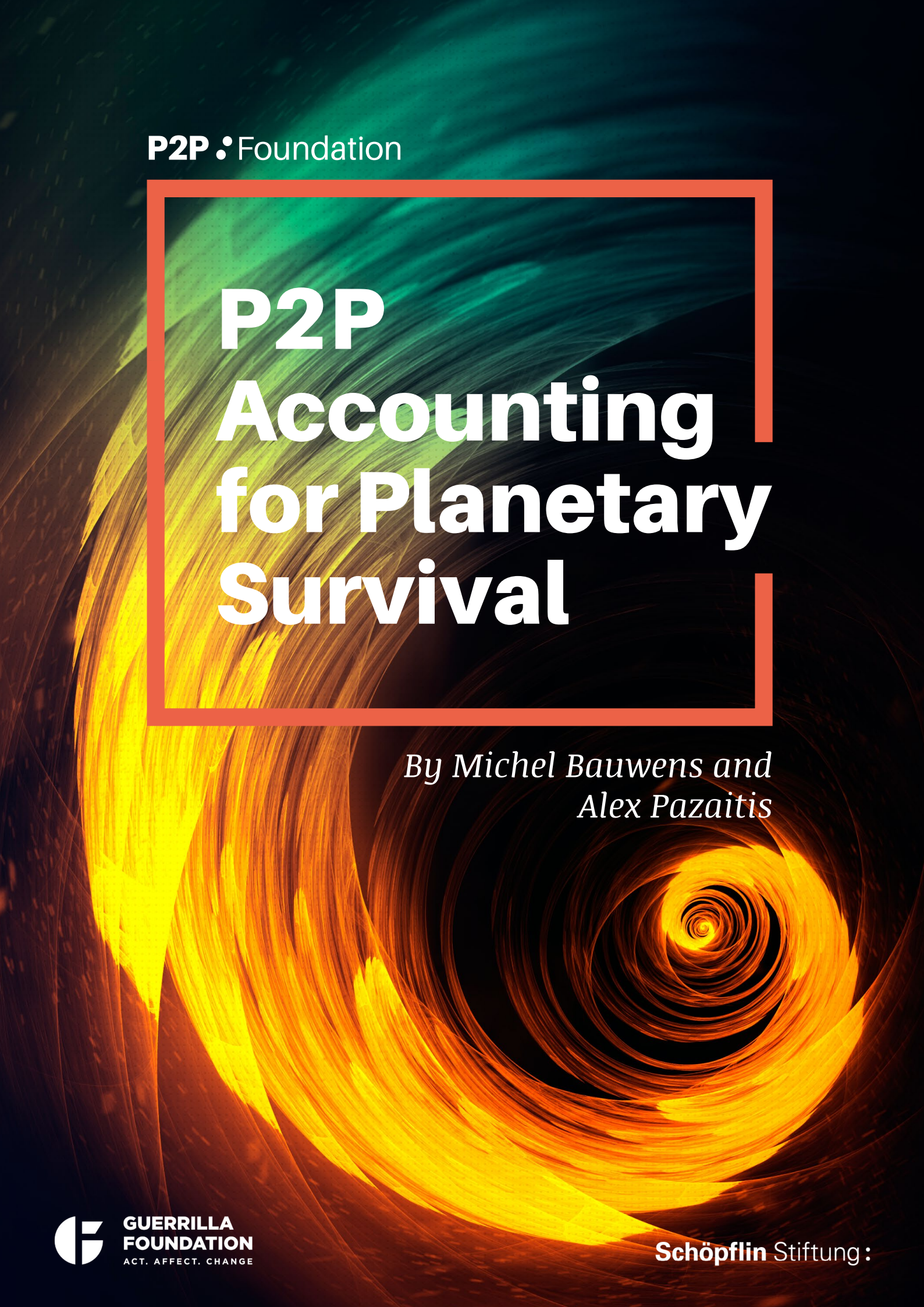
P2P Foundation
P2P Accounting for Planetary Survival
By Michel Bauwens and Alex Pazaitis
GUERRILLA FOUNDATION
ACT. AFFECT. CHANGE
Schöpflin Stiftung

P2P Accounting for Planetary Survival

Towards a P2P Infrastructure for a Socially-Just Circular Society

How shared perma-circular supply chains, post-blockchain distributed ledgers, protocol cooperatives, and three new forms of post-capitalist accounting, could very well save the planet.

By Michel Bauwens and Alex Pazaitis

A joint publication between the P2P Foundation, Guerrilla Foundation and Schoepflin Foundation.

Credits

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Image Credits

Cover: *Nullfy*
Chapter 1: *Nullfy*
The Seven Tendencies of blockchain Technology: *Wikimedia Commons*
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Chapter 3: *Nullfy*
Back cover: *Nullfy*

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Foreword by Kate Raworth

Eurostar: 10.52 am, Brussels to London. I'm standing in line for passport control and I spot a familiar face in front of me: it's Michel Bauwens! He's clearly surprised to hear his name called from just behind him in the queue, but his surprise quickly turns into our mutual delight on realizing that we'll get to have an all-too-rare chance to catch up.

We meet up in the train's dining carriage where, travelling at 150 miles an hour under the English Channel, Michel tells me about his summer writing project. He's only a few moments into describing it and I have to pull out my notebook and start jotting things down because, in typical Michel fashion, he is coming out with intriguing phrases that I have never heard before but that have instant appeal. Cosmo-local production. Labour mutuals. The thermodynamics of peer production.

This resulting report, written over the last year by Michel, Alex Pazaitis, and *a team of contributors*, brings those ideas together with many more to envision the commons at the heart of a 21st-century economy designed to deliver social and ecological health. In its ambitious vision, this report combines a long-standing commitment to commons-based peer production with a new, globally localized approach to the circular economy and, in the process, redesigns distributed ledger technology (think: beyond blockchain) in order to make it feasible.

So leave behind today's widespread obsession with smart contracts, platform capitalism and economies of scale: these only serve to reinforce last century's dominant and extractive modes of production. Instead, dive into this report and discover the possibilities of Ostrom contracts, platform cooperativism and economies of scope. These ideas are the seeds of a generative commons-based economy that is fit for the 21st century's social and ecological challenges.

If you want to flip your economic mind, and leap to the cutting edge of commons-based thinking, simply read on.

Executive Summary

How to read this report: If you are not an expert but interested in future infrastructures, then chapter 1 is the most readable 'visionary' chapter, which will give you the broad background about what we want to achieve with this report. Chapters 2 and 3 are aimed for the more motivated experts who are specifically interested in a number of technical tools that are becoming available to enable this vision. Each of these chapters also has its own contextual introduction, which might be useful for the less technical reader.

The key issue addressed in this study is how to change a system which incentivizes and rewards extraction — but cannot recognize and reward the wealth created by generative activities — towards a system which is able to reward and incentivize generative practices.

This report is based on the understanding that one of the main weaknesses of the current political economy is its inability to recognize and deal with 'externalities', in regards to costs and benefits received or caused by economic actors that are not accounted or paid for. Under capitalism, a firm becomes competitive in large part because of its ability, and that of the system as a whole, to not 'pay' for positive social and environmental contributions, and to leave the reparations of social and environmental damages to other actors, that is, mainly the citizenry or the state. There is no structural solution to fund (re)generative activities except mostly 'after the fact' or through 'regulations' that are imposed 'from the outside,' by the coercive force of the state. This report looks at efforts underway, even in prototypal and experimental forms, to remedy this situation, that is, to have a productive systems that can fulfill human needs without violating external boundaries, pretty much like Kate Raworth has explained it in her book Doughnut Economics. These solutions would be located much more 'internally,' within the system of production itself. This way of thinking is analogous to thinking about more socially just 'predistribution' of wealth, rather than mere 'redistribution.' These solutions would not replace external regulation, which still has a role, but rather complement it.

We believe that a significant number of these necessary ingredients for such a structural change are available through some of the emerging techno-social systems that are co-evolving with distributed networks.

The first structural element is shared supply chains for a perma-circular economy. At the P2P Foundation, we believe a circular economy cannot be achieved without sharing the logistical knowledge that is presently locked up in the walled gardens of private logistics. Only by sharing each other's input and output can partners in an open ecosystem adapt towards a real circular economy. In this report, we pay some attention to a shift towards ecosystemic collaboration, but without going into the details of supply chains themselves. The concept of 'perma-circularity' refers to the necessity for the growth of our material and energy usage to remain under one percent a year, in order to avoid the exponential increase in resources we need from our planet.

We do pay attention to a number of technologies that will allow us to shift towards ecosystems of collaboration, specifically open and shared distributed ledgers, mostly coming from the so-called 'blockchain' space of technical development. But we focus in part on 'post-blockchain' developments, which avoid a number of systemic problems associated with the first generation of blockchain technologies, for example, issues of scaling, exponential energy usage, etc. Protocol cooperatives are global open source repositories of knowledge, code and design, that allow humanity to create infrastructures for the mutualization of the main provisioning systems (such as food, habitat, mobility), and that are governed by the various stakeholders involved, including the affected citizenry.

With distributed ledgers, three new forms of collaborative accounting can be introduced, which will allow economic actors to manage their production while recognizing positive and negative social and ecological externalities. 1) Contributive accounting, which we discussed in our previous report. 2) Values in the Commons Economy, allows for the recognition of all types of contributions, not just waged labor. 3) REA accounting, i.e., accounting for Resources, Events, Agents, allows actors to see their transactions as part of an ecosystem of collaboration, which is 'flow accounting' rather than a vision based on the accumulation of assets in a single firm. Finally, we need direct access to the real 'thermodynamic flows' necessitated by production, in other words, the amounts of matter and energy needed, in the context of planetary boundaries.

Chapter 1 of this report is a summary of ten years of research at the P2P Foundation (including that carried out by our own P2P Lab but also by our partners in common research programs) of what we know today about the emerging commons economy. It includes a basic account of why the 'invention'

of the blockchain has been important, but stresses that the distributed ledgers needed may take other forms in the future. This section may not offer a lot of new elements for those that are already technologically savvy about the topic, but it does present a critical engagement with the qualities and flaws of the current model, and suggests how it can be tweaked and transformed to also serve as a basis for a post-capitalist, commons-centric economy.

Chapter 2 of this report goes into the details of various technological projects that could be used as tools to develop ecosystems of collaborations, based on distributed ledgers. Our objective here is to show that solutions are being worked on, but remain fragmented to date, so our aim is to demonstrate that an alignment in a higher integration would lead to significant advances towards sustainable production.

Finally, *chapter 3* focuses on the accounting innovations that we will need, and which will need to be integrated in the new practices based on shared supply chains using shared ledgers. This includes, as explained above, tools for contributive, flow-based, and thermodynamic accounting.

This report focuses not on the innovations within mainstream industrial players striving towards more sustainability, but on seed forms that, by not having legacy systems to deal with are better able to reorganize themselves in direct harmony with the possibilities offered by the new tools reflecting the new paradigm. Of course, this means they have fewer resources, but they offer more clear pointers to a possible future.

The aim of this report is therefore to encourage open-mindedness towards new possibilities of integration so that we can transition to a regenerative economy, and to show that emerging tools are available to implement these necessary changes.

“The moment we stop optimizing the digital economy for the growth of capital and instead optimize it for the circulation of value between people, everything will start to get better really fast.”

- Douglas Rushkoff [1]

“In the next economic system, “value” will mean the health of the planet, not numbers on a balance sheet.”

- John Thackara

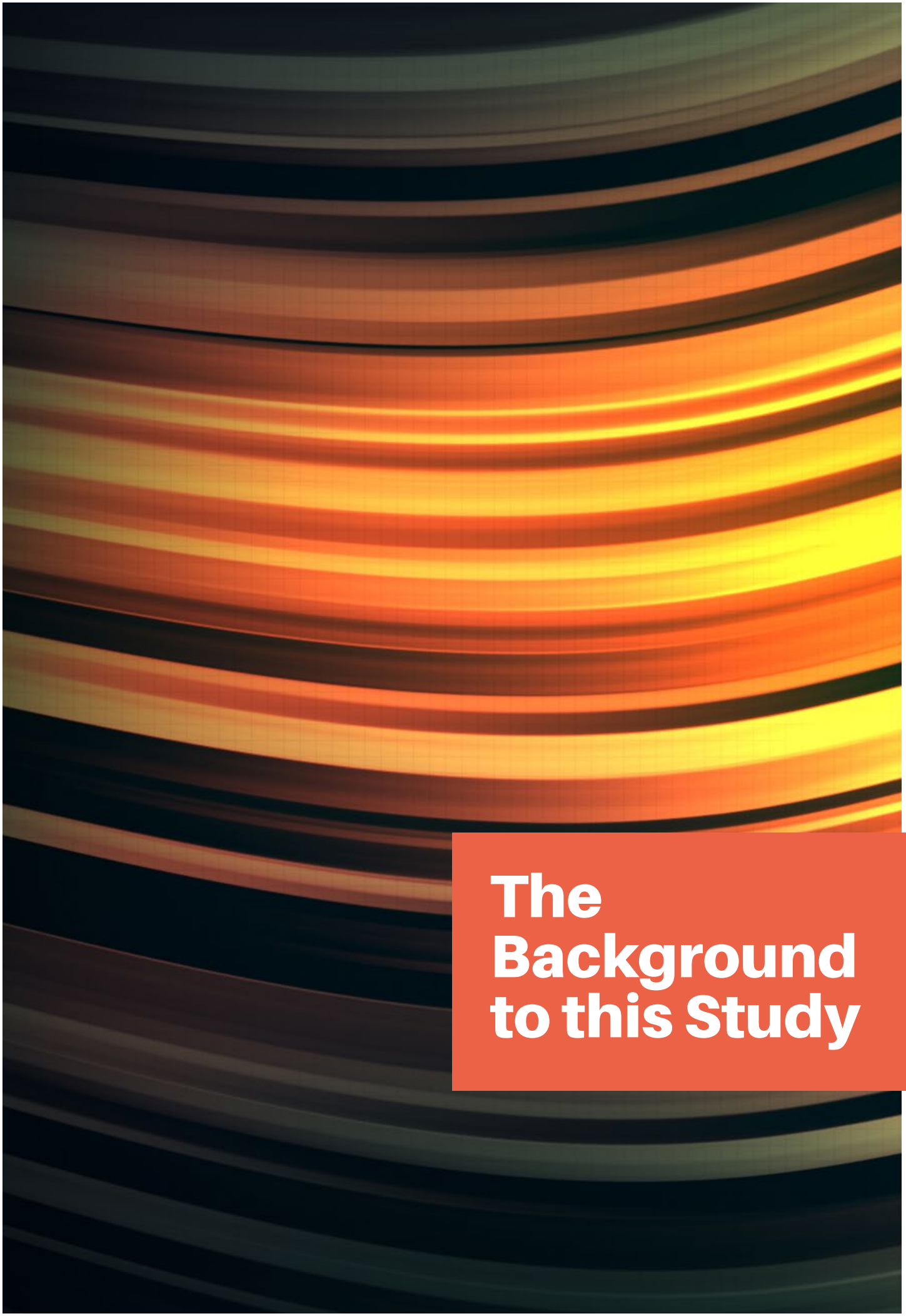
“What’s going on today is more than a few accounting oversights here and there. The distance between today’s industrial systems and truly sustainable industrial systems — systems that do not spend down stored natural capital but instead integrate into current energy and material flows — is not one of degree, but one of kind. What’s needed is not just better accounting, but a new global industrial system, a new way of providing for human wellbeing, and fast.”

