic features of its normal functioning. However, the neo-Marxist critique (see Wolff 2010; Harvey 2007; 2010) puts emphasis on the inherent unsustainability of capitalism aiming at a different system – “modern society can do better than capitalism”, Wolff (2010) writes – whereas neo-Schumpeterians, such as Carlota Perez (2002) or Christopher Freeman (1974; 1996), see crises as a chance for moving the capitalist economy forward. The take of this paper is integrative trying to highlight the potential of new modes of social production which are immanent in capitalism but, in the long term though, might be transcendent to the dominant system. That is why we chose to develop our narrative within the Perezian framework applying the interpretative theory of TEPS.

1. The Theory of Techno-Economic Paradigm Shifts in a Nutshell

If we follow Schmoller (1898/1893), the main figure of German Historical School, history is the laboratory of the economist. Despite the unquestionable uniqueness of each historical period in the socio-economic development, the theory of TEPS accepts recurrence as a frame of reference and, having each period's uniqueness as the object of study, tries to interpret the potential and the direction of change (Perez 2002). Moreover, it embraces the Schumpeterian (1982/1939) understanding of economy as "an interdependent sequence of dynamic forces of change and static equilibrating forces" (Drechsler et al. 2006, 15). The essential fact about capitalism, according to Schumpeter (1975/1942), is the process of creative destruction which incessantly revolutionises the economic structure from within, destroying the old one, while it creates a new one. Each techno-economic paradigm (TEP) is based on a constellation of innovations, both technical and organisational, that consists the driving force of economic development (Perez 1983), and plays the central role in the recurring pattern of the cyclical movement: from gilded ages to golden ages; from an initial installation period, through a collapse and recession which consist the turning point, to a full deployment period (Perez 2002; 2009a). Therefore, in the Perezian framework (2002; 2009a), progress in capitalism takes place by going through various successive great surges of development which are driven by successive technological revolutions. Each of these overlapping great surges of development, which lasts approximately 40-60 years, consists the process by which a technological revolution and its paradigm propagate across the economy, "leading to structural changes in production, distribution, communication and consumption as well as to profound and qualitative changes in society" (Perez 2002, 15).

According to the TEPS theory, during the last three centuries civilisation has experienced five technological revolutions: the first industrial revolution based on machines, factories and canals (initiated in 1771; birthplace: Britain); the age of steam, coal, iron and railways (1829; Britain); the age of steel and heavy engineering (1875; Britain, USA, and Germany); the age of automobile, oil, petrochemicals and mass production (1908; USA); and the age of information technology and communication (1971; USA). Each of these processes evolved "from small beginnings in restricted sectors and geographic regions", and ended up "encompassing the bulk of activities in the core country or countries and diffusing out towards further and further peripheries, depending on the capacity of the transport and communications infrastructures" (Perez 2002, 15). A great surge of development consists of four phases, which, although not strictly separated, can be identified as sharing common characteristics throughout history. Firstly we have irruption (technological explosion) that is the initial development of the new technologies in a world where the bulk of the economy is made of old, maturing and declining industries; then frenzy follows, which is a very fast development of technology that needs a lot of finance (this is when the financial bubbles are created). These two first phases constitute the installation period of the new TEP, when finance and greed prevail and the paper economy decouples from the real one. Next, turbulent times come (i.e. collapse, recession and instability) in what Perez calls the turning point, which is neither a phase, nor an event but a process of contextual change when the institutional changes are made for the deployment period of the installed paradigm to begin. A lot of institutional innovation takes place and economies are enabled to take full advantage of the new technology in all sectors of the economy and to spread the benefits of the new wealth creating potential more widely across society. These synergies occur in the early stage of deployment (synergy phase) until they approach a ceiling (maturity phase) in productivity, new products and markets. When that ceiling is hit, there is social unrest and confrontations while the conditions are being set for the installation of the paradigm which will be based on the next technological revolution.

2. At the Turn of the Century: The Two Major Bubbles

Perez (2009b) brings to the fore the special nature of major technological bubbles (MTB), which are endogenous to the process by which the society and 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 paper values occurs), to the deployment period, when the 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, i.e. the information and communications technology (ICT) revolution, occurred in two episodes. First, it was the internet mania, based on technological innovation, which ended in the NASDAQ collapse in 2000; followed by the easy liquidity bubble, based on financial innovations accelerated by the new technologies, which ended in the financial crisis in 2007-8. The essential implication of Perez' argumentation (2009b, 803) 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' essay (2009b) on the double bubble, aligned with the TEPS theory, 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 ICT revolution's wealth-generating potential.

Supposing that the Perezian framework of TEPS is valid, this article calls attention to the phenomenon of social production, i.e., Commons-based peer production (Benkler 2006) which is a recapitulation of the civil society within global information-based economy (Bollier 2009), in relation to the recession of the current TEP and outline possible directions for social policy, development and change. This paper begins with addressing briefly the major challenges posed by the current recession in a Perezian line. Then, based on theory and cases related to Commons-based peer production, it argues that the role of civil society – in the form of the "multitude" (Hardt and Negri 2001), "general intellect" (Virno 2001), "prosumers" (Toffler and Toffler 2006), "produsers" (Bruns 2008), "users" (von Hippel 2005) or just "people" – in creating favourable conditions for a sustainable global knowledge society in the deployment period of the current TEP, is of a great importance, arguably much greater than it was in previous TEPs. This brings to the fore the concept of partner state which provides a tentative basis for institutional innovations that can make the best of the impending opportunities and create the enabling synergetic infrastructure. Finally, a brief summary of the argument follows with a reference to its implications in terms of policy challenges.