- David Roberts [2]

“Like so much that the P2P Foundation has done before, this is a paradigm-making vision for how to flip the future of the economy right side up. Once I started reading, I couldn’t put it down until I was done. It was hard to imagine leaving the world it describes for the one we have.”

- Nathan Schneider

1. *https://kernelmag.dailydot.com/issue-sections/features-issue-sections/15982/douglas-rushkoff-throwing-rocks-at-the-google-bus-interview/*
2. *https://grist.org/business-technology/none-of-the-worlds-top-industries-would-be-profitable-if-they-paid-for-the-natural-capital-they-use/*



The Background to this Study

Chapter 1
The Background to this Study

The P2P Foundation's study of the commons and the commons transition

When we began working as the P2P Foundation in 2006-2007, we started out with a basic premise of what was wrong with the current political economy of capitalism. We claimed that the system combined strategies of artificial scarcity and pseudo abundance in a way that increased social injustice and inequality.

The idea of pseudo abundance is based on the mistaken premise of infinite material growth on a finite planet, where natural resources are actually fundamentally limited. Artificial scarcity refers to the strategies that prevent the sharing of technological and scientific progress because of excessively restrictive intellectual property rights. A sensible alternative is, of course, to recognize the limits of what we can use from the world of nature, of which we are an intrinsic part, and to allow for the sharing of all knowledge that can contribute to living within the limits of this 'biocapacity.' Right now we have a production system where competitiveness is achieved by externalizing human costs to nature and society as a whole. Capitalism has become a scarcity-engineering machine that prohibits the occurrence of natural abundance.

From this beginning, our theory of change was based on the idea that the seed forms of a new system grow within the old one, usually embedding an alternative logic to systemic crises.

We would point out that before capitalism became a fully dominant system, there were inventions like

- double entry accounting, which focuses on the rational expansion of private capital (Gleeson-White, 2013)
- ideological innovations like the new Catholic concept of Purgatory,[3] which allow Christians to lend money while buying back their sins through indulgences, and which authorize 'sinful' commercial activity (Legoff, 1981)

3. Purgatory can itself be interpreted as a karmic accounting system, an exchange system where money is exchanged for the forgiveness of sins.

- the printing press, which enabled the rapid production and distribution of knowledge, bypassing the knowledge monopolies of the Church and the guilds

These new patterns and solutions, which created a proto-capitalist subsystem (dominant at first in the Italian cities and new medieval city-communes) (Spufford, 2002), were paradoxically first used by forces in the dominant feudal society, such as the monarchy, for their own ends. However, due to this allegiance and investment the seeds of the new system were allowed to grow under the direction of the "capitalists"[4] themselves. Seed forms emerge and slowly find each other to form more coherent subsystems, which eventually become the new dominant norm. This is not a smooth or conflict-free process. Nevertheless, it is important to pay attention to the emerging forces rather than merely focussing on the established power structures and struggles. Today, this requires giving priority to analysing and supporting post-capitalist forms of human activity, rather than only paying attention to the fights for redistribution within the old system, or just 'anti-capitalism,' that is, waiting for a 'final overthrow' of the system as a whole. These last struggles remain an important part of reality, which must be honoured and understood, but which are not creating the necessary seed forms; however, it is important that forces of resistance also become prefigurative in their demands.[5] What we propose is to construct seed forms that concretely solve social and environmental challenges, and a kind of politics that seeks to initiate policies that are able to replicate or scale such solutions.

According to De Angelis (2017), both the commons and social movements are enabling environments where individual emancipation takes place. They interrelate insofar as the commons provide alternatives for which the social movements may strive. The process of social revolutions necessitates an alignment of the commons with social movements, synchronizing their respective sequences "to turn the subjects of movements into commoners and make commoners protestors" (De Angelis, 2017, p. 371). They thus become mutually reinforcing, through the expansion of the commons, which in turn forms a new basis for more powerful movements. Commons-Based Peer

4. In this work, we use the concept of capitalism in a generic way, as a specific type of market system which separates commodified labor and ownership of capital, and is geared towards the accumulation of privately owned capital. It includes the various forms such as industrial, financial, and cognitive capitalism. In the context of the commons, we are especially interested in non-capitalist market forms based on distributed ownership, in which capital is used for purposes other than its own accumulation.
5. Cfr. Buckminster Fuller's often quoted line: "You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete." Sourced from *https://www.goodreads.com/author/quotes/44478.R_Buckminster_Fuller*

Production (CBPP) then serves as a driving force for the material recomposition of the commons. It enables the conditions to sustain livelihoods for the commoners and the deployment of social forces to reconfigure their relations to the current social systems, including capital and the state.

We also claim that the emerging world-system would be commons-centric, and that the existing state and capitalist market forms would be transformed under the new 'dominant' logic of the commons. What we saw emerging was a new mode of production and exchange, where communities create shared value through open contributory systems, govern their common work through participatory practices, and create shared resources that can, in turn, be used in new iterations. This cycle of open input, participatory process and commons-oriented output is a cycle of accumulation of commons,[6] as opposed to the accumulation of capital. This mode of production, which Benkler (2006) called "commons-based peer production," thrives in ecosystems comprising 1) contributory communities sharing knowledge and capacities; 2) entrepreneurial coalitions creating livelihoods around the commons; and 3) for-benefit infrastructural organizations,[7] which support and guarantee cooperation in the ecosystem, allowing it to continue over time.[8]

Before this becomes a new form of civilization, it becomes apparent as distinct, new, hybrid ecosystems in which post-capitalist seed forms exist within a framework dominated by the old forces. This understanding imposes a double priority on our work as activist researchers: first of all, to document the emergence of these seed forms, as they are adapted and used by the current dominant forces for their own survival and benefit, but also to look at how we can strengthen and create more autonomy for these commons-based productive communities. Our strategy is to identify, understand and promote the commons-centric, post-capitalist logics present in these emerging new forms. In the commons economy[9] that we notice emerging and want to strengthen, we see that the value created by open productive communities is translated into material resources for 'social reproduction' and livelihoods through ethical and generative enterprises, and that the common infrastructures maintained by democratic foundations bring the

6. **The 'Circulation of the Common' is an analytical concept proposed by Nick Dyer-Witheford in a landmark essay of the same title.** It refers to the social reproduction mechanism of Peer Production, in a process analogous with the Circulation of Capital described by Marx. Source: *http://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/4519/circulation%20of%20the%20common.pdf?sequence=1&isAllowed=y*
7. See the discussion here at *https://wiki.P2Pfoundation.net/For_Benefit*
8. For a more detailed description of the CBPP ecosystem see: *http://commonstransition.org/commons-transition-P2P-primer*.
9. See Bauwens & Niaros, 2017. Source: *http://commonstransition.org/value-commons-economy/*

various stakeholders together in dialog so as to jointly manage the common infrastructure.

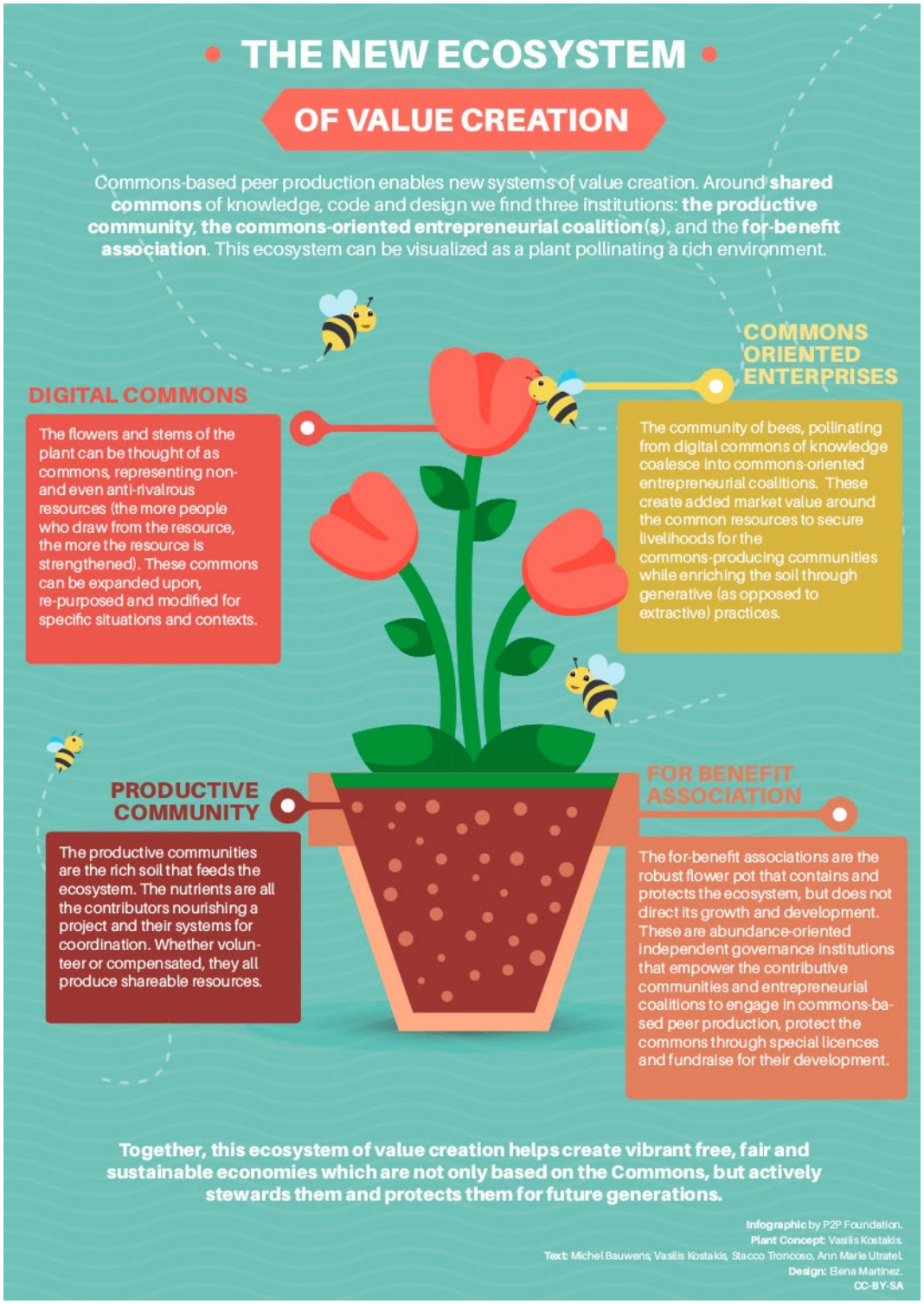


Figure 1: Value creation in the commons economy

A very important distinction for us is the one between extractive and generative practices, and the institutional and ownership forms that enable it (Kelly, 2012).[10] For example, every year that a farmer practices industrial and toxic agriculture, the soil is impoverished until it becomes exhausted for farming, but every year that an organic and biodiverse farmer works on the land, the land is enriched. From the point of view of the soil, the first mode is extractive, the second is generative. Extractive are, for example, the companies in the most often mis-named 'sharing' economy. While Uber and Airbnb scaled up the necessary mechanisms for 'idle-sourcing' (i.e., allowing the re-use of idle resources), they are socially extractive, destroying social welfare standards, creating precarity and insecurity, etc. The key issue addressed in this study is how to change a system which incentivizes and rewards extraction and dispossession, but *cannot* recognize and reward the wealth created by generative activities, towards a system which *can* reward and incentivize generative practices. Furthermore, we are looking for generative practices that are embedded inside the productive system itself, and do not have to be imposed on it from the outside. Our current system is extractive towards nature and human beings, and looks for corrective measures 'after the fact.' What we need are productive systems that are 'organically' or 'institutionally' generative.

In today's context, we see, on the one hand, that the traditional, natural-resource based commons identified by Elinor Ostrom are under stress by the development of capitalism, while, on the other hand, we observe the growth of new types of commons. For example, we have seen the rapid emergence and expansion of open-source communities, co-producing shared knowledge, software and design. After the crisis of 2008, this was followed by the emergence of the platform economy, which brings supply and demand together in corporate-owned platforms, but also the emergence of alternative platform cooperatives that are co-owned and/or co-governed by their stakeholder communities. And as the crisis was felt concretely in the cities where most people now live, we saw the emergence of urban commons, where commoners start taking the infrastructures for provisioning into their own hands. In our study of the city of Ghent,[11] we saw an exponential growth of urban commons in every area of human provisioning, e.g., food, mobility, habitat. However, except for the sectors of organic food and distributed energy, which have

10. Marjorie Kelly, in her book Owning Our Future: The Emerging Ownership Revolution, has outlined five characteristics of 'generative ownership.' See also *https://wiki.P2Pfoundation.net/Emerging_Ownership_Revolution#Characteristics_of_Generative_Ownership_Forms* for further details.
11. See our report Changing Societies Through Urban Commons Transitions. By Michel Bauwens and Vasilis Niaros. P2P Foundation, 2018. Source: *http://commonstransition.org/changing-societies-through-urban-commons-transitions/*

highly developed ecosystems with commons-centric forms of organization, most of these urban commons pertain to a different distribution of the goods and services, and not to their production. Nevertheless, the last two examples point to a future where physical production itself could become commons-centric in its organization.

It is important to see what we are already capable of doing in terms of our techno-social capacities:

1) Open source communities are able to scale small-group dynamics by interconnecting tens of thousands of individuals and small groups, as well as larger groups, into large ecosystems for open coordination through 'stigmergy' (i.e., coordination through signalling), by relying on open and transparent systems; the creation of shared knowledge (Wikipedia), shared software (Linux), and shared design (Arduino), already operates that way.

2) Platforms allow for the easy exchange of idle objects and services, using massive person-to-person interaction on a global basis.

3) Urban commons communities are able to organize access to resources that are more equitable and ecologically responsible.

The next step in the evolution of the ongoing transition to commons-centric ways of producing and distributing value is therefore 'physical production' itself. The central concept of the P2P Foundation in this context is 'cosmo-local production'[12] or DGML:[13] design global, manufacture local. This means that the technical, social and scientific knowledge needed to organize production is available through global open design communities, but that a large part of production for human needs can be relocalized through distributed manufacturing. What we favour is the subsidiarity[14] of material production, in other words, to produce in order to minimize the huge costs of transportation currently necessary under neoliberal globalization. In this new model, 'economies of scale', that is to say, bringing down the costs of production per

12. For a detailed treatment, see: Kostakis, Vasilis, Niaros, Vasilis, Dafermos, George, and Bauwens, Michel. 2015. "Design Global, Manufacture Local: Exploring the Contours of an Emerging Productive Model". Futures, 73, 126-135. http://www.P2Plab.gr/el/wp-content/uploads/2015/09/Futures.pdf.
13. For a basic treatment, see *http://wiki.P2Pfoundation.net/DGML*.
14. See the following citation: "Things are best done, in other words, at the smallest appropriate scale. Hence, Schumacher's vision wasn't that everything should be small and local, but that in all things, ranging from decision-making in firms, to growing and distributing food and generating energy, our default position should be toward human scale. In this, the distance between decision and consequence, production and consumption, is kept as short as usefully and practically possible. Every neighbourhood might, therefore, have its own bakery, but not a factory making trains." (*http://www.guardian.co.uk/commentisfree/2011/nov/14/small-is-beautiful-ef-schumacher*).

unit by a massive scaling up of productive capacity through centralization, which necessitates ever more natural resources and transportation, are replaced by 'economies of scope,'[15] that is, making global knowledge and innovation instantly available to all nodes of the network, which can then apply circular economies, biodegradable materials, and more, to produce more directly for local need, as needs emerge, without necessitating constant over-production and the constant promotion of over-consumption. With economies of scope, the object of production becomes 'doing more with less,' creating value through variety rather than through volume.