3. The Turning Point and the Three Structural Tensions

After the paroxystic culmination of almost 30 years, since the introduction of the microprocessor in November 1971 in California, 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, Schafranek, Hakken, and Breen 2010, 193). In other words, we are witnessing, as we will later see, the swing of the pendulum from the extreme individualism to the collective, synergetic well being with the whole system trying to recompose (Perez 2002), while political unrest (for example the EU coherency crisis triggered by the debt crisis) and protests (from the Indignados movement in Spain and Greece to the Occupy Wall Street movement in the USA) are globally erupting. It is not, though, this paper's goal to describe either the strands and ramifications of the current crisis, as this has be done elsewhere (see Harvey 2007; 2010; Chomsky 2011; Funnell, Jupe, and Andrew 2009; Stiglitz 2010), or the historical parallels of previous turning points within capitalism, as Perez has done it in detail in her 2002 book. It can be claimed, however, that the two bubbles at the turn of the century bring to mind the 1929 depression as they share one fundamental characteristic: the structural tensions within capitalism make the system, at least in its current form, unsustainable. The world is arguably at a crossroads where the excesses, the fallacies and the unsustainability of the current practices have to be recognised; appropriate regulatory changes have to be made where usual recipes to confront the tensions fail; and the conditions, where the production capital is put in control, greater social cohesion is achieved and the desperation and anger turn into creation, have to be facilitated (Perez 2002; 2009a; 2009b). In other words the turning point is a time of indetermination realising

the full potential of the current ICT paradigm, creating the new fabric of the economy and overcoming the tensions that cause this premature saturation (Perez 2002).

In this paper the discussion is organised with regard to two of the three structural tensions which, following Keynes (1972), build up and lead to the recession. It is important to note down that since the goal of this essay is to call attention to CBPP and its conjunction with desktop manufacturing as well as to shed light on the partner state approach within the TEPS framework, it is chosen, here, to take a Keynesian position which is aligned with this theory. We are aware of significant neo-communist or socialist perspectives which have been quite influential recently. Just to mention Douzinas' and Zizek's edited book (2010) which emphasises the continuing significance of the communist idea and the need to reconfigure the concept; Dean (2012) who claims that if people, with the aid of ICT, organise on the basis of their common and collective desires revolution is still possible; Panitch, Albo, and Chibber (2011) who dispute the allegations for an ongoing economic recovery phase highlighting the mobilisations that reject "the neoliberal offensive" or "its accumulated devastation" (20111, x); Harvey's (2007; 2010) and McNally's (2010) works on the crises of capitalism and the proposed emancipatory scenarios/solutions; or Lapavistas (2012) collected volume which, mainly drawing on (neo)Marxist theory of finance, attempts to examine domestic and international aspects of financialisation and the 2007-9 crisis in an arguably appropriate social context.

As said, this paper's narrative is based on the idea that moving to the synergy phase requires overcoming these tensions in a Keynesian line (1972) informed by Perez' work. This can happen through institutional recomposition; through the introduction of a wide range of new instruments and processes; and even through the "overturning of some eternal truths" (Perez 2002, 132). The first tension, which takes place between the growth of paper values divorced from real economy and the capacity for the creation of real wealth, can lead to an unsustainable casino economy (Strange 1997; Sinn 2010) and scandals, due to extreme pressures for serving unrealistic short-term financial criteria put upon the production world. Thus, according to the TEPS framework, for this tension to be overcome paper values have to be readjusted and brought back to meet realistic expectations through directed institutional action and regulation (Perez 2002; 2009a; 2009b). The absence of a proper regulatory framework and the introduction of New Public Management practices can set the ground for havoc to be created by speculative interests (see Drechsler 2005). In this paper the focus is placed, however, on the two other tensions which our discussion about the emerging civil society's production models is relevant to. The second tension is between the potential for further productive developments, on the one hand, and the profile and rhythm of existing global and local demand on the other (Keynes 1972; Perez 2002). The third tension to overcome is provoked by the pressures generated by the increasing gap between the countries and the populations that have been getting richer and those that have been trapped in debt, crisis, despair and anger (Keynes 1972; Perez 2002). Arguably there are no ready-made recipes and successful grandiose systemic substitutions, but the steps towards the deployment phase should be harmonised within the logic of the current TEP and apply widely its new "common sense" principles.

4. Towards a New Fabric of the Economy: The Role of a Civil Society With New Capabilities

4.1. The Emergence of Commons-based Peer Production

It has been a common assumption during the last decade or two that the world has been shifting towards information- and networked-based structures, with information production in the limelight (see Castells 2000; 2003; 2009). During the installation period of the current TEP, based on and led by ICT, two parallel shifts have taken place: not only did the economically most advanced societies move towards an information-based economy, but the declining costs of ICT also made them available to a much wider part of the world population (Benkler 2006; Castells 2000; 2003; 2009; Perez 2002). Yochai Benkler (2006) has argued that this has led to the creation of a new communicational, interconnected, virtual environ-

ment from which a new social productive model is emerging, radically different from the industrial one. He describes this new model, exemplified by the free/open source software (FOSS) projects or the online encyclopaedia Wikipedia, as Commons-based peer production (CBPP), which reduces the value of proprietary strategies and allows for large-scale, voluntary information production efforts (Benkler 2006). Therefore, CBPP, in this context, could be considered a new mode of production, enabled through internet-based co-ordination where decisions arise from the free engagement and co-operation of the people, who coalesce to create common value without recourse to monetary compensation as key motivating factor (Bauwens 2005; Bauwens cited in Orsi 2009; Benkler 2006). It is a mode arguably more productive concerning the creation of information value, in which the creative energy of civil society is co-ordinated into meaningful projects without the traditional hierarchical organisation (Bauwens 2005; Benkler 2006; Weber 2004).