COSMO-LOCAL PRODUCTION	Traditional manufacturing enterprise	Distributed manufacturing enterprise (neo-liberal global factory)	Cosmo localization
IP / knowledge sharing regime	Held by one company	Held by one company or consortium (e.g. Apple)	Shared under open or CC or Peer Production license etc.
Location of manufacturing	A single or local manufacturing center	Global factory, wherever the product can be most cheaply and effectively produced, elements of product can be produced	Global distributed networks of localized manufacturing, depending on take up and use of global design comons
Transport and trade	Product sent from local manufacturing centers to other places	Parts move across many countries and once assembled and shipped for trade	Requires developent of localized production ecosystems for complex manufacturing, Micromanufacturing clusters
Enterprise model	Publically Listed Corp., Family Owned Corp., Nationalized Corp.	Corporation or consortium with complex supply and distribution ecosystems	Open value network model, Platform Cooperatives, Maker Spaces, Phyles / Transnational collectives

Figure 2: Cosmo-local production

15. For a basic treatment, see *https://wiki.P2Pfoundation.net/Economy_of_Scope*.

The socio-technical requirements for this shift are essentially the following:

- We need open and shared supply chains to instantiate a perma-circular economy,[16] so that all the players in the ecosystem can plan and coordinate their production and distribution activities. The circular economy refers to 'circular' production systems, where the output of one process becomes the input for another, thereby drastically reducing waste. The 'perma' qualifier refers to the need to stabilize the growth of our usage of matter and energy so as to make these processes sustainable over the long term. The limit to material growth has been calculated to be a maximum of one percent per year.[17]

- We need shared accounting systems and distributed 'ecosystemic' ledgers, so that value streams can be exchanged. These systems need to allow permissionless contributions, and need to reward these contributions in a fair way. Open and contributive accounting will be discussed in chapter 3.

- The open and shared accounting systems also need to reflect an integrated or 'holistic' knowledge of the actual 'metabolic streams,' i.e., thermodynamic flows of matter and energy, and create a context-based sustainability for all the players in the ecosystem. What this means is that the limits to the usage of resources should be directly visible in the ecosystems that create and distribute the particular product and service. Solutions for this will be discussed in our third chapter. As James Gien Wong explains: "Here we have the concept of localizing planetary boundaries down to a granular level. There should be thresholds that signal that a value exchange is coming close to exceeding a regional boundary. We need to have multi-scale set points alert us that we are within acceptable ecological footprint boundaries."

16. "The expression is a composite of 'permaculture' and 'circular economy.' In a nutshell, I use it to designate a genuinely circular economy — one that not only insists on a generalized cyclical metabolism of the economy, but also on a culture of permanence: a deep questioning of the principle of economic growth. It's not an anti-growth concept per se. It merely follows common sense: What we need is selective and provisional growth of those things that are valuable for ecological and human viability; what we don't need is the across-the-board and unlimited increase of all things deemed valuable by those who see technological and financial capital as the primary drivers of social progress." - By Christian Arnsperger, https://carnsperger.wordpress.com/2016/06/15/welcome-to-perma-circular-horizons/
17. Xavier Rizos writes: "Francois Grosse, (former french engineer of Veolia) shows that circular economy cannot work above 1% growth, you merely differ the resource depletion of raw materials by maximum 60 years, but right now, most material use curves are actually 2-3%, which means they are all following an Exponential Function. So even with recycling rates of 90% we have no solution for material depletion! So we need to limit growth, not of GDP which is a fairly meaningless metric, but directly related to the extraction of materials." Source: *https://wiki.P2Pfoundation.net/Thermodynamic_Efficiencies_of_Peer_Production*

The aim of this study is to offer an overview and synthesis of the seed forms that are emerging to make this a real possibility in the coming decades. The concepts, prototypes, experimentations and actual practices already exist; with some exceptions, many of the seed forms have been developed, but they are still fragmented and have not yet created generative ecosystems.

The next step in the creation of such budding ecosystems requires paying attention to the technical structures being put in place as we speak, for example the extraordinary developments around the deployment of distributed ledgers for shared accounting and coordination of production. The key issue that needs to be solved in order to achieve truly sustainable production for human needs is whether what we produce is compatible with the survival of our planet and its beings. It is equally necessary to pay attention to the distribution of value. Indeed, most models developed today involve using open source and the commons to establish highly unequal extractive capitalist market forms, and do not use generative ones that would help strengthen the autonomy of the commons and the commoners.

Technology is, of course, not neutral, since its design reflects human intentions, material interests, and a particular balance of power between developers, funders, users, etc. We have a four quadrant model to explain this value-driven design in technology.

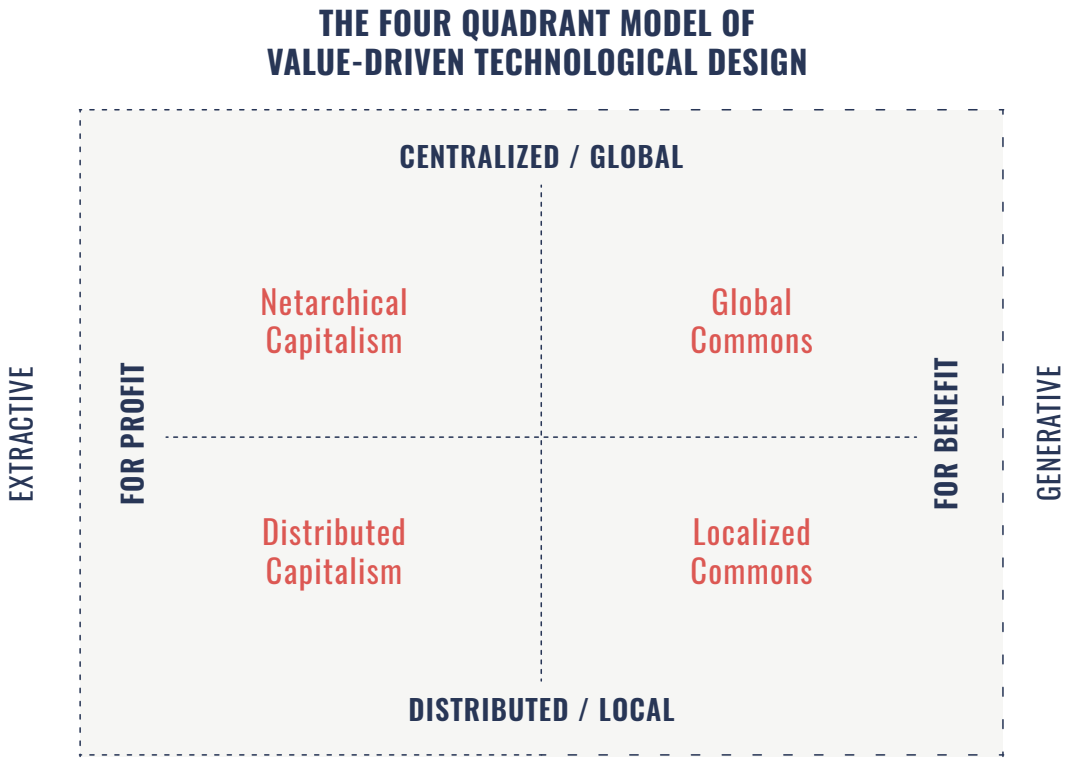


Figure 3.1- P2P socio-technical dynamics

A first model involves enabling P2P behaviours (both commoning and P2P-forms of market exchange) through centrally owned and controlled corporate platforms: think Facebook/Google and Uber/Airbnb as prototypes for this. This model, which also includes state actors that aim to control internet communication and platforms, could be called Leviathan, since it is about surveillance, the control and nudging of human behaviour, and the capture of value from commoners.

The second model, which is the one that will be most discussed in this study, is the model of distributed capitalism. This is made up of formally decentralized systems that aim to create permissionless usage by avoiding centralized gatekeepers (we will amend this over-simplification later on). We call this model Mammon,[18] as the aim is to extract profits, despite the usage of open-source technologies and code commons.

The third model involves creating commons for local provisioning (this is the dominant model amongst urban commons) that do not aim for profit-maximization. Enzio Manzini has characterized these models as Small, Local, Open, and Connected, or 'SLOC.'[19] This model type can share global knowledge over common platforms, but still aim to operate locally, in other words, the global serves the local.

Finally, there is a fourth model based on global open design communities that aim to create global common goods and are organized beyond the local. In this model, the global is recognized as a priority in its own right. These projects are often managed by non-profit and democratically-run foundations, but at present only rarely complemented by not-for-profit[20] entrepreneurial coalitions.

For the third and fourth models, we tend to use the name of Gaia, the Greek Goddess of the Earth, since these projects are most often geared towards sustainability. The third model in particular is specifically "generative" in its orientation towards local communities and ecological and social goals. In the

18. The name is inspired by the Hebrew word for "money" and identifies a god of material things in the Bible. See *https://en.wikipedia.org/wiki/Mammon*.
19. Ezio Manzini writes: "the focus shifts from the wider, amorphous whole to the smaller specifics of a system designed for the human scale. Such systems, by their nature, must be small, comprehensible and manageable. Once this is in place, they can then begin to connect with one another and interact with other similar smaller systems to reconstruct the whole. I call this complex relation between being small and being an open system, Cosmopolitan Localism." Sourced from the article: The New Way Of The Future: Small, Local, Open And Connected, by Ezio Manzini. *http://www.lcsi.smu.edu.sg/downloads/SocialSpace2011-The%20New%20Way%20of%20the%20Future%20Small,%20local,%20open%20and%20connected%20-%20Ezio%20Manzini%20.pdf*.
20. In not-for-profits any profit is reinvested towards the purpose and mission of the organization.

fourth model, the ecosystems are generative towards the creation of global common goods that are universally available.

This means that we are not merely discussing competing models and platforms in the name of efficiency or profitability, but also worldviews with different social and political priorities.

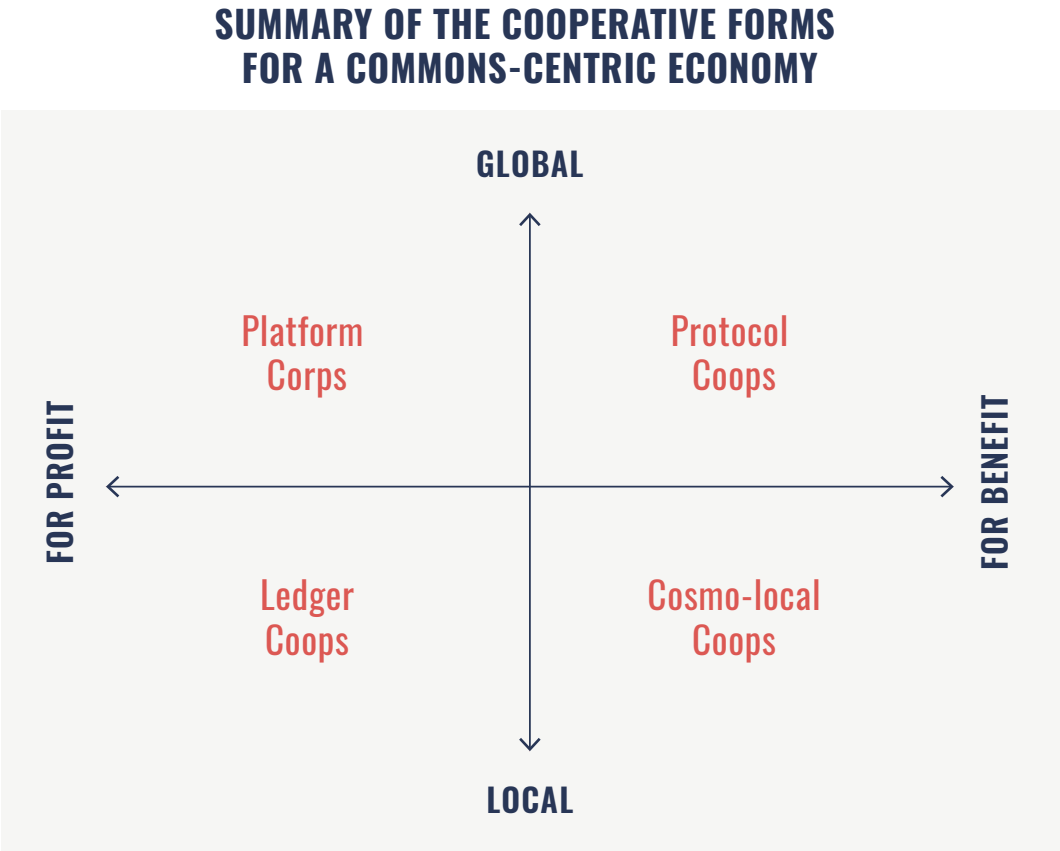


Figure 3.2: Cooperative forms

In the context of the P2P Foundation's own views, this means that we look at how to transform the functions of the central corporate platforms, into platform cooperatives[21] and open cooperatives[22] that do not merely capture the value created by their users, but can also be co-owned and co-governed by their stakeholder communities. In the case of the infrastructures of

21. This is a marketplace where the platform itself is cooperatively owned or managed by several stakeholders, instead of being a privately owned and often extractive business model.
22. At the P2P Foundation, we consider coops to be one of the appropriate governance forms to manage shared resources; open cooperatives are coops that are institutionally committed to produce commons for the larger public.

distributed capitalism, such as the blockchain, this means we will try to tweak and transform them so they can be used to expand socially equitable and ecologically regenerative models of production to fit human needs, thus serving the requirements and interests of the commoners. In this context, we explore the concept of ledger coops.[23] The third quadrant calls for urban provisioning coops. In the fourth one, the generative global quadrant, we call for 'Protocol Cooperatives.' A protocol coop is basically a governance form for global open design depositories, collectively managed hubs of software that endeavour to assist in the deployment of local systems for the mutualization of provisioning systems. In this scenario, leagues of cities could, with other allies, cooperate in the setting up of such common infrastructures, for instance, in order to replace the extractive model of Airbnb with generative models such as Fairbnb, thereby avoiding duplication of effort. Please note that we use the concept of 'cooperative' in a generic way here, to indicate all institutional forms that are not geared towards profit-maximization but towards generative purposes.