In addition, it has frequently been argued (Bauwens 2005; Benkler 2006; Bruns 2008; Lessig 2004) that simultaneously culture is becoming more participatory and self-reflective, "where many more of us participate actively in making cultural moves and finding meaning in the world around us" (Benkler 2006, 15). Millions of blogs and media hubs, the open-access and open-content movements and the free dissemination of music, photography and literature via Commons-oriented licenses provide an account of the "free culture movement".

On the other hand, Keen (2007) asserts that this "free culture movement" is actually a threat to our culture, and thus to humanity, being full of seductive utopian delusions and fostering low-quality creativity. In his 2012 book, Keen's critique focuses on social media companies like LinkedIn or Facebook arguing that the social media transformation is disorienting and dividing people rather than leading to a new egalitarian or communal era. Furthermore, Lanier (2010) compares the collaborative communities of CBPP projects to Fascist, Stalinist or Maoist-style collectivism to reach the conclusion, in almost the same vein as Keen (2007; 2012), that the internet users are marching towards a dystopia under the guidance of an authoritarian collective voice. It has been also argued (Carr 2011) that the internet, premised on the industrialist ethic of efficiency and consumption, weakens people's capacity for concentration, contemplation, and reflection. Moreover, lately it has been common to consider the internet to be an unprecedented tool for political progress, as it arguably celebrates and fosters some crucial democratic values. However, "history", as Diamond writes, "cautions against such hubris. In the fifteenth century, the printing press revolutionized the accumulation and dissemination of information, enabling the Renaissance, the Protestant Reformation, and the scientific revolution" (2010, 71). But also the printing press enabled the emergence of the centralised state and facilitated censorship (de Sola Pool 1983; Diamond 2010). Today, not only authoritarian states such as China and Malaysia, but also countries of the Western world are trying to control the internet. Morozov (2012) maintains that the internet is a tool that both revolutionaries and authoritarian governments can use. For example, in Iran and China, Morozov (2012) says, social media have been used to entrench dictators and threaten dissidents leading to a democratic decline. However, in China, for instance, although various quasi-Orwellian control practices of the internet are exercised, "there is too much communication and networking […] for the state to monitor and censor it all […] Chinese netizens – particularly the young who are growing up immersed in this technology – are inventive, determined, and cynical about official orthodoxy […] they quickly share what they learn" (Diamond 2010, 74).

It is obvious (just to mention the recent global demonstrations against the proposed copyright legislations, namely ACTA and SOPA/PIPA) that there is a battle amongst governments, which are trying to turn the internet into a tightly controlled information medium, and users who are "quickly sharing what they learn" and are trying to keep the medium independent. Some of them also take part in this new social productive mode of Commons-based production, whose import has been grasped and interpreted in different manners. For instance, Virno (2001), reading Marx's *Grundrisse* (1993/1983) and building on the concept of the "general intellect", wonders whether the public character of information production can form the actual basis for a new, radical form of democracy and of a more autonomous society free of capitalist relations. Whereas capitalists of information production (for example the

owners of the platforms: Google, Yahoo, Facebook or Apple with its application-based economy) see the creative multitudes as a chance to achieve economies of aggregated attention, labour valorisation, appropriation of social innovation and thus profit maximisation (Kostakis 2009, 2012).

Many scholars have highlighted the original characteristics of CBPP and the Commons considering them either as immanent (Benkler 2006; 2011; Moore and Taylor 2008; von Hippel 2005; Tapscott and Williams 2006), transcendent (Hardt and Negri 2011; Merten and Meretz 2009; Siefkes 2007; Rigi 2012) or even, following an integrative approach, both immanent and transcendent (Bauwens 2005; 2009a) to the capitalist system. Bauwens (2005; 2009a) argues that CBPP simultaneously creates a new form of capitalism while pointing out how that new form can be overcome. As a hyperproductive mode CBPP forces the for-profit entities to adapt to its characteristics, "thereby further integrating it into the existing political economy, but not without the transformative effects of its market transcending aspects" (Bauwens 2009a, 121). The take of this paper concerning the potential of CBPP is in line with Bauwens' idea that this passionate mode of production (Moore and Karatzogianni 2009) is part of a new type of capitalism that has seriously been developing since the beginning of the current TEP as well as that it has many post-capitalistic aspects capable of building an alternative civilisation and, under certain conditions, could rise to a dominant role in the long future, though. For the moment being the latter possibility is not the case and, with regard to the aforementioned criticism which mistakenly equates proprietary-based initiatives (e.g. Facebook) with Commons-based ones (e.g. FOSS), the ICT revolution exhibits both emancipatory/creative and exploitative/dystopic aspects, and the role of the civil society is to foster the one over the other strengthening the Commons (Fuchs 2008; Kostakis 2009).

4.2. Fundamental Characteristics and Challenges of Commons-based Peer Production

According to Benkler (2006), CBPP is a more productive system for informational value than the market-based or the "bureaucratic-state" ones. It produces social happiness as it is based on intrinsic positive motivation and synergetic co-operation (Benkler 2006; Hertel, Niedner, and Herrmann 2003; Lakhani and Wolf 2005). Benkler makes, amongst others, two intriguing economic observations which challenge some "eternal truths" of the so-called Standard Textbook Economics (STE). Commons-based projects serve as examples where the STE's assumption – today often theoretically softened but practically still ubiquitous – that in economic production, the human being solely seeks profit maximisation is fundamentally challenged. Volunteers contribute to information production projects, gaining knowledge, experience, reputation and communicating with each other, i.e., motivated by intrinsically positive incentives. This does not mean that the monetary motive is totally absent; however, it is relegated to being a peripheral concept only (Benkler 2006). The second challenge comes against the conventional wisdom that, in Benkler's words, "we have only two basic free transactional forms – property-based markets and hierarchically organized firms" (2006, 463). CBPP can be considered the third one, and it should not be treated as an exception but rather as a widespread phenomenon, which, however, for the moment, is not counted in the economic census and the institutional design (Benkler 2006). In STE terms, what is happening in CBPP can be considered, as Bauwens (2005) maintains, "only in the sense that individuals are free to contribute, or take what they need, following their individual inclinations, with a (sic) invisible hand bringing it all together, but without any monetary mechanism". Hence, in contrast to markets, in CBPP the allocation of resources is not done through a market-pricing mechanism, but hybrid modes of governance are exercised, and what is generated is not profit, but use value, i.e. a Commons (Bauwens 2005).