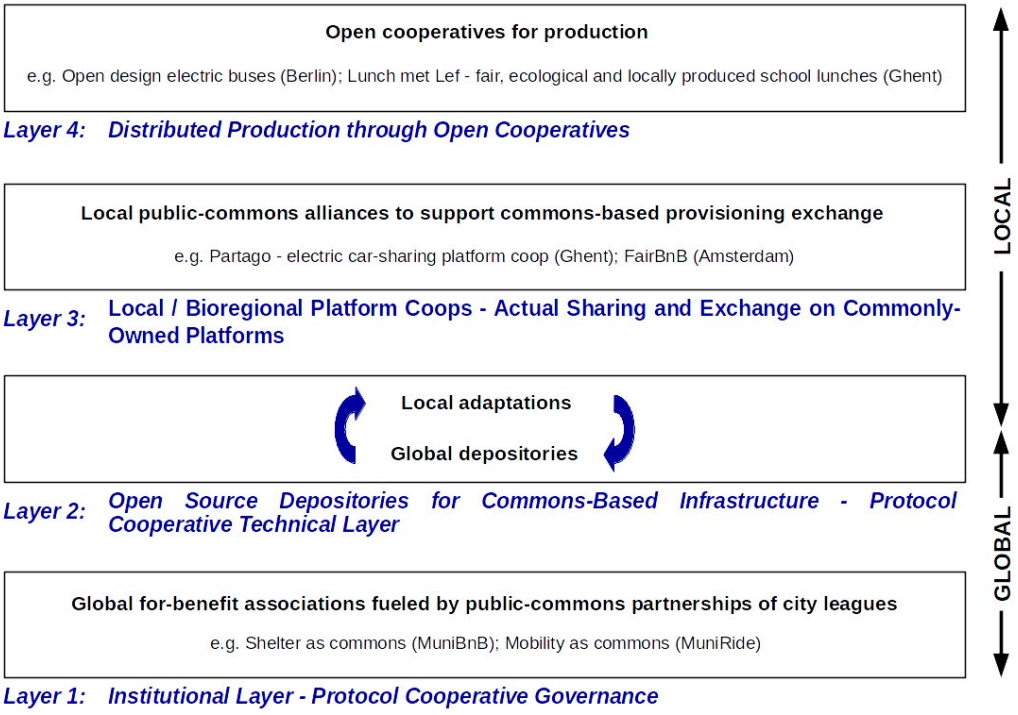


Figure 4: City-supported cosmo-local production infrastructure

23. For example, we are exploring the concept of Distributed Income Support Cooperatives. *https://wiki.P2Pfoundation.net/Distributed_Income_Support_Cooperatives*

The first law of thermodynamics, regarding the conservation of matter and energy, states that no matter/energy can get lost, only transformed. This can be linked to the development of the idea of liberalism and the generalization of support for growth-oriented capitalism, that is, an economic system based on the idea of material abundance and infinite growth, since indeed, nothing can be lost.

The second law, on the dissipation of energy from high levels of order to lower levels of order, i.e., entropy, introduces the idea of scarcity and a demand that basic needs should be covered, before they are unequally distributed. This new insight could be seen as reflected in the socialist aims of the labor movement.

But as Yochai Benkler (Benkler, 2011) and others have described, for the last few decades a much deeper appreciation of how human cooperation (and that of other living beings) as well as synergy lead to negentropic effects. This means that life and society create temporal and territorial exceptions to entropy and lead to domains where order and complexity increase over time (some have argued this should be construed as a third law of thermodynamics). The new generations of technology should reflect this understanding, and become ecosystemic and ecological in their approaches to producing and distributing value. This is only happening partially, in that our emerging systems are becoming ecosystemic but not truly ecological yet.[24]

The next two sections outline what we have discovered about value streams in the commons economy, and introduces the issue of externalities.

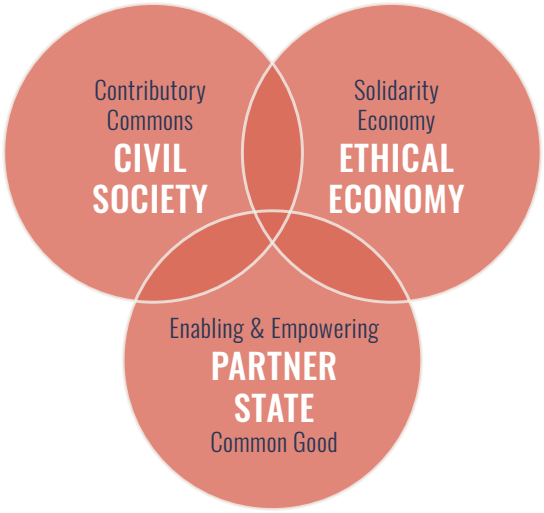


Figure 5: The three great spheres of social life in commons transition

24. There are various competing notions for this third law, which is scientifically still contentious. We are using James Quilligan's hypothesis because it makes the most sense in our specific context here.

THE EVOLUTION OF THE COMMONS

We can use the following framework to 'historize' the evolution of the commons:

1) The original commons are the natural resource commons, such as fishing grounds, irrigation systems, shared pastures, etc.; these types of commons, still prevalent in parts of the global South, face enormous stress in the capitalist systems, which tend to privatize and enclose such commons.

2) Once the enclosure movement starts in Great Britain, and the common grounds are privatized, farmers have to move to the cities for survival. The workers' movement ushers in an important emergence of social commons, in which 'life risk' is mutualized in mutual-aid societies; many of these social commons will be nationalized to create social security systems.

3) October 1993 (the web and the browser) is the beginning of an exponential growth of networked knowledge commons: billions of people have access to such shared knowledge, which is also applied to cooperative production of free software and open design.

4) After the crisis of 2008, we see an exponential growth of urban commons for the reorganization of provisioning systems in the context of state and market failure, with food and energy already being self-produced by local commons-centric ecosystems.

5) Cosmo-local production occurs when collectives start moving to the production of material goods and services, whereby 'all that is light is global and shared, and all that is heavy is redistributed and produced more locally.'

THE EVOLUTION OF RESEARCH IN THE P2P FOUNDATION

The research base of the P2P Foundation started with a re-examination of the logic of transition periods, when one social or civilisation system is replaced by another. The key focus of the P2P Foundation is observing and understanding seed forms that exemplify successor systems. We started by examining networked socialities and open-source production communities, that are developing commons-centric forms of organization.

Based on our understanding of the logics of peer production, peer governance and peer property, we focused on the optimal relationships between the commons and the market, and the question of creating ethical livelihoods by tweaking and transforming market practice to allow the emergence of a commons-centric economy.

Subsequently, we moved to public-commons cooperation and the commonification of public services, i.e. looking at how cities, regions and state could relate to the emergence of these new forms of civic collaboration.

Once a grounded understanding of these three institutional realities and their mutual relations was in place, we started focusing on the enabling conditions, centering on two main themes: the sustainability of material production (i.e., the thermodynamics of peer production), as well as new forms of human solidarity for the contributive economy in a networked age (commonfare).

Value in the Commons

This report builds on our findings in previous research reports.

The P2P Value research project[25] showed that a majority of the 300 peer production projects under study were engaged in using, prototyping, or experimenting with contributive accounting, i.e., forms of accounting not based on hourly labor but recognizing all other ways of contributing in these open and permissionless production communities.

Our study, *Value in the Commons Economy* (Bawens & Niaros, 2017), based on different case studies of advanced peer production communities such as Enspiral and Sensorica, outlined the following concepts and practices:

- The new peer production communities are directly oriented to the production of use value, not exchange value, and make claims to 'value sovereignty,' in other words, the right to determine context-based value regimes that differ from the sole recognition of commercial value under capitalism. This allows for an autonomous flow of value within the communities and for the recognition of all kinds of contributions, not just paid 'commodified labor.'
- These new communities create a membrane between the commons and the market, which enables them to regulate the flows of value between income from the market and state-based value models, as well as the internal flow within the commons, which can be differentiated from each other. In other words, it is possible to accept revenue from outside the commons, while distributing according to the norms of a particular commons.
- We recognized three models: one in which the commons and the market are clearly demarcated, allowing free, unpaid contributions and free usage within the commons, which is thereby protected against contamination by market exchange logics; a second model in which contributions are rewarded by a different value equation, which are then funded post hoc by income from the market and the state; and, finally, a third one that more intimately and directly links commons contributions to market income.

25. The P2P Value research project was undertaken by a EU-funded research consortium of which the P2P Foundation was a partner. It also concluded that contributors identified with their transnational contributory community and that reputation functioned as a real capital good, opening access to resources. See: https://P2Pvalue.eu/

- These communities practice and experiment with reverse cooptation of market income and investments, i.e., 'transvestment'.[26] While investment concerns using capital to obtain more capital, transvestment uses market and state investments, but translates them into the growth of commons assets and infrastructures. For example, capital is attracted and even remunerated, but increases the common stock of free software, or commonly-owned land in a land trust, etc. One of the techniques is to create a wall between investments and the purpose-driven generative entities creating livelihoods for the commoners.

- A few are experimenting with new forms of licensing, halfway between the 'free-for-all' copyleft licenses and the privatizing copyright licensing models. In copyfair models, the sharing of knowledge remains entirely free, but commercialization is conditioned by some forms of required reciprocity with the commons.

A landmark study for us has been our research publication about the 'Thermodynamics of Peer Production'.[27] In this study, we show the vital impact of mutualization of infrastructures of production and consumption, to the lowering of humanity's footprint, which is already visible, among other places, in the local commons-centric food economy. This is also obvious in the sharing of resources, for example, in car-sharing that follows non-profit or cooperative modalities (but DOESN'T use models like Uber, which augment resource use), where every shared car can replace from 5 to 15 private cars,[28] thus dramatically reducing the needs for matter and energy expenditure.

These advantages were confirmed in our study of the urban commons in Ghent, where we were able to determine that, for every single provisioning system in the city, there are now no longer just choices between private and public models (say private housing vs state-sponsored social housing), but also commons-based alternatives (such as commons-based cooperative housing modalities). Various studies have confirmed, at least for car-sharing, that this type of mutualization effectively overcomes Jevons Paradox, which states that lowering cost and efficiency often leads to higher consumption. Our challenge is to place the advantages of mutualization in lowering the human footprint in a sufficient systemic change effort, so that gains in one sector are not undone by higher consumption in other sectors.

26. For a detailed treatment of transvestment, see *https://wiki.P2Pfoundation.net/Transvestment*
27. See our report, Peer to Peer and the Commons: A matter, energy and thermodynamic perspective. (parts I and II). By Céline Piques and Xavier Rizos with Michel Bauwens. P2P Foundation, 2016. Available at: *https://commonstransition.org/peer-peer-commons-matter-energy-thermodynamic-perspective*.
28. For the sources for these figures, see *https://www.transportenvironment.org/sites/te/files/publications/Does-sharing-cars-really-reduce-car-use-June%202017.pdf*

We cannot stress this enough: putting commons center stage, i.e., shared resources self-managed by their stakeholder communities, is a vital necessity in any social and ecological transition. This is confirmed by the HANDY study,[29] which compares resource crisis moments of hundreds of past civilizations, starting from the Neolithic period. Far from being exceptional, HANDY shows that civilizational collapses are a regular occurence in class-based societies, where ruling classes are perforce engaged in competition with their peers and, driven by this necessity, over-use their local resource base to the point of collapse.

The study shows that inequality is a vital part of accelerating and deepening such collapses: the more unequal the society, the more egregious the over-use, the deeper the fall, and the longer it takes to recover. Equality mitigates these crises, and can perhaps even avoid them. Mark Whitaker[30] has produced a comparative study of more recent collapses and resets in China, Japan, and Europe, and has shown the vital role of mutualization in the revival of these societies. Notice the parallel between the role of pan-European exchange of knowledge by Christian monastic communities, the mutualization of their production infrastructures in the monasteries, and the relocalization of production in the feudal domains, with the current emerging reactions: the creation of vast open-source and open-design communities, new forms of mutualizations of infrastructures in the models of coworking and makerspaces, as well as the 'sharing economy,' and the increasing experimentation with cosmo-local models of distributed manufacturing.

Changing class dynamics and structures within society is an important part of any systemic change. The shift from the Roman system, based on conquest and slavery, to the feudal system, based on local production in local territory, was a shift from slavery to serfdom and from slave-holding to feudal status. The shift from feudalism to capitalism was a shift from serfdom to working in factories, from land ownership to ownership of investment and financial capital.

29. Human and nature dynamics (HANDY): Modeling inequality and use of resources in the collapse or sustainability of societies. By Safa Motesharrei, Jorge Rivas and Eugenia Kalnay. Ecological Economics, Volume 101, May 2014, Pages 90-102. Source: http://www.sciencedirect.com/science/article/pii/S0921800914000615. Added discussion via *https://wiki.P2Pfoundation.net/HANDY_Model_for_Civilisational_Collapse_Scenarios*
30. Ecological Revolution: The Political Origins of Environmental Degradation and the Environmental Origins of Axial Religions; China, Japan, Europe. by Mark D. Whitaker. Details and discussion via *https://wiki.P2Pfoundation.net/Political_Origins_of_Environmental_Degradation_and_the_Environmental_Origins_of_Axial_Religions*.

In our analysis, the current evolution involves a shift towards netarchical capitalism, i.e., the direct exploitation and capture of value, not from commodity labor in factories and offices, but from peer to peer exchange in platforms and from participating in commons-based peer production. In other words, the new capitalism is a commons-extracting capitalism, which directly enables, but also exploits, human cooperation.[31] One could say that we have evolved from a Marxian capitalism, with surplus value directly extracted from labor as a commodity, to a Proudhonian capitalism, since the latter argued that surplus value was derived from the extra value generated by human cooperation.[32]

In this particular conjuncture, we see increasingly larger parts of the working class evolving, at least in Western countries, from a subordinate salariat to a condition of generalized precarity (some call it 'the precariat') (Standing, 2011),[33] but this also involves the growth of post-subordinate autonomous workers who are simultaneously involved in networks, commons, and markets.[34] These workers need to participate in networks to create connections, expertise and reputational capital, and are often passionately involved in contribution-based and permissionless digital commons; but they often operate as freelancers in the market. They frequently have a strong desire for and demand autonomy and free cooperation. In many ways, this 'cognitive working class' is at the forefront of social change today, becoming an active agent in the transformation of the system, largely due to their vital place in the knowledge ecosystem. This is evident in the growth of open source economies tied to the urban commons and other areas beyond what is usually perceived as "knowledge work." In this report we will concentrate on the growth of systems of production and distribution of value using distributed ledgers, or what is now known as the blockchain or cryptoeconomy.

For the last year, one of the authors has been closely involved with a large European platform cooperative, SMart (.coop), which is also called a labor mutual. In a labor mutual, formally independent workers, who in the best of cases have a passionate life project that allows them to filter their work engagements, are able to create solidarity by converting their invoices into

31. For a detailed description and analysis of these new and poorly compensated 'digital labor' practices, see: **Heteromation, and Other Stories of Computing and Capitalism.** By Hamid R. Ekbia and Bonnie A. Nardi. MIT Press, 2019.
32. This 19th-century controversy is discussed in detail in: *Commun. Essai sur la révolution au XXIe siècle*. Pierre Dardot and Christian Laval. La Découverte, 2017.
33. Excerpts via (http://goo.gl/Q8GcO).
34. We recommend the thoughtful treatment by Alex Foti in his *General Theory of the Precariat*. Source: http://networkcultures.org/blog/publication/general-theory-of-the-precariat.

salaries, thereby gaining access to the social protections of the welfare state. These autonomous, post-subordinate workers, also represent a convergence model between the precariat and the salariat, and are prime candidates for the emerging commons economy, They have a big role in the creation of the post-corporate ecosystems that we will be describing in one of the chapters of this report. Please note that we do not see these new types of workers as the sole actors in transformation, but we do believe they play a very important role in this particular transition. To the degree that the laboring classes start to see themselves not as merely adversarial to the current system, but as active commoners in the creation of new life forms, they are also joining the new commoner or 'hacker class.'[35]

35. "The hacker class is the class with the capacity to create not only new kinds of object and subject in the world, not only new kinds of property form in which they may be represented, but new kinds of relation beyond the property form. The formation of the hacker class as a class comes at just this moment when freedom from necessity and from class domination appears on the horizon as a possibility.... Hackers must calculate their interests not as owners, but as producers." Sourced from an interview with McKenzie Wark, at http://frontwheeldrive.com/mckenzie_wark.html.

THE ROLE OF LABOUR MUTUALS, COMMONFARE AND POST-SUBORDINATE WORKERS

An increased number of workers, especially in Western countries, are either forced or choose to work more 'autonomously,' considering work as a series of contributions or projects, but such a transition is often characterized by precarious living conditions. One of the ways to remedy this is through the creation of labour mutuals, through which workers start to mutualize their common work infrastructure, as well as to facilitate access to social security services. One of the potential solutions is the model of a post-subordinate salariat, i.e., a model through which workers retain their freedom to choose or refuse projects, yet join a co-owned cooperative in which they are formally salaried, thus benefit from social security. In such a scheme, members' invoices are bundled to generate a regular salary upon which taxes will be paid, but in exchange for access to the services of the welfare state. Such a model is developed, for example, by the SMart cooperative (SMart.coop), which is active in nine different European countries.

The emerging crypto economy as a signpost for the cosmo-local transition

If we look at the evolution of contemporary commons, from the emergence of the immaterial 'digital' commons for knowledge, software and design, via the mostly redistributive provisioning systems of the urban commons, we now see the emergence of a new phase that involves bringing the use of the open-source and commons models straight into the physical production processes. For example, the Economic Space Agency speaks of a shift from open-source software production methodologies, to open-source economic spaces, i.e., from the mere production of knowledge, code and design, to full-scale economic cooperation around the production and distribution of all kinds of value so as to secure livelihoods.

The emergence of the distributed bitcoin currency, and most importantly its underlying infrastructure broadly discussed as blockchain technology, is a very important signpost in this regard, as we explain further in this document. In this chapter, we aim to provide a short explanation of this emergence, critiquing the current models from a P2P and commons-based point of view, so that we can suggest the main tweaks and transformations that are necessary for the support of a true, solidly commons-oriented mode of production and exchange in the sphere of physical production. This would combine our priorities for open and freely shared knowledge, respect for the biocapacity of the planet, and fair distribution of the rewards for common work.

The aim of this work is to see how, in our management of the production and distribution of value, we can 'internalize' what is presently 'externalized,' i.e., not accounted for and not cared for.

The design, emergence and success of bitcoin was a very important first pivot. Over the last decade, there has been an increasing number[36] of locally-based complementary currencies, but with limited numbers of local users and turnover. To date, they very rarely achieve scale even in their local contexts.[37] By contrast, bitcoin was the first attempt for a globally scalable currency that was based on social sovereignty, instead of corporate or state-based rule. The trust of the community was ensured, not by mediating third party

36. According to Bernard Lietaer, there are currently 6,000 to 7,000 types of local currencies: *https://payment21.com/blog/complementary-currencies-entering-digital-era*
37. New measurement techniques may be able to change this general appreciation. See the efforts of Grassroots Economics in Kenya and other African countries: *https://www.grassrootseconomics.org/single-post/2018/12/13/Proof-of-Impact*

institutions but by trust in the integrity of cryptographic rules. For the first time in recent history, we have a currency that was created autonomously and gained the trust of a global community, while achieving tangible and spectacularly recognized levels of market value. Following bitcoin, many other cryptocurrencies are also achieving relative success, even amid the speculative frenzy. We can observe a surge of permissionless creation of currencies, with a relatively autonomous capacity to allow value flow outside of the traditional banking channels, which gave rise to the idea of crypto-assets. These value flows are coordinated in more decentralized ways, even if new types of intermediaries may be facilitating this. Cryptocurrencies have thus been envisioned as a store of value and a kind of global reserve backing, like gold, but their usability in day-to-day exchanges in real marketplaces has not been realized, except very marginally. At any rate, cryptocurrencies introduce the idea of pluralist value streams and the circulation of assets in decentralized P2P networks.

However, even if the bitcoin code is open source and supported by a global community, there are also huge issues that do not make it an appropriate currency for the commons economy. Essentially, the commons are subsumed here to social and ecological extraction. On the one hand, social extraction, because the particular design means that early entrants can sell bitcoins at a higher price later (since production is designed to slow down and even stop over time, while demand grows without set limits, thereby structurally stimulating demand over supply).[38] This has made bitcoin into a tool for financial speculation.[39] On the other hand, ecological extraction, given that its production necessitates exponential energy usage.[40]

Value in bitcoin is created through the monetary mechanism itself, not by the creation of productive value. In fact, bitcoins are created through an extremely resource-intensive process called "mining," which is extremely capital- and resource-intensive, as it requires huge computational capacity. Bitcoin thus relies essentially on capitalist mechanisms for its existence.

38. Dan Kervick describes the problematic deflationary design as a scheme for extraction here: http://neweconomicperspectives.org/2013/04/talking-bitcoin.html.
39. We agree with the evaluation of James Gien Wong: "in hindsight, it was natural that it emerged at the intersection of distributed computing networks and capitalism, but from the commons perspective it is at the very bleeding edge. Its importance to the commons is that it proved that there is a global appetite for it, but it still shares fundamental DNA with the traditional form of extractive capitalism that birthed it. Now the job is to replace extractive distributed value exchange with a more equitable form." From a comment to our draft report.
40. See in particular: *https://arstechnica.com/tech-policy/2017/12/bitcoins-insane-energy-consumption-explained/*. For various additional statistics on its energy usage, see: *https://wiki.P2Pfoundation.net/Bitcoin#Energy_Usage_Aspects*.

Furthermore, almost the entirety of bitcoin mining has gradually been taken over by vast mining plants, specially designed to afford enormous processing power, making it almost impossible for single users to engage in any mining themselves.[41] Hence, bitcoins for them can only be acquired in exchanges, again via the capitalist market (or by working for the owners).

Most cryptocurrencies are traded as financial assets on open markets, that is to say, their price is based on supply and demand, and is denominated in regular fiat currency. Value flows from one currency into another, but the currency is a representation that does not create value by itself any more than a balloon creates 'volume.' In other words, bitcoin owners extract rent from productive value creators in the rest of the economy: it is a distribution of rent-seeking.[42] Bitcoin is most certainly a currency of and for the market, more specifically a currency for decentralized capitalist market dynamics, specifically for market forms that seek to escape governmental and societal control.

Beyond bitcoin and other cryptocurrencies, a second generation of blockchains introduced autonomously executed computer processes broadly known as "smart contracts." These are software programs stored on a blockchain and employ a set of predefined rules that may be enforced automatically once certain conditions are met. Multiple parties in a distributed network can access and interact with smart contracts, but they are largely autonomous and very difficult to reverse once deployed.

Ethereum was the first initiative supporting the deployment of smart contracts on a blockchain. It envisioned a potential use of blockchains that goes beyond the storage or reference of transactions, but may include any type of information that allows users to define the functionality of decentralized applications (dapps). Ethereum also implements its native cryptocurrency called "Ether" that, much like bitcoin, is allocated to miners through a similar process and can be transferred in the network.

Smart contracts gave rise to an ever-increasing number of potential uses of blockchains, on every domain where formal agreements have to be encoded

41. There are mining pools (https://bitcointalk.org/index.php?topic=1975844.0) and cloud mining services (https://hashflare.io/) (the latter considered problematic by many in the crypto community), that allow for individuals and groups to do their own mining.
42. This discussion is separate from any recognition that a cryptocurrency network has a 'value in itself' as a new form of infrastructure. Philip Honigman argued in a comment on our draft: "irrational speculation aside, which certainly plays a role, there is a value intrinsic to decentralized autonomous money – and the cost to produce it, as excessive as it might seem today – is an inherent requirement to its production."

and enacted, including financial transactions, insurance and securities, and intellectual property rules. Probably the most ambitious deployment of smart contracts has been new types of decentralised organisations, commonly referred as "Decentralized Autonomous Organizations" (DAOs), which rely purely on blockchain code and the distribution of tokens to enforce their rules to control decision-making and operations. The DAOs have stimulated discussions and experiments around the provisioning of digital services and transactions that take place with little or no direct human action, while they arguably cede agency to non-human subjects, including machines, objects or even natural ecosystems.

It is especially in this light that the blockchain, or more broadly 'Distributed Ledger Technology' (DLT) has been acknowledged as an even more radical innovation. We note that accounting and civilization have developed together. Writing was invented as a by-product of accounting, when temple-state, class-based civilizations emerged in Mesopotamia, to keep track of the coming and going of commodities in the temples' storage places, as well as to record debts. These first forms of accounting accompanied the birth of class-based civilization and the accompanying state forms. When the Franciscan monk Pacioli standardized 'double entry' Venetian bookkeeping in the year 1494,[43] it announced the birth of capital accumulation which would eventually engulf the whole world a few centuries later. Today, next-generation accounting models, such as Resources - Events - Agents[44] abandon double-entry to favor ecosystem- and network-based accounting flows. What we get is something that goes beyond closed corporate accounting and potentially announces and accompanies a huge civilizational shift away from atomized institutions that compete with each other, and instead points towards a more networked structure based on much higher levels of collaboration over joint platforms.

The blockchain encodes and shows the viability of open and shared accounting in representing the multitude of transactions and actions occurring during physical production.

This is historic, as it allows us to move from corporate and nation-state accounting (which, even as they are publicly regulated and accessible to

43. Luca Pacioli's "Summa de arithmetica, geometria, proportioni et proportionalita" (1494, Venice: Paganino di Paganini) is regarded to be the first known printed treatise on double-entry bookkeeping. For more details see: Sangster, A. (2010). Using accounting history and Luca Pacioli to put relevance back into the teaching of double entry. *Accounting, Business & Financial History*, 20:1, 23-39.
44. REA accounting is explained in chapter 3. It is an accounting solution for entities and individuals working in a networked ecosystem, and situates every transaction in the flow of all actors of that system.

the public, are 'privative' accounting internal to bounded entities, in which externalities are invisible), to ecosystemic accounting in networks with multiple participants and in an environment of permissionless contributions. In other words, it allows for large-scale mutual coordination of physical production, and makes practical the scaling of circular economies. It is an extension of the principles of the open source economy, to physical production.

Distributed ledgers furthermore allow both the recognition of a variety of contributions, i.e., open and contributive accounting, but also the capacity to integrate directly the visioning and management of physical flows of matter and energy.[45] This differs from the previous approaches such as Ecological Economics, that converted resources in price signals.[46] The combination of distributed and shared ledgers, as well as the capacity to integrate externalities, constitute a radical innovation.

Presently, the production of immaterial value, i.e., knowledge, software and design, enables 'stigmergic coordination'[47] between permissionless contributors, who can access open and transparent depositories that represent the flow of work. With shared accounting, this capacity for mutual coordination moves to the physical plane. But because physical production calls for specific reciprocity in terms of material capital (which otherwise would get depleted), and not just the principle of free universal usage, it requires that distributed ledgers add this layer of value exchange.

To use the 19th-century language, for example, as used by Marx:

- As far as immaterial production is concerned, we already have the principle of 'communism' at work in the very heart of the capitalist economy (in its original sense of 'everyone can freely contribute and everyone can freely use'), which some authors like Richard Barbrook have called cyber-communism (or 'cybernetic communism', Barbrook, 2015),[48] because of the 'abundance' of digital knowledge which is easily and cheaply reproducible, and thereby overwhelms the scarcity dynamics of supply and demand, moving the market functions to the periphery of open-source production communities, with the commons in the middle. Paradoxically, this cooperative coordination is largely incorporated in the corporate economy, inspiring some scholars to

45. As an example, see footprint analysis: https://data.footprintnetwork.org/#/exploreData
46. For example, see: https://en.wikipedia.org/wiki/Ecosystem_valuation#History_and_Economic_Model
47. For details about stigmergic coordination, see: *https://wiki.P2Pfoundation.net/Stigmergy*
48. Richard Barbrook (2000) CYBER-COMMUNISM: How the Americans are Superseding Capitalism in Cyberspace, Science as Culture, 9:1, 5-40, DOI: *10.1080/095054300114314*.

speak of the 'communism of capital.'[49]

- In physical production, however, we need reciprocal flows to avoid depletion of non-renewable resources, either through market exchange (but not necessarily capitalist exchange) or through contributory recognition ('to each according to his/her contribution;' this was defined by Marx as 'socialism').[50] Capitalist markets are nominally based on the idea of equal exchange, but in their actual practice they are based on the constant extraction of surplus, from nature and other humans, in order to accumulate capital in private hands.

Ethical and generative markets use monetary signals, but are not focused on profit maximisation. Many pre-capitalist markets were socially embedded, as Karl Polanyi has shown. We will later show that we need to move from pricing signals, which reflect current supply and demand – but not the necessities of protecting and maintaining resources in the long term – to monetary signals, i.e., to currencies that are directly related to the status of the natural resources we need to maintain and replenish.[51] If such a linkage between the amount of natural reserves that are sustainably available and a corresponding monetary mass could be achieved, then the monetary signals themselves would be a technique for responsible material production.[52] An example of this is the Fishcoin project, in which the amount of coins that can be spent reflect the stock of fish that can be used without endangering the reproduction of the fish.

So, the blockchain, like bitcoin, has received extensive attention and a huge wave of investments, viewing it as a new infrastructure layer for a more distributed economy. And precisely because it is linked to the design philosophy of bitcoin, it shares some of its fundamental limitations. Bitcoin's design and infrastructure are based on an individualistic understanding of the economy that combines elements from the marginalist traditions,

49. See our own article on this topic: From the Communism of Capital to Capital for the Commons: Towards an Open Cooperativism. By Michel Bauwens, Vasilis Kostakis. Triple C, Vol 12, No 1 (2014). Available at: http://www.triple-c.at/index.php/tripleC/article/view/561.
50. See this article for the distinctions: *https://j-humansciences.com/ojs/index.php/IJHS/article/view/3152*.
51. An early proposal was the Terra, a global complementary currency designed to provide an inflation-resistant international standard of value; to stabilize the business cycle on a global level; and to realign stockholders interests with long-term sustainability. *http://www.lietaer.com/2010/01/terra/*
52. Charles Eisenstein presents a proposal for this in *Sacred Economics*: "Once we have decided how much of each commons should be made available for use, we can issue money 'backed' by it. For example, we might decide that the atmosphere can sustain total sulfur dioxide emissions of two million tons a year. We can then use the emissions rights as a currency backing. The same goes for the rest of the commons. The result would be a long list comprising all the elements of the commons we agree to use for economic purposes." See here for full context: *http://sacred-economics.com/sacred-economics-chapter-11-currencies-of-the-commons/*

Austrian Economics, and 'anarcho-capitalist,' 'propertarian' philosophy. It is based on 'methodological individualism,'[53] the premise that society consists of individuals seeking maximum advantages in a competitive game in which every human being is seen as an entrepreneur, which contracts with others in order to conduct his or her business.