Following Bauwens (2005; 2009a) CBPP is based on practices which stand in contrast to those of the market-based business firm. More specifically, CBPP is opposed to industrial firms' hierarchical control, but rather based on communal validation and negotiated coordination, as quality control is community-driven and conflicts are solved through an ongoing mediated dialogue. In addition, instead of the division of labour in CBPP, a distribution of modular tasks takes place with anyone able to contribute to any module while the thresh-

old for participation is as low as possible. Further, CBPP is opposed to the for-profit orientation of market-driven projects, as CBPP projects have a for-benefit orientation, creating use value for their communities. And finally, it is opposed to the rivalry (scarcity of goods) through which market profit is generated, as sharing the created goods does not diminish the value of the good, but actually enhances it. The CBPP projects typically flourish in states of abundance, which is arguably a natural, inherent element of information in contrast to the conventional understanding of intellectual production (Kostakis 2012). The latter, through the introduction of intellectual property (IP) in the form of strict patent and copyright law, constantly tries to artificially create scarcities in order to generate profit (Kostakis 2012). IP supporters claim that it offers the necessary motives, i.e. the profit/revenue motive, for information production and innovation to occur. However, there is a vast amount of literature critical of the concept of IP (see Lessig 2004; Bessen and Meuer 2009; Boldrin and Levine 2007; Burrell and Coleman 2005; McLeod 2007; Patry 2009), which maintains that IP is actually a government grant that leads to private monopolies, and can be extremely dangerous for social innovation, culture and society, and calls for change in institutions and laws.

Information is a non-rival good with near zero marginal cost of reproduction and the public use of information increases its value creating several positive externalities (Benkler 2006). The CBPP is facilitated by free, unconstrained and creative co-operation of communities, which lowers the legal restrictive barriers to such an exchange, inventing new institutionalised ways of sharing, such as the Creative Commons or the General Public Licenses (Kostakis 2011a; 2011b; 2012). This new property forms allow for the social reproduction of peer projects, as they are viewed to be inherently more distributive than both state property and private exclusionary property (Bauwens 2005; Lessig 2004). In terms of property, the Commons is an idea radically different from the state ("public") property, where the state manages a certain resource on behalf of the people, and from the private property, where a private entity excludes the common use of it (Bauwens cited in Kostakis 2009; 2011b). It is, however, important to highlight that the latter approach to property "does not assert that sharing is an ethical absolute" (after all each is, or should be, free to choose what type of license will adopt). "It warns us that copyright, patent and trademark maximalism can turn our technical systems into a Panopticon" (Mueller 2010, 268). The aim of CBPP is to make the best possible product for the community and not to outcompete rivals and create a monopoly situation in which, using IP regimes, it can generate profits, staggering innovation till competition calls for more of it, as happens in market-driven production.

Thus, it becomes obvious that what sets CBPP apart from the proprietary-based mode of production – the "industrial one" (Benkler 2006) – is its mode of governance and property, whose foundation stones are the abundance of resources, openness, communal ownership and the underestimated, from the STE theories, power of meaningful human co-operation that can deliver innovative, remarkable results, in contrast to the allegations for low quality (Keen 2007, Lanier 2010), such as the Apache web server, Mozilla Firefox browser, Linux kernel, BIND (the most widely used DNS software) or Sendmail (router of the majority of email). CBPP arguably carries some innovative aspects which create a political economy where economic efficiency, profit and competitiveness cease to be the sole guiding stars (Moore and Karatzogianni 2009); where innovation is harnessed; and where civil society has a more fundamental role bringing the notions of mutual cooperation back into the very heart of economy (Orsi 2009).

To put CBPP into the TEPS framework, it seems that the former, a mode that has been emerging from the interstices between the old industrial-based TEP and the new information-based one, reflects Perez' description (2002; 2009a; 2009b) of the swing of the pendulum, during the turning point, from the extreme individualism to the collective well being representing a spontaneous manifestation of the creative civil society, which, to put it in the Marxist tradition, increases its control over some essential means of production.

4.3. The Conjunction of CBPP and 3D Printing: The Relocalisation of Manufacturing and the Shift from Economies of Scale to Economies of Scope

In the synergy phase there is a tendency to "encompass greater and greater parts of the economy and larger and larger parts of society in the benefits of growth" (Perez 2002, 133). With regard to that, Perez (2002) mentions certain sectors that will support development and need financing. The first concerns the core industries of the paradigm which are still advancing and expanding. Markets such as China and Russia seem to be a long way from saturation and could catalyse a massive market expansion necessary for the whole economy to move forward. However, this idea of eternal expansion and growth is questioned regarding its sustainability in the long term as we live in a world of perpetual resources (Eisenstein 2011; Barnes 2006). Further, the double bubbles contributed to the diffusion of the ICT revolution, investing enough in infrastructure that can make the deployment of the paradigm possible. For such a period to come, this infrastructure needs to be extended increasing its coverage and services (Perez 2002).