For example, when blockchain projects talk about governance and 'consensus,' what they emphatically don't mean is collective governance based on democratic deliberation, but they merely mention the coordination of individual actions with common intentions.[54] Because liberalism believes that the common good results from individual and corporate competition, it has no clear concept to articulate it other than the accumulation of individual gains, and it does not see the interdependence between the market and a whole host of societal and environmental realities. The commons and open-source dynamics are often appropriated to emphasize individual freedom, mostly restrained to a 'one dollar, one vote' context, disregarding the elements of social fairness and ecological sustainability.

As Arthur Brock has argued, there are no people and communities in the blockchain design, no community governance, 'only transactions organized in blocks linked to a chain";[55] there is no organic connection between the blockchain and the open-source communities and commons that undergird it.[56]

Furthermore, bitcoin and blockchain are not truly distributed, that is,

53. Rachel O'Dwyer writes: ""What kinds of subjectivity do we want to algorithmically inscribe into our systems? Blockchain start-ups begin from the assumption that there is no trust and no community, only individual economic agents acting in self-interest. Fair enough, you might think, it's precisely the fact that projects like Ethereum engineer confidence and provide economic incentives for contribution that may distinguish it from other services like Freenet. But it also proceeds from a perspective that already presumes a neoliberal subject and an economic mode of governance in the face of social and/or political problems. 'How do we manage and incentivise individual competitive economic agents?' In doing so, it not only codes for that subject, we might argue that it also reproduces that subject." Source: *https://www.academia.edu/11627298/The_Revolution_Will_not_be_Decentralised_Blockchain-based_Technologies_and_the_Commons*.
54. "Even narrower is that consensus is a technical term describing how different nodes agree on which block to publish next. This article is part of a series on consensus and governance and is illustrative of the kinds of debates: *https://blog.coinfund.io/the-consensus-series-part-i-the-basics-of-collectivity-a11d76ff4d5d*.
55. Arthur Brock writes: "In computer science, an ontology describes what EXISTS in a system. For example, in bitcoin what exists are transactions organized into blocks linked in a chain. The first transaction in each block gets to create new coins (cryptographic tokens). The other transactions spend a coin by signing (with a private key) the previous transaction to a new owner (using their public key as their address/identity). There are also nodes with which you send and receive transactions. Notice no people in that ontology. They don't exist. With no people, there are no relationships, no communication, no interconnection, no community. How can a community that doesn't exist regulate itself?" Cited from *https://medium.com/metacurrency-project/cryptocurrencies-are-dead-d4223154d783*.
56. This is why, by contrast, Holochain is entirely 'agent-centric,' i.e., designed around people, see chapter 2.

consisting of equipotent peers that voluntarily create nodes through their free and open cooperation, but they are rather decentralized. This means that while they avoid the domination by vertically integrated oligarchic companies, they are still based on major power blocks, such as influential 'miners,' large investors, etc. Bitcoin's inequality coefficient,[57] measured by the Gini metric, is higher than the inequality in the sovereign currencies that it aims to replace. Blockchain has an oligarchic design,[58] as most mechanisms used to reward contributions (the 'proof of work' mechanism) and resources (the 'proof of stake' mechanism) reward those that can already provide the most.

Sam Pospischil writes that "blockchains are too slow and expensive for a large variety of use-cases. If you look at something like, say, *OriginTrail*, they've built a separate overlay network to store structured graph data and document attachments. Pretty much everyone has something similar, with varying levels of "decentralised-ness" ranging from traditional SQL databases to networks that anyone can spin up and participate in just like a (public) blockchain."[59]

Different layers of the blockchain ecosystem are routinely dominated by a small group of dominant players, even if they have to contend with the other layers in the system: miners, developers, users.

What matters in this report therefore, is not necessarily the blockchain idea in the narrow sense, but the generic concept of distributed ledgers.[60] Nevertheless, it would be a mistake to underestimate the innovative features of the blockchain design, which Sarah Manski has summarized.

57. We have collated various figures about the unequal distribution of bitcoin, here: *https://wiki.P2Pfoundation.net/Bitcoin#Bitcoin_inequality_statistics* . For the Gini statistic, see: Gini Coefficient = 0.87709 ; Bitcoin Wealth Distribution extremely unequal (Bitcoinica data), the 1% own 50%; more at http://ow.ly/trKoy.
58. "If someone tells you they're building a "decentralized" system, and it runs a consensus algorithm configured to give the people with wealth or power more wealth and power, you may as well call bullshit and walk away." Sourced from Arthur Brock at *https://medium.com/holochain/blockchain-blind-spots-1904d490218d*.
59. This is copied from an email conversation with one of the authors.
60. Please note that these collaborative or interoperable ledgers need not be tamper-proof. As noted in a comment by Marco Fioretti: "In some cases, namely food, delivering what promised may cause LOTS of extra pollution and consumption of raw materials. In addition, it may even destroy small producers, making informal/grey economy impossible, if it happens without simultaneous deep changes in tax and other regulations."

THE SEVEN TENDENCIES OF BLOCKCHAIN TECHNOLOGY BY SARAH MANSKI

1) *Verifiability* Transactions are assured through encrypted network consensus mechanisms in such a form that all transactions from the very first to the most recent are recorded in a ledger open to its maintainers, reducing information asymmetries

2) *Globality* Digital transactions and cultural information flows transcend geographic space and national borders

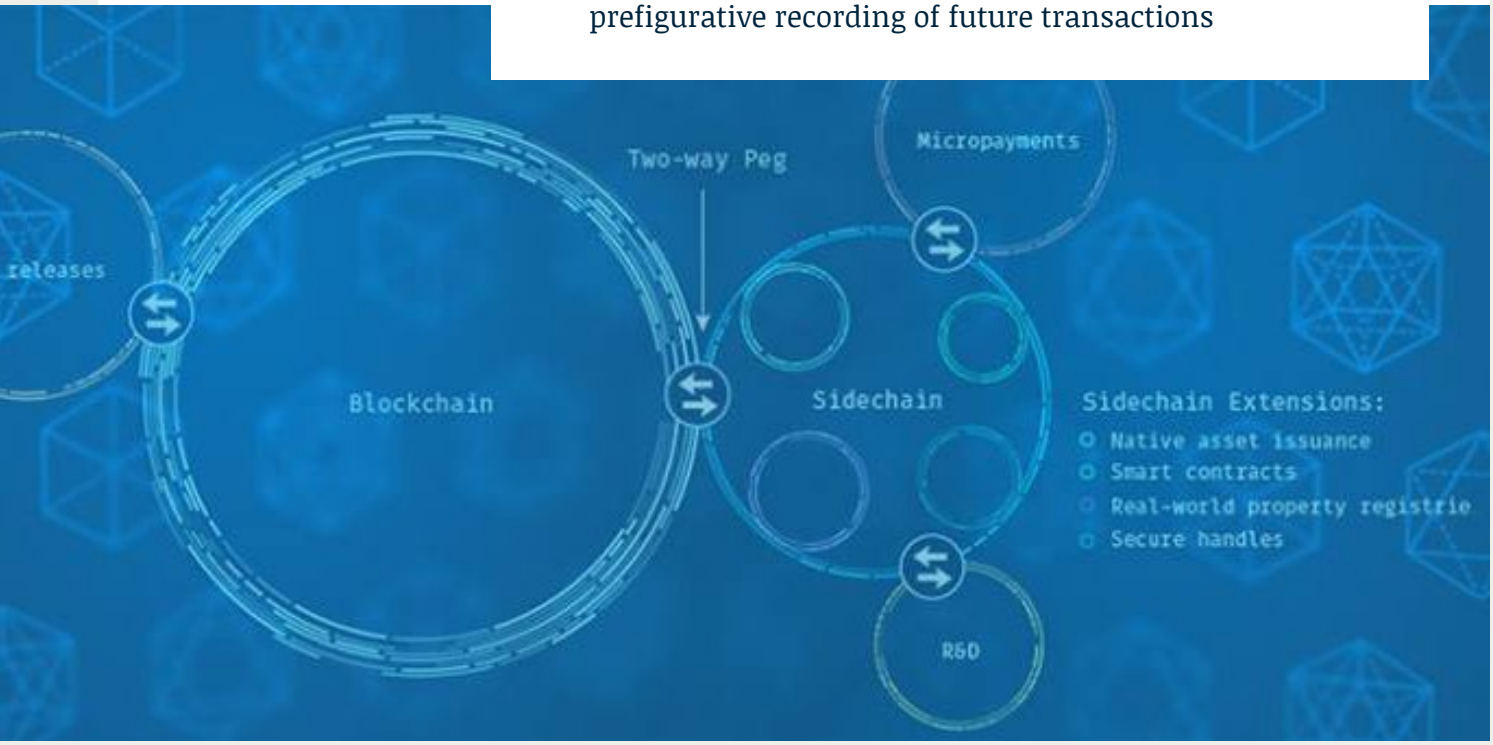
3) *Liquidity* Value liquidity is enhanced as the location of a store of value that does not depend or is not under the direct control of a sovereign, central bank or private corporation

4) *Permanence* The ledger of transaction is immutable by design

5) *Ethereality* Transactions are conducted in a digital medium

6) *Decentralization* The ledger is widely distributed among many stakeholders and maintainers

7) *Future Focus* Found in newer developments of blockchain such as Ethereum, a stored autonomous self-reinforcing agency (SASRA) is formed in the temporal displacement of action through the use of smart contracts enabling the prefigurative recording of future transactions



Sarah Manski has also analyzed the underlying political visions of the blockchain designs, resulting in five possible futures:[61]

- The first one is the individualist future, based on anarcho-capitalist visions of the world, in which every individual is seen as a competitive entrepreneur.
- The second one is the corporate vision, which can use ledgers for a variety of for-profit and surveillance and control uses.
- The third one is the vision of particular state forms with a desire for control and surveillance.
- The fourth one is the technocratic future, expressing the fear that such technologies can become automatic and sovereign, beyond human control.
- But the fifth one is the cooperative future, in which distributed ledgers are used for the commons. This is the vision that animates this report.

Rachel O'Dwyer also provides an extra warning: If we design distributed ledgers following the values and processes of 'methodological individualism,' then we also end up generalizing and socially reproducing these neoliberal mechanisms.[62] As Salvatore Iaconesi warned, distributed ledgers may end up transactionalizing our entire lives (scenarios 1 and 2 from Manski).[63]

At the very least, though, the new distributed capitalism can create more

61. Sourced from: https://www.academia.edu/36871389/No_Gods_No_Masters_No_Coders_The_Future_of_Sovereignty_in_a_Blockchain_World
62. Rachel O'Dwyer writes: "What kinds of subjectivity do we want to algorithmically inscribe into our systems? Blockchain start-ups begin from the assumption that there is no trust and no community, only individual economic agents acting in self-interest. Fair enough, you might think, it's precisely the fact that projects like Ethereum engineer confidence and provide economic incentives for contribution that may distinguish it from other services like Freenet. But it also proceeds from a perspective that already presumes a neoliberal subject and an economic mode of governance in the face of social and/or political problems. 'How do we manage and incentivise individual competitive economic agents?' In doing so, it not only codes for that subject, we might argue that it also reproduces that subject." Sourced from *https://www.academia.edu/11627298/The_Revolution_Will_not_be_Decentralised_Blockchain-based_Technologies_and_the_Commons*.
63. Salvatore Iaconesi writes: "On the one hand, they are a very powerful agent towards the 'transactionalization of life,' that is, of the fact that all the elements of our lives are progressively turning into transactions. Which overlaps with the fact that they become 'financialized.' Everything, including our relations and emotions, progressively becomes transactionalized/financialized, and the Blockchain represents an apex of this tendency. This is already becoming a problem for informality, for the possibility of transgression, for the normation and normalization of conflicts and, thus, in prospect, for our liberties and fundamental rights, and for our possibility to perceive them (because we are talking about psychological effects). On the other hand, they move attention onto the algorithm, on the system, on the framework. Instead of supporting and maintaining the necessity and culture of establishing co-responsibility between human beings, these systems include 'trust' in procedural ways." Source: *https://startupsventurecapital.com/the-financialization-of-life-a90fe2cb839f*.

capacities for what Adam Arvidsson (Arvidsson, forthcoming 2019), following Giovanni Arrighi (Arrighi, 2009), calls 'industrious capitalism' (or rather, 'industrious modernity,' as it can also be non-capitalist).[64] This is a vision of capitalism and markets seen in the context of a 'class struggle' for markets, whereby workers and a multitude of small firms use market forms for their own benefit, until today mostly in rather invisible informal economies. Distributed capitalism may put these forms on steroids.

The interesting White Paper by Outlier Ventures, a venture capitalist firm founded by Jamie Burke which exclusively invests in 'decentralized infrastructures' is very illustrative on the proposed relationship between open-source commons, in the form of blockchains and tokens, and how it fits in a new vision for capitalism. Their paper on Community Token Economies[65] argues that 'siloed innovation' is inherently wasteful, on the one hand, because of its endless duplication in the creation of common infrastructures, but also because, in case of failure, which is the norm rather than the exception, valuable innovation is lost each time the Intellectual Property is lost. Therefore, businesses must massively mutualize their common infrastructures, and community tokens serve to align the various stakeholders, while also providing a funding mechanism for open-source developments. While there is an obvious call for more inclusion and fairness in the ecosystem through decentralization, there is no questioning of the primacy of profit maximization. Thus, blockchain capitalism is indeed a new form of capitalism in which the commons are embraced, but also to a large degree instrumentalized.

64. Adam Arvidsson writes: "I suggest that the people excluded from an industrial modernity that is declining in importance and attractiveness are driving to make up a new industrious modernity. Like the industrious revolution that pioneered the emergence of a new market society during the European Middle Ages, industrious modernity is marked by labor intensive and capital poor actors that rely to a large extent on common knowledge, resources or technologies and that are driven by endogenous motivations like creativity, impact or self-realization. Taking this industriousness seriously provides us with a new perspective on the future of digital society, capitalist or not. " Sourced from *http://aihr.uva.nl/content/events/events/2018/11/industrious-modernity.html*.
65. See: White Paper: Community Token Economies (CTE): Creating sustainable digital token economies within open source communities. By Jamie Burke et al. Outlier Ventures, September 2017. Available at: *https://gallery.mailchimp.com/65ae955d98e06dbd6fc737bf7/files/02455450-8a66-4004-965a-cf2f19fed237/Community_Token_Economy_Whitepaper_1.0.1_2017_09_01.pdf*

Our Vision

We stand for a different vision.

First, we want to make these distributed networks truly cooperative, much more egalitarian, and sustainable, i.e., we want to

- Embed different values in the design of the shared ledgers, such as through replacing the blockchain with the holochain
- Replace the principles of trustlessness with a web of trust, that is, integrate real human relationships in trust-scaling technologies[66]
- Replace smart business contracts with Ostrom contracts[67] that reflect the principles that govern the commons, i.e., have smart contracts respect the ethical principles of a sustainable and more socially just economy
- Replace competitive game incentives, based on purely individual motivation and desire for gain, with cooperative game mechanics
- Diminish the attraction and rewards of extractive activities by rewarding generative activities, etc.