Maybe the proposal of Rifkin (2011) for an "energy internet", in which ICT and renewable energies merged creating a powerful new infrastructure for energy production, is a good chance for financing and viably move the economy forward. According to Rifkin (2011), the locus of control over not only information production but also energy production is beginning to shift from giant fossil-fuel-based centralised energy companies to millions of small producers and co-operatives, which can generate their own renewable energies in their places and trade or share surpluses in info-energy Commons. Whether it is factually true or not that this is already happening, the envisioned trajectory is clear, and it is supported by such examples as the initiatives of the Nordic Folkecenter from Denmark (2012; Mercier and Jean 2006) or Barefoot College (2012) in India which are developing small-scale energy production practices. Especially the latter provides basic services and solutions to problems in rural communities, with the objective of making them self-sufficient and sustainable. Furthermore, it would be interesting to mention the numerous open design communities, like the non-profit organisation Onawi (2012) from England or New Guinea (2012) from Greece, that follow CBPP approaches to the development, amongst others, of blueprints for small-scale, autonomous energy production.

Following Carlota Perez' theory of techno-economic paradigm shifts, such a trajectory is to be expected, because the traditional, highly centralised mode of energy production would have to be modernised according to the special characteristics of the current ICT-based paradigm. A convergence of CBPP practices in designing, sharing and improving blueprints, along with desktop manufacturing capabilities, could be such a modernisation and thus would underscore the general importance of autonomous energy production. For example, see the realised goal of the Helix_T project (Kostakis, Fountouklis, and Drechsler submitted) which was to collaboratively develop a functional wind turbine module (its designs are distributed under a Creative Commons license) which can be 3D printed – except for the motor part – by anyone owing a low-cost 3D printer.

3D printing – actually a subset of additive manufacturing – is, in short, the process of joining material, layer-by-layer, to make objects from 3D model data (usually created by a computer-aided design software or a scan of an existing object), in contrast to subtractive manufacturing technologies (American Society for Testing and Materials 2010). This technological capability has been around for more than three decades and has been known as the "rapid prototyping machine" (Bradshaw, Bowyer, and Haufe 2010; Campbell et al. 2011). It was called "rapid" because one-offs could be made more easily and quickly than by the conventional numerically-controlled machines and it was called "prototyping" because it was too slow and expensive to be used for production (Bradshaw, Bowyer, and Haufe 2010). For example, an architect could print in 3D the design of a building or an automobile engineer could print a prototype of a part from the car for further refinement of the design. However, lately 3D printers have been adopting, especially by aerospace and health care industries (Bullis 2011), to make functional products as well whereas the rise of relatively cheap (€500 - €1200) desktop 3D printers, such as RepRap, MakerBot or Ultimaker (Kalish 2011) have

given the chance to hobbyists to experiment, design and produce things moving gradually from “prototyping” to “manufacturing”.

A strategic advantage of 3D printing is its capability of fabricating more complicated and intricate shapes than any other primary manufacturing technology (Bradshaw, Bowyer, and Haufe 2010) without the need of an inventory of new products, spare parts and retooling (Campbell et al. 2011). Thus, it lowers the risk and the costs as well, as it reduces production constraints and barriers for entry into the business. 3D printing offers the geometrical freedom in engineering design and thus new chances exist for design in diverse industries such as aerospace, automotive, and bio-engineering (Campbell et al. 2011). Moreover, this technological process offers reduced waste and minimal use of harmful chemicals along with the possibility to use recycled materials (Campbell et al. 2011).

Further, 3D printing customises and localises production promising to reduce the need for an assembly line, not to mention the reduction in the carbon footprint due to less transport. And finally, nanotechnology gives 3D printing the ability to create light, strong structures with an increasing variety of novel materials: from metal and carbon nanoparticles (the latter can be used even for bone tissue engineering) to ceramics and semiconductors nanomaterials (Campbell et al. 2011). It would be interesting to mention a recent project at the University of Glasgow which shows that it is even possible to create chemical compounds, including new ones, by using 3D printing technology with a low-cost open source printer such as the Fab@Home (Symes et al. 2004). In other words, this means that techniques from chemical engineering are made accessible to typical synthetic laboratories (Symes et al. 2004).

On the other hand, 3D printing processes have numerous drawbacks. To mention a few, they are limited for mass materials production purposes since, on average, they can create a 1.5 inch cube in about an hour (Campbell et al. 2011). Moreover, most 3D printing processes use proprietary polymers which are weaker than their traditionally manufactured counterparts and, thus, part strength is not uniform – due to the layer-by-layer fabrication process (Campbell et al. 2011). Further, 3D printing processes repeatability needs improvement since parts made on different machines may have different properties (Campbell et al. 2011). Also, the expansion of desktop manufacturing technologies make weapons manufacturing easier since guns, bullets, bombs, etc., could become cheaper, more accessible; not to mentioned that they could be more easily disguised (Campbell et al. 2011).

Further, a problematic area that comes to the fore with the advent of low-cost 3D printing is certainly the property regime. We have referred to the “battle” over the IP status of information products which, contrary to the material ones, have lower, if not near-zero, marginal costs. It has been proposed (Söderberg and Daoud 2012, 74) that the boundary work of hackers, activists and academics campaigning against IP is being destabilised due to the introduction of a new narrative element, in the Silicon Valley spirit: “atoms are the new bits”. Söderberg and Daoud (2012) mention that the conjunction of CBPP with desktop manufacturing capabilities will lead to an expanded conflict over IP which will soon encompass tangibles as well, expecting the expansion of Digital Right Management systems to new areas. The emergence of “augmented property” will consist a convergence of IP and traditional property: “In the up-coming conflict over augmented property, piracy will be generalised to every corner of society. And everywhere we will hear the battle cry: atoms want to be free too” (Söderberg and Daoud 2012, 75)! However, as Bradshaw, Bowyer, and Haufe notice, the household domestic usage of 3D printing will have a gradual impact, “as unlike file-shared MP3s it will not immediately provide for the reproduction of faithful copies” (2010, 31). Therefore, they argue, this would “allow for a more measured consideration of the legal issues that will arise from such use” (2010, 31).

There is the prediction that 3D printing will continue to grow in capability, improve its efficiency and accuracy, being able to use a wider range of materials (Atkinson 2006). Gershenfeld's articulation (2007) that the final frontier in 3D printing is “to introduce functional as well as structural materials, in order to print complete working systems” is nowadays topical “toward making one machine that can make anything”. It is not, however, the only technology that can boost desktop manufacturing. Laser cutting, 3D scanning and different kinds of milling machines or open hardware products, such as the microcontroller Arduino or the global

village construction set of the Open Source Ecology project, make it possible "to make (almost) anything" and develop solutions to local problems (Gershenfeld 2007).

We argue that the ecology of CBPP, open design and open manufacturing/hardware communities could co-exist with certain for-profit companies in a synergetic spirit. To become more specific, communities have already begun to exist around open source hardware companies like the Makerbot Industries, which produces the Makerbot desktop 3D printers and runs the sharing design platform Thingiverse.com; the open source microcontroller Arduino which is based on flexible hardware and software (Troxler 2011); or the Wikispeed which is an open source automotive manufacturer that produces modular cars (this case is discussed later in more detail). These Commons-oriented communities produce use value for the public domain while they support financially (e.g. buying the physical products) the for-profit entities who run the infrastructure. Of course, CBPP practices could not just be copied to and applied in the open design and open manufacturing realm without alteration, not taking into consideration the constraints of the material production (Troxler 2011). It seems that the desktop manufacturing technological capabilities will be related to a plethora of different models that may embrace various aspects of CBPP, "with users switching between different models as appropriate" (Troxler 2011, 94). "It will be interesting to see", as Troxler concludes, "whether and how traditional businesses will be able to adapt to a new reality of real prosumer choice" (2011, 94).

It might be maintained that in contrast to the industrial paradigm whose competitive dynamics were about economies of scale, CBPP and desktop manufacturing, with the support of nanotechnology on the material level, could develop economies of scope. While the advantages of scale rest on cheap global transportation, which is facing problems because of the increasing oil prices and the environmental crisis (Rifkin 2011), the economies of scope share infrastructure costs (intangible and tangible productive resources), taking advantage of the capabilities of the fabrication tools. And following Neil Gershenfeld (2007, 13-14) in that "some of the least developed parts of the world need some of the most advanced technologies", CBPP and desktop manufacturing may offer the necessary tools for thinking globally but act locally (Perez 2002) in response to certain problems and needs, such as addressing the need for energy via small-scale energy production. The expansion of CBPP practices into the physical production can create networks of individual producers, co-operatives, non-profit foundations and for-profit companies which work globally but produce locally.

It might be of particular interest, because of the symbolic role of the automobile for the previous TEP, the recent partnership between the OSE project and the Wikispeed company to co-build a high-performance modular open source car (Jakubowski 2012). The OSE community has been working on an open technological platform (the global village construction set) that allows for the easy fabrication of fifty different industrial machines necessary to building a small civilisation with modern comforts embracing various aspects of CBPP (Jakubowski 2012). In the same vein, the Wikispeed team is an all-volunteer distributed agile/scrum team whose members contribute their work from various locations globally and iteratively enhance the vehicle every two weeks (Jakubowski 2012). This productive model allows high-speed development, especially when paired with rapid-prototyping manufacturing tools (Jakubowski 2012). The Wikispeed team has managed to design and build a high-performance modular car that gets 100 mpg and meets USA safety standards, using a globally distributed team of volunteers, in three months (Jakubowski 2012). They will collaborate together on the designs of the Wikispeed modular car, which can be manufactured globally using only the OSE technological platform. The finished plans, according the press release (Jakubowski 2012), will be open source and available to anyone while the car will target the needs of developing countries and economy transport while retaining USA automotive safety standards.

We claim that amongst the interests of the production capital that have to be served by the financial capital for a deployment period to come, this conjunction of CBPP practices and desktop manufacturing should be of a particular interest. In the turning point, technological innovation moves from an intense period of exploration and trial-and-error experimentation to a period of consolidation and sustainability. "What this means", Perez writes (2002 135), "will

depend on the specific socio-institutional framework established". Before dealing with the socio-institutional framework that will support the expansion of CBPP and desktop manufacturing, it is important to address one of the most serious problems of CBPP, "the crisis of value", that will influence our discussion about the institutional changes to take place.

4.4. The Crisis of Value in CBPP: The Case of IBM and Linux

Arvidsson wonders whether "this archipelago of social production can be understood as a (however embryonic) manifestation of a new economy" (2008, 14; italics in the original) to state that in this "ethical economy" that is created around CBPP processes the issue of value is of a great importance. It has been already argued that what actually CBPP creates is not commodities for exchange, thus not an exchange value, but goods with use value. The use value may either be consumed as a final good or be used as a resource for new production. We adopt Graeber's (2001) trans-historical anthropological examination of value which argues that there is nothing that can consistently be called "value" that exists over time across all cultures, as value has always been contextual. Thus, by the term "use value" we mean utility as valuable to someone. The problem with the crisis of value in CBPP has been discussed by Arvidsson (2008), Bauwens (2009a; 2012), and Arvidsson, Bauwens, and Peitersen (2008) and can be summarised in a single question: What happens if more and more of Commons-based peer producers' time goes into producing use value but there is not a substantial return of income to them?