66. Bitcoin has been called 'trustless' because the system was designed so that nobody has to trust anybody else in order for the system to function, and aims to replace the reliance on 'third parties,' to one based on the soundness of the verification algorithms; by contrast, the web of trust is a scaling mechanism for personal trust, following the logic: 'if a trusts b, and b trusts c, then a can also trust c.' In this context, Holochain applies this principle by making context-specific ledgers, where trust exists locally and contextually, being interoperable with other ledgers that are similarly trustful.
67. See *https://blog.P2Pfoundation.net/tag/P2P-models* for an explanation of Ostrom contracts.

LIBERTARIAN	VS.	COMMONS-BASED
Examples:		
Bitcoin, Ethereum, Blockchain		Holochain, Faircoin, EcSA
Principles:		
Commodity-Based Tokens and Cryptocurrencies		Mutual Credit, Contribution-Based and Asset-Backed Tokens
Competitive Games		Cooperative Games
Smart Contracts (individual to individual)		Ostrom Contracts (social contracts and charters)
Oligarchic Proofs of Consensus (one dollar, one vote)		Distributed and Contributory Proofs
One World Ledger to Rule Them All Ethereum		Interoperable P2P Ledger Systems Holochain
Market Value		Value Sovereignty
Extractive Ecosystems		Generative, Nature-Friendly Ecosystems
Profit-Driven		Impact, Purpose, For-Benefit Driven
Trustless		Trustful (Web of Trust)

Figure 6: Contrasting the Propertarian Blockchain with Commons-Based Ledger Systems

Our proposals reflect the conviction that we can tweak and transform the general idea of the distributed ledger to make it into a set of tools for production for the common good. More importantly, even if we also want to use distributed ledgers, the aim of their use is to recognize all contributions to the common good and by specific projects, not just the commercial value acknowledged by the capitalist market. Not only do we want to recognize them but also make them visible. Just as importantly, we aim to integrate the limits necessary to preserve our planet and its multitude of beings for a long time, including a future for our children and the next generations by making visible, in our distributed accounting systems, the thermodynamic flows of matter and energy, creating a context-based sustainability framework[68] for all participants in these networks.

68. See also *https://wiki.P2Pfoundation.net/Sustainability_Context*

Automating some of these functions may help managing them. Expanding our capacity to integrate commons-based, permissionless and passionate contributions in our productive system, however, is equally important. Even as we want to create ethical and generative livelihoods for all contributions, this does not mean necessarily directly linking commons activities to market income. As we explained above, the solution is to create a membrane which regulates the relation between market and commons. This is of supreme importance if we want to avoid a hyper-rationalisation of our behaviour, and avoid a transactionalization of all aspects of life. We don't want to subsume the commons to the market and its logic, but to embed and subsume the market into the necessities of human and non-human commons. By automating some of the aspects of human cooperation, we want to create more space for non-market commoning.

And thus, despite these limitations and our critique of the current blockchain, the qualities and advantages that the blockchain has brought into the world are of paramount importance. What matters is not just the flawed technology, but the patterns of thought and interaction that it makes possible.

- First of all, it has enabled the flow and exchange of crypto-assets and forms of value, outside of the control of the existing and centralized financial system. It is now possible to finance open source network infrastructures, in ways that go beyond the prior dependency on the banking, payment, and financial- and venture-capital based entities.
- This enabled a different line of thought on value and money. Alternative value systems can be embedded in currencies, as money is a social construct: imagined and designed by humans. While local complementary currencies have shown the potential for creating local solutions, the new systems show that socially sovereign currencies are scalable, and can be used by global virtual communities.
- Blockchain economies subsume bounded firms under the logic of the network, based on the use of open-source commons and autonomously created monetary tools. Corporations become codependent on multi-stakeholder networks and commons.
- Token-based blockchain economies have the potential to shift the balance of power between labor and capital. They may allow a bigger part of the surplus value to flow to workers and other stakeholders, avoiding domination by venture capital demand for an equity stake.

The question is: will these techniques, which favour a particular fraction of the labor aristocracy of developers and technical-cognitive labor, also be applied to the wider commons economy? Our position here is positive: all commoners can and must learn about how this has been achieved, and whether it can be properly replicated elsewhere.

The specific design used in the creation of tokens is also paramount. Tokens allow for the expression of multiple forms of value, which can eventually allow for the value sovereignty we call for. The issuing of tokens for use as a medium of exchange/store of value within communities can be done in a way that incentivizes preferred behaviours and reinforces preferred values. That is, it creates a direct break of the dominant perception of money as commodity and opens up the possibilities for other types of perceptions of value. Most importantly, blockchains enable and ascribe the general consensus to such subjective perceptions among communities, while facilitating the interaction among them. Simply put, when a group of people agree that a certain activity has merit, they can create a permanent and tamper-proof record of this agreement. Let's imagine for instance an energy cooperative building small-scale wind-turbines. Its members may collaborate and create a set of rules for the issue of tokens to engage more people in their cause (e.g., energy engineers, households that want to reduce their dependence on fossil fuels, etc.), and interact with other groups that may provide resources or support services (e.g., a group of smart-grid experts, an impact finance firm, etc.).

Moreover, crypto-tokens allow for crowdfunding or direct crowdsales, either through utility tokens (a right to purchase the assets created by a blockchain project) or through market-based tokens, which allows stakeholders to partake in the surplus value realized in the market. This allows founders, developers and workers to go around the centralized banking and venture capital system and find their own funding more directly. These crowdfunding campaigns, based on the sale of tokens that are open to all types of buyers, are called Initial Coin Offerings.

Speculative 'Initial Coin Offerings' can also be initial community offerings, as in the crowdfunding campaign by Holochain. If the crowdfunding is successful, projects can go ahead outside the control of Venture Capital, which expects equity, i.e., co-ownership, in return for its investments. By contrast, tokens and Initial Token Offerings, allow for the direct funding of the workers, developers and other stakeholders. If the project is successful and the token-price moves upward, the work-related tokens rise in value, directly benefiting the workers, who partake in the surplus value that was previously captured by the funders.

As Fred Ehrsam of Coinbase expressed it:

"So how do you get people to join a brand new network? You give people partial ownership of the network. Just like equity in a startup, it is more valuable to join the network early because you get more ownership. Decentralized applications do this by paying their contributors in their token. And there is potential for that token (partial ownership of the network) to be worth more in the future".[69]

We believe that the organization of a crypto economy for the common good, based on enabling commons-based peer production, which combines a recognition of a wider variety of contributions, and helps achieve biocapacity accountability, will be based on

1) a better integration of free and cooperative mutual coordination, exchange and
2) the mobilization of resources through a fair and generative ethical market, and
3) fall within a planning framework that reflects a protection of planetary boundaries, and regulates access to the flows of matter-energy in order to determine the bounds of usage through thresholds and allocations of natural resources, as well as societal priorities.

69. *https://blog.coinbase.com/app-coins-and-the-dawn-of-the-decentralized-business-model-8b8c951e734f*

Technology	Description	Applications	Characteristics/ Advantages
Tangle	A network data structure designed to facilitate a range of secure transactions. To carry out a transaction you need to validate two random previous ones.	**IOTA:** resource sharing platform for Internet of Things devices	– no miners, no transaction fees – consensus mechanism embedded in transactions – faster with more users – focused on machine-to-machine communication
Hashgraph	Platform for decentralized applications featuring a graph-like structure, where all the nodes share information with each other. Transactions are validated through a gossip-like function of information sharing among random nodes.	**Swirlds:** platform for distributed applications	– indirect consensus – scalable – patented technology, many details unknown – not tested at scale
peaq	A smart-contract enabled infrastructure, building on Tangle technology. Any new transaction must approve random previous ones.	No formal applications yet.	– no miners, low transaction fees – faster with more users – apt for micro & nano transactions
Nano (RaiBlocks)	A database of blockchains where each node has its own blockchain, equivalent to its transaction history. Each transaction requires the deduction of an amount from the sender's balance and an addition to the receiver's.	**Nano:** cryptocurrency	– asynchronous consensus – no miners, no transaction fees – fast transactions – faster with more users – focused on peer-to-peer payments
Chainspace	Platform for a decentralized web of blockchains, extensible through smart contracts. The integrity of smart contracts is maintained by the trusted parts of the infrastructure and the contract sub-calls.	**Decode project:** building and piloting technologies for secure civic services for the cities of Barcelona & Amsterdam through open data commons	– general purpose; supports different programming languages for smart contracts – uses Proof-of-Stake for weighing trust relationships – higher scalability through sharding across the infrastructure nodes – sharded protocol can run multiple chains at once
Tendermint Core	The protocol ensures that the machines in a distributed network record the order of transactions the same way through consecutive rounds of validations.	**Cosmos network:** a multi-chain framework platform **Regen Network:** (see Chapter 3)	– general purpose, supports different programming languages – uses Proof-of-Stake – tolerant in arbitrary failure of nodes (Byzantine Fault-Tolerant)
Secure Scuttlebutt	Protocol for building decentralized applications. It provides standards for defining identities and managing information feeds based on trusted peer-to-peer information sharing. Users keep their own data along with updates on the people they trust.	(inter alia) **Patchwork:** decentralized social network **Git-ssb:** decentralized git **Dark Crystal:** application for trust-based social backups of private keys and secrets **Tick Tack:** long-form blogging platform	– supports offline work – agent-centric; high data integrity and control – general purpose; supports many types of decentralized applications – active user base, including all the developers; high ethical and political values

Figure 5 : Alternative Distributed-Ledger Technologies

Tools and technologies for integrated, fair, and sustainable ecosystems of production

Chapter 2
Tools and technologies for integrated, fair, and sustainable ecosystems of production

Introduction

We are witnessing the surface of a broad array of digital tools and practices that are relevant to representing the value of social and economic interactions. Various social groups have started to organize their efforts to harness the opportunities of shared technological infrastructures, investing their own vision and ambitions in their development.

In this chapter, we provide a brief overview of the main enabling technologies and some exemplary tools that are investing in this potential. Our focus is mainly directed towards different complementary solutions that allow for the representation of social and environmental externalities. Such externalities, both positive and negative, are largely invisible from the current accounting media, which recognize almost exclusively price-mediated transactions. By contrast, we now have increasing technological and social capacities to account for a more pluralistic, socially and environmentally embedded, economic reality.

Our mapping is structured in three layers:

- A **mutual integration layer**, where distributed ledgers and shared supply chains[70] are used to facilitate information and knowledge flows in productive communities in order to enable and guide contributions. By generalizing information on the current state of affairs and the agents across an ecosystem, the form of stigmergic coordination that determines CBPP in immaterial goods can shift to physical production.

70. Coordination of production requires direct signals between nodes in resource flow paths as well as the capacity to represent dynamic flows, while ledgers only reference static realities. Distributed ledgers are therefore not sufficient for coordination. See the article: The Role of Metadata and the Blockchain in Open Supply Chains for Distributed Manufacturing. By Orestes Chouchoulas at: https://wiki.P2Pfoundation.net/Role_of_Metadata_and_the_Blockchain_in_Open_Supply_Chains_for_Distributed_Manufacturing. Bob Haugen explains that in the emerging REA accounting systems, each resource is linked to its total event history, the events are linked to the processes and exchanges they were related to, the processes to their inputs, ad infinitum.

- A layer of **circulation and exchange** mechanisms that procure and allocate the required human cooperation, as well as material and energy resources. The use of alternative signals (whether monetary or not) can coordinate and monitor the input and output relations by embedding socially and environmentally desired outcomes.
- A layer of **planning frameworks** for global thresholds and allocations allow the management of matter and energy flows and ensure the biocapacity accountability of the actors in these networks. The planning framework can also be used to direct resources to societal priorities (Kate Raworth's Doughnut Economics are a good framework for looking at the interaction of these two facets).

The rest of this chapter describes tools for mutual integration, followed by tools for circulation and exchange. The specific accounting and planning frameworks will be discussed in chapter 3.

The distinction with regards to the three layers above or the different functions of the tools is not always straightforward. There is in fact a broad area of overlap and complementarities among different tools and their underlying technologies, as well as the principles and objectives underpinning their design. Moreover, our description concerns largely the conceptual intentions of the various tools and is not constrained by any given technological feasibility at the present time. Simply put, our main intention is to illustrate what is simultaneously *possible* and *desirable* in the way we guide the design of the technologies that would largely define the collective institutions of future societies.

The relevant data stem from the various descriptions of the projects through their own and popular media, but also the internal legal and operational documentation, where available. Therefore, the description represents the vision of a project that instigators themselves want to communicate about their project, interpreted with a critical outlook by the authors. Nevertheless, the aim is to illustrate the popular view for its own sake and identify trends and patterns of interpretation, rather than to represent an empirical set of evidence for a number of technological solutions.

What we are specifically doing in the next two chapters is asking ourselves the question: How can we tweak and transform the current wave of blockchain-based distributed ledger technology, with its libertarian, anarcho-capitalism and 'Austrian economics'-based premises, so that we can arrive at ledger

technologies which are more compatible with a socially just, ecologically sustainable manufacturing and production system?

- We can imagine for example, a ledger design that is not centralized, without oligarchic validation: this is what Holochain brings to the table.
- We can imagine a set of protocols that let us build commons-centric economic subsystems, as ECSA would allow us to do.
- We could imagine replacing the competitive games of game theory, which are now governing the incentive schemes of blockchain projects, with 'cooperative games' as R-Chain proposes to do.
- We could imagine replacing Smart Contracts, based on individual agreements, with Ostrom Contracts, allowing more collective, commons-based agreements (Sustans).
- We can imagine replacing currencies that are based on speculative supply and demand (commodity currencies), with currencies that are linked to human contributions, based on a web of trust (Trustlines), or that give us direct information about the ecological state of a resource (asset-backed currencies such as Fishcoin, Mangrove Coin, SolarCoin).

Tools for Mutual Integration

This section is dedicated to the basic tools that create a common environment for actors in a production and value ecosystem, to work together and align their actions towards one another.

Technical readers will find details in the main descriptions of the selected tools, while their strategic significance is highlighted in an introductory paragraph in bold type.

Below, we present the following projects involved in such endeavours:

- The Economic Space Agency (ECSA), which is developing an environment for interconnected economic spaces and commons-based Distributed Programmable Organizations
- Holochain, a distributed ledger which is not a blockchain, and whose organization is based on biomimicry, centered around people (agents) and their actions, allowing anyone to interoperate contextual ledgers
- DaoStack, which is building tools so that productive communities can work with each other, using tools for collective governance

In describing these tools, we make no claim as to their full technological maturity and workability at this stage, but the projects were all selected because they have effectively started the production of their coding and infrastructures.

Economic Space Agency (ECSA): An environment for interconnected economic spaces and commons-based Distributed Programmable Organizations

ECSA extends the notion of a Distributed Autonomous Organization to that of a commons-based 'Distributed Programmable Organization (cDPO). It wants to create the tools to move from the cooperative production of immaterial software, that is, extend the open-source paradigm to commons-based 'open-source economic spaces.'