In other words, although CBPP projects, for the moment being, seem to be sustainable collectively, they are not, in general, sustainable individually as the individual participants normally are dependent upon a paid labour, working either for a firm or for the state. To quote Bauwens, a CBPP project "can sustain itself through the renewal of its volunteer labour force, but at the individual level, volunteering cannot be a permanent state" (2009a, 131). Despite the fact that the civil society produces with an increasing pace innovations (von Hippel 2005) in the form of use value, it fails to monetise it in the level of making itself fully sustainable. CBPP is highly dependent on the surplus of capitalism and is possible because "the current system has created sufficient interstices in which people can operate outside the commodity and wage logic, but only as an 'aspect of their lives"' (Bauwens 2009a, 130).

For instance, in the FOSS economy – around which foundations, industries and business models have already been developed (Maxwell 2006; Ghosh 2005; Riehle 2007) creating a more complicated but mature (compared to other Commons-based projects) ecosystem – the software that is produced substitutes the proprietary one, whereas the monetary returns are less than the potential monetary value of the substituted proprietary software (i.e. its exchange value if it was to be sold in the market were there no FOSS). It creates an economy with explosions of use value for the Commons-based community, society in general and the firms who take advantage of the produced use value. The case of the International Business Machines corporation (IBM) and Linux is well-known and widely discussed (see Tapscott and Williams 2006; Coleman and Hill 2004; IBM 2010) which shows how a firm entered the FOSS ecology and invested monetary and human capital (improving the reliability of Linux by testing code, error handling etc) in the development of FOSS. IBM, according to its corporate report (2010), holds significant roles in a large number of FOSS projects such as in the development of Linux Kernel, Apache, Eclipse, Ubuntu etc, working closely with Red Hat, a leading distributor of enterprise Linux. On the one hand, the IBM's involvement enhanced the quality of the outputs and the sustainability of the projects creating chances for wage labour for some of the most active Linux developers in the market economy. On the other, for IBM the rewards from such an involvement have been considerable. According to Tapscott and Williams (at least at the time of their writing in 2006) IBM would spend about $100 million per year on general Linux development. So if the Linux community produces use value of $1 billion (if it was to be produced by paid labour), and even half of that is useful to IBM, then the firm gets $500 million of software development for an investment of $100 million (Tapscott and Williams 2006). "Linux gives us a viable platform uniquely tailored to our needs for

twenty percent of the cost of a proprietary OS" says Cawley, IBM's business development executive, in Tapscott and Williams (2006, 81).

There are several different business models followed in relation to FOSS (see the collection *Perspectives on Free and Open Source Software* by Feller, Fitzgerald, Hissam, and Lakhani (2005) for an extensive account) and the IBM case should not be considered as an all-exhaustive one. This case makes evident that the crisis of value is partially ameliorated by the alliance of CBPP communities and foundations with for-profit business firms. However, in the way the owners of proprietary platforms in sharing/aggregation economies (Kostakis 2012), such as Facebook or Google, are dangerous as trustees of the common value that is created due to their speculative nature and the opaque architecture (closed source) of their platforms (Bauwens 2007; Kostakis 2012), CBPP projects should not be so dependent on the alliances with firms whose sole aim is profit maximisation. This threatens their autonomy and self-governance as well their agenda setting, which all of them made social innovation in the first place possible (Benkler 2006; Henkel and von Hippel 2004; von Hippel 2005).

According to Arvidsson, CBPP is capable of pushing "a reform of capitalism in a more ethical, 'blended value' direction" (2008, 27) under the condition that a sort of global New Deal is achieved around sustainability and social responsibility. It is argued that this "New Deal" can be partly realised through a partner state approach (seeds of this concept can be found in Bauwens 2009a; 2009b; Kostakis 2011b; Orsi 2009) that would take full advantage of the possibilities of the current TEP offering solutions to the aforementioned crisis of value. The state, which according to the TEPS framework is the orchestrator of the deployment phase, should recognise that CBPP is a considerably social advance, through which the role of the civil society is being redefined. Hence, it needs to be supported and stimulated, as it is impossible to achieve sustainability and independency outside the market mechanisms, in a co-operative and synergetic ecology.

5. The State as a Partner to Civil Society's Creativity

Building our argumentation within the framework of the TEPS theory, we try to avoid resting our case on a naive technological determinism while we aim "to locate normative standards and emancipatory political possibilities precisely within the historically unfolding constellation" (Fraser 2007, 8; see also Ruggie 2004; Mueller 2010). It is also important to note that in this paper the term "state" refers to the more abstract way that some tend to use the term "government" – for instance, the debate whether we need more or less government intervention (Mueller 2010) – and not necessarily confined to the nation-state concept. In the Perezian vein, this paper understands that globalisation should not be inextricably tied to the "free market" doctrine since it has many other potential forms. Just as in the former TEP (mass production) the state intervention took several different forms, "another" globalisation could be socially and politically shaped to lay the ground for the full deployment of the current TEP. Based on the principles of the globally-oriented and networked-based TEP, Perez (2002) claims that the state should adopt a common regulatory framework at the world level and increasingly adaptive diversity in descending levels.

In a period of extreme polarisation and not having reached an equilibrium regarding the global governance of the internet necessary for the deployment period to occur, it is argued that, on the one hand, CBPP signals for some fundamental changes to take place juxtaposing them against an old order that should cast away (Mueller 2010). On the other, the proposed legislations of ACTA/SOPA/PIPA that enforce strict copyright; the efforts for a regulatory regime with an architecture of transactions in the first place (rather than policing the transactions afterwards) (Boyle 1997); the attempts for surveillance and censorship by both authoritarian and liberal countries; and "the growing tendency to link the Internet's security problems to the very properties that made it innovative and revolutionary in the first place" (Mueller 2010, 160) are only some reasons that have made scholars, like Zittrain (2008), to worry that digital systems may be pushed back to the model of locked-down devices centrally controlled information appliances. Moreover, a stark element of the current surge is that globalisation is actually a fundamentally different set-up and the states' response to cyberse-

curity and cybercontrol problems should be on a global basis and in harmony with the very new characteristics of the TEP reconstituting relationships among business, government and civil society. In the early twentieth century and after three decades of mass production, depression, nationalism, political turmoil and war which all of them triggered structural transformation within economy and society, the western civilisation reached equilibrium around social democracy and the welfare state (Perez 2002; Mueller 2010). In the current TEP, this paper, in line with Mueller (2010) and Perez (2002; 2009a; 2009b), claims that the transformations of ICT produce its own set of competing practices, processes and ideologies that may, or should, reach equilibrium around an interconnected partner state this time, at least concerning the processes which are highly dependent on information production.

In this sense, the partner state or the partner state approach (PSA), as it is more of an approach rather than of a single, isolated state in the conventional understanding, relies on Mueller's idea for a dependence on "contractually constructed Commons rather than statist redistribution" (2010, 261). In other words the PSA could be a cluster of policies whose fundamental mission is to enable and empower direct social value creation by user communities, and to focus on the protection of the Commons sphere (both physical and digital) as well as on the promotion of sustainable models of entrepreneurship in a synergetic spirit. While the civil society continues to build an alternative political economy within the traditional one, by adopting a PSA the state becomes an arbiter, retreating from the binary state/privatisation dilemma to the triarchical choice of an optimal mix amongst government regulation, private-market freedom and autonomous civil-society projects (Bauwens 2009a), "enabling its members to be better equipped in facing the risks attached to the dynamism of contemporary knowledge-based societies" (Orsi 2009, 44).

Concerning the crisis of value a serious state involvement in social productive practices would facilitate access to technology and other means of production, enable (instead of repressing) sharing and other new forms of distribution as well as it would stand up against global pressures to enforce restrictive IP legislation (Arvidsson, Bauwens, and Peitersen 2008). In addition, a PSA would entail some form of comprehensive valorisation of the CBPP economy so that the peer produces who create use value outside of the market would be able to live off their efforts (Arvidsson, Bauwens, and Peitersen 2008). The CBPP and open hardware/manufacturing projects create innovations networks which are both global, but at the same time they enable a relocalisation of the productive economy, with many small companies producing for local markets and re-invigorating domestic economies (Bauwens 2009a; 2009b). A PSA could support the benefit-driven institutions, which are responsible for the financial sustainability and social reproduction of the CBPP projects. The state could orchestrate and catalyse the expansion of this hybrid productive ecology that combines the existence of global self-managed open knowledge and open design communities, for-benefit associations in the form of non-profit foundations, which manage the infrastructure of cooperation, and an ecology of associated businesses which benefit from and contribute to this CBPP (Bauwens 2009b). The PSA predicates that an equilibrium regarding the issues of IP – even more than now when the low-cost 3D printing is going to have serious implications on IP (Bradshaw, Bowyer, and Haufe 2010,) – and the governance of the internet is achieved favouring CBPP practices.

6. Conclusion

Within a Perezian framework, the goal of this paper was to call attention to the CBPP whose conjunction with 3D printing and other low-cost manufacturing techniques should be counted in the economic census and our institutional design, playing an important part in overcoming the current recession as well as to manage the social, political and environmental instability. The self-reinforced fantasy of a system of eternal growth can be overcome with the development of economies of scope, and here, as well, the civil society can play an important role contributing to the raising of the whole productive structure to a higher plateau of more sustainable and customised productivity. This effort attempted to provide bird's-eye view to this plateau being aware of the danger of technological determinism. Further, it is true

that many issues, problems and threats rise due to the large democratisation of the means of production, and especially regarding the physical ones. For instance, the recyclability of advanced nanomaterials is still questioned; weapons manufacturing could become easier; not to mention the implications on counterfeiting (Campbell et al. 2011) and on IP (Bradshaw, Bowyer, and Haufe 2010). Moreover, concerning CBPP we discussed one major limitation, that of the crisis of value. The state, here, has to be responsive and manage all these transformations embracing their creative sides and supporting synergies.

If the mass-produced automobile is the representative example of the previous TEP where a constellation of most of the innovations of the time, both technical and organisational, were embodied, then we could say that the internet is one of the most prominent innovations of the ICT revolution, which influences and is influenced by the development of the current TEP. It can be argued that the internet exemplifies the basic characteristics of the common sense and the practices of our time. It embodies an unusually (for the common sense of the former TEP) successful example of the complementary relationship between private market and the civil society (Mueller 2010). As Mueller writes, "the basic protocols are open, nonproprietary standards that can be freely adopted by anyone" (2010, 270). Simultaneously, he postulates: "the Internet is a network of networks, the constituent parts of which are privately owned and administered. This aspect of the Internet leads to privatization and decentralization of network operations and policies. By facilitating interoperability, the Internet standards commons promotes a private decentralized market for software applications and information contents. Thus, at the endpoints of the Internet, the free market and privatization rule; at the core standards level, a commons is in place [...] In short, it is the combination of the private and the common that works" (Mueller 2010, 270-71).

It was proposed that a PSA is needed for making the best of this synergetic combination, taking advantage of both civil society's increasing creative efforts and the constructive sides of sustainable entrepreneurship building a collaborative economy.

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