The Economic Space Agency (ECSA) is a research and development organization dedicated to open-source solutions that can enable new economic forms. Its current flagship mission envisions the creation of a techno-economic stack that would allow the initiation, finance and operation of entities, along with the conditions for their cooperation and interaction. The vision is centered around a platform that builds on distributed ledger technology to support an ecosystem of autonomous projects and initiatives. These initiatives could entail any sort of activities, from collaborative projects to start-up companies and social enterprises, with for-profit or non-profit orientation, even political parties and think tanks. ECSA calls these 'open-source economic spaces' and considers them to be an extension of the open-source economy. In essence, ECSA aims to deploy smart contracts and agreements to create a set of coherent templates, from which these entities can choose. It envisions an extension of the notion of Distributed Autonomous Organizations to commons-based "Distributed Programmable Organizations,"[71] thus re-embedding the agency of "autonomous" organizations to the actual people involved.

71. See: *https://medium.com/economic-spacing/programmed-decentralised-commons-production-2b1fac7cf9a8*.

The ECSA stack comprises two interrelated systems, "Gravity" and "Space," supported by a consulting service named "Accelerator." Gravity is a distributed infrastructure that provides a protocol for the creation of cryptographically-secured applications. Gravity is described as a World Computing Fabric, which is modular architecture for building resilient, verifiable networks of virtual machines (ECSA, 2018). The World Computing Fabric connotes the ECSA critique to the World Computer model that is characteristic of Ethereum, due to its redundancies and limitations for decentralised applications. In contrast, Gravity offers more resilience and flexibility in networks of decentralised computers.

Space is a modular software development tool that facilitates the creation of (semi-)autonomous programs called "economic spaces."[72] It aspires to replicate human sociality and enable embedded forms of collective finance. Finally, the Accelerator offers a broad range of support services, ranging from the design, creation and implementation of economic spaces, to research, organization, education and market operation.

The economic spaces generate the necessary resources for new economic entities of the ECSA ecosystem by issuing equity-based tokens. The tokens are customized to the intrinsic values and motivations of the community involved, and their issuance embeds the organizational and operational arrangements desired at a given time. The equity of tokens may represent various forms of contributions for diverse groups of stakeholders, including funds, skills, collaboration or know-how.[73]

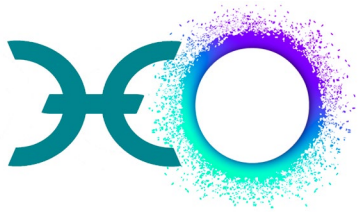
The ECSA ecosystem and technological tools provide an alternative vision of finance, by enabling diverse forms of investments or contributions that are committed to the actual production of the initiatives involved. Especially for the commons-oriented initiatives, access to finance is usually restrained and the rules are not aligned with the internal principles of the communities. Simultaneously, the blockchain scenery has so far been dominated by speculative incentives.

ICO investors are not so much interested in whatever is produced by new

72. ECSA economic spaces are described as an evolution of DAOs, called Distributed Programmable Organizations (DPO). The fundamental difference is that the notion of autonomy in DPOs is understood not in relation to human intervention, as in DAOs, but in the sense of a capacity to set the desired outcomes of the participants. For more details see: *https://medium.com/economic-spacing/why-dpo-not-dao-f7d93a2a3eb3*.
73. Authors' interpretation from: *https://medium.com/economic-spacing/features-of-economic-spaces-9e921c639dfe*.

ventures, but are mainly speculating on a potential rise in the price of crypto-tokens, in order to sell them for quick profit. ECSA makes an important step to counter this tendency, by connecting the value of tokens with the productive relations and the internal ethics of the communities issuing them. Moreover, they can acknowledge different forms of contributions and generate an immutable record of them to guide the economic interaction in the ecosystem.

Holochain: An alternative to a global distributed ledger, based on biomimicry



The main reason why bitcoin and its blockchain are inefficient in terms of energy consumption is that every new transaction has to be validated by the whole network, leading to an exponential increase in the number of resources needed to maintain the system. Holochain does this significantly different. It is technically not a blockchain, but simply a way for separate ledgers to cooperate and become interoperable with each other. Hence, Holochain is infinitely scalable at marginal cost.

Holochain stands for "holographic storage for distributed applications." As the name implies, it is a framework for the development and hosting of distributed applications. Holochain can be described as an alternative to a distributed ledger comprising a significantly "lighter" architecture. Instead of storing a copy of the whole ledger on every node of the network and enforcing its validation, Holochain takes an agent-centric approach and splits the data to many different nodes and ensures access only to the data that are useful or relevant for every node. This means that every agent generates and holds on to their own data on their own device. The only types of data that are transferred to – and are readable by – other agents are the ones to which they need access or are authored in a "shared space." In Holochain there is no global view on all data, unless specifically and consciously designed to be.

Subsequently, data integrity in Holochain is ensured through a P2P validation system. It doesn't entail resource-intensive processes like "mining," which allows Holochain to be easier to deploy on less powerful devices, such as

mobile phones. Holochain rather relies on its peers to ensure the integrity of the data shared among them. The peers of the network hold part of the data and validate it against a set of shared validation rules, which are specific to the protocol or an application (hApp). In other words, users audit each other's actions to see whether they have been authored in accordance with their common validation rules.

The validation rules may vary among different applications, as some may require stricter rules than others. For instance, a cryptocurrency can have different validation rules from those of a social network. Hence users in the Holochain system do not interact directly with the data shared among the peers of the network. All interaction is rather effectuated through the code of applications, so that they enforce their own rules, restrictions and objectives. The very concept of an application in Holochain begins to break down. Thanks to the level of composability of functionality and because of the loose UI coupling, the ecosystem rather evolves as a collection of micro services arranged in intricate relationships with each other tailored for the user.

Much like Ethereum, Holochain was developed to support the functionality of applications, based on sets of agreements among the people that use them, from social media and messaging applications to shared logistics management and cryptocurrencies. In the old client-server model, the existence of a central node served to maintain the integrity of the data and ensure the enforcement of the agreed-upon rules. With distributed ledger systems, this central node is replaced with a network of nodes synchronizing to a common state. Holochain enables this function without the need of a central node, to which everyone is accountable and should report. It does so by requiring each node to agree to the shared set of rules, cryptographically verify it with a hash function as the initial entry in their own record, and require every subsequent action to be validated against the same set of rules.

Simultaneously, it solves some of the main scalability issues associated with blockchain technology. Holochain does not require every node to update a unique database held by everyone on every interaction in the network. Instead, nodes validate each other based on the information that is mutually relevant and on rules that are context-specific. This way, the system becomes more efficient with the addition of new nodes, which allows for network effects to be harnessed.

Ultimately, the type of interaction enabled by Holochain will be determined by the applications that will eventually run on top of it. However, we do not

suggest that Holochain, as, in fact, every technological infrastructure, is neutral. Bitcoin, and to a large extent most blockchain-based infrastructures, was imbued with the principles that were of importance to their designers: anonymity, immutability and the by-passing of human trust. Conversely, the design of Holochain has several characteristics that are relevant to the commons. This can form the basis of a new economic reality that is more democratic, more inclusive, more open and better informed on the local and global environmental thresholds.

More specifically, *Holochain creates the conditions that may allow diverse economic entities to mutualize and share resources more freely and agree on common rules of conduct that can be enforced in a P2P fashion*. This can accommodate a more even distribution of power among the participating agents and increase transparency. Holochain alone is not a protocol for social cooperation, but it can support the creation and enforcement of such shared protocols. Combined with the possibility to issue and distribute crypto-tokens, communities may create fairer reward systems and new media to interface with the market, while maintaining their integrity to their values and principles. Furthermore, Holochain goes beyond crypto-tokens, by enabling and favoring forms of mutual credit crypto-accounting, which have a much greater expressive capacity than tokens. Finally, the Holochain framework can produce massive efficiency gains by unlocking unused processing and storage capacities, as well as shared information, to allow for more sustainable use of vital computation resources and increased trust among collaborating agents.

DAOstack: Integrated mechanisms for large-scale governance

DAOstack is a decentralized platform that aims to facilitate self-organization of productive communities by providing tools for collective self-governance.

DAOstack, as the name already implies, provides a stack of technological tools for the development of DAOs, comprising: a) a framework for the deployment of smart contracts on the Ethereum blockchain (Arc); b) a front-end developer environment for the development of decentralized applications (Arc.js); and c)

a user interface enabling the funding and resource allocation of decentralized organizations (Alchemy). The latter has been designed so as to allow people without advanced technical knowledge to interact with the other layers of the DAOstack, launch DAOs, issue crypto-tokens and invite others to participate and support their ideas.

The main motivation of DAOstack is to provide a technological infrastructure to different decentralized organizations, one that would create a collaborative environment, accessible to a critical mass of people, to launch and participate in. It is often characterized by its instigators as a "Wordpress for DAOs."[74] In the same way as Wordpress enabled people with no preexisting programming skills to manage the content of websites, DAOstack envisions to facilitate the generation of DAOs that define the rules for decentralized organizations.

Moreover, the DAOstack instigators aspire to effectuate a fine balance between *scalability*, i.e., the number of decisions a collective can make in a period of time, and *resilience*, i.e., the incorruptibility of those decisions. For this purpose, a collective decision-making process has been developed, called *Holographic Consensus*. This process relies on small groups of people making decisions on behalf of the larger majority, but in a way that guarantees perfect alignment between the two groups. Holographic Consensus allows faster and locally-situated decisions in a large-scale DAO, by aligning local decisions with the global opinion via a crypto economic game. Essentially, a possible mismatch between the two is presented as an economic opportunity, which predictors can exploit for economic gains, whilst supporting the upscaling of the DAO governance.

Instead of building a specific protocol to support different projects, DAOstack provides access to different layers for different sets of skills, so that diverse teams may develop their own protocols, based on their own values and principles. The coordination of these teams and their interaction with the rest of the DAOstack ecosystem is guided by the issuance and distribution of crypto-tokens — these function like price signals, i.e., as incentives for investments (of effort and energy); the difference is that there are different values co-encoded beyond simple supply and demand. Contributors of value to the network are rewarded with tokens, which in turn gain their value from the usability of the application offered. Subsequently, tokens may also be circulated among different decentralized organizations in the ecosystem to support or benefit from each other's services.

74. More details here: *https://medium.com/daostack/an-explanation-of-daostack-in-fairly-simple-terms-d0e034739c5a*.

Moreover, DAOstack is itself a DAO that issues its native token (GEN). This serve to facilitate and incentivize collective decision-making on the development of the DAOstack ecosystem and the support of new projects on top of and along with it. An attention and reward system guides this interaction, and it is reflected in the distribution of GEN tokens and reputation, which is also reflected in voting power.[75]

The model of DAOstack operates on top of the Ethereum blockchain and it is thus arguably constrained by the limitations related with it. Moreover, the model of Holographic Consensus shares many of the assumptions of free-market economics, where individuals share a common "rationality" to exploit opportunities for economic gains and efficiently align global supply and demand. But governance is arguably more than a mere balancing of attention and decision-making needs. It requires collective, ethically-binding, and value-sensitive mechanisms that markets' signaling alone cannot achieve.

However, it offers a new perspective on the issuance and distribution of crypto-tokens, which is oriented towards the support of collective, ecosystemic efforts. Like ECSA, it ties the value of tokens to the actual production of useful products and services from network-based collaboration, allowing the peers to decide upon and enforce their own rules of coordination and reward systems. More importantly, it offers an interface that opens up these possibilities to a greater number of people who do not necessarily have programming skills, along with a native system to facilitate the launching and support of new initiatives.

Tools for Circulation and Exchange

This section focuses on tools for implementing the exchange and distribution of 'value.'

We discuss the following projects:

- FairCoin and FairCoop, an ecosystem for open cooperative ecosystems of exchange of fair value
- Envienta, which is developing a system for globally-integrated sustainable and open-source manufacturing
- FabChain is a project of the Fab Lab ecosystem, aiming to link specific

75. More details on the DAOstack economic model here: *https://daostack.io/wp/DAOstack-White-Paper-en.pdf*.

Fab Labs, to real-life manufacturing systems, for which they function as collective R&D resources, in cooperation with cities

- Terra0, though in the early experimental stage, is based on the radical concept of giving agency to natural resources, by considering them as "DAO's"

FairCoin and FairCoop: Tools for a cosmo-local, open cooperative ecosystem

FairCoin, FairCoop and the larger ecosystem of which it is a part of, aims to be an open cooperative ecosystem for the exchange of value between communities both locally and on a global scale. It is driven by the ideas of an 'integral revolution' championed by the Catalan Integral Cooperative[76] and is already being used by various local communities mainly in Spain and Greece. It is much more than simply a new and more 'fair' currency, within an ecosystem that is democratically governed. Rather, it aims to offer a total solution for post-capitalist practices.

FairCoin is a currency created by FairCoop, the global open cooperative ecosystem. The motivation behind FairCoin has been the creation of a medium of value for the FairCoop economic system that would be controlled by its global community. FairCoin was initiated by an anonymous developer who distributed the first 50 million units for free to people that had expressed their interest, but the currency was then grandfathered by the FairCoop system as a means of payment.

In line with the FairCoop values, FairCoin is premised on the principle that value is generated by cooperation, in contrast to the broadly applied methods of minting or mining that generate and escalate inequalities in the user community. The first version of FairCoin experimented with a hybrid consensus protocol between proof-of-work and proof-of-stake, aiming for a more ecologically friendly model; some additional units were generated as

76. For more on the Catalan Integral Cooperative see our extensive report, authored by George Dafermos: *https://P2Pfoundation.net/wp-content/uploads/2017/10/The-Catalan-Integral-Cooperative.pdf*

well. However, it was soon realized that a completely different approach had to be developed.

This led to the second version of FairCoin, which implemented a unique consensus algorithm called proof-of-cooperation. This protocol is not meant to create any additional units, rather it relies on a network of trusted Cooperatively Validated Nodes (CVN) to validate transactions and generate blocks. CNV operators are appointed and approved by the FairCoop general assembly. A new block is created every three minutes and the process is coordinated among the CVNs by a round-robin system. A small transaction fee is charged on the users by the CVN that generates a block at any given time, which mainly serves to avoid spam activity and also covers the operational costs of the system.

The design of the FairCoin system allows it to run efficiently with very low requirements in processing and energy use. FairCoop claims that a network of up to 30 computers with regular processing capacity suffices to cover its operation, requiring the equivalent of a 4-member household in annual energy consumption.[77] Furthermore, FairCoin is substantially less prone to speculation, thereby tying its value to real productive activity that takes place in the global FairCoop economic system. Its exchange rate is regulated through democratic procedures by the FairCoop general assembly, rather than free-market operations. Only a small fraction of FairCoins are held by people not directly involved in FairCoop, while the majority of the units are circulated within a community of people sharing its common values.

FairCoin is a very specific case of a currency that has been created to serve a specific purpose by a specific community. Nevertheless, its relevance arguably stretches beyond the FairCoop ecosystem, being a medium of value explicitly designed to embed rules for social and ecological sustainability. Furthermore, the fact that it is based on the original bitcoin client eloquently exemplifies the potential of blockchain technology in enabling different socio-institutional outcomes, despite its original underpinnings. Regardless of its limited scope, it showcases how small-group dynamics of high-trust communities can be scaled on a global level, facilitated by a technological infrastructure that embodies their shared values and aspirations.

77. https://fair-coin.org/en/faircoin-2-revision-one-most-promising-cryptocurrencies.

Trustlines: Mutual credit for common good

Most cryptocurrencies are speculative 'commodity' currencies, whose value depends on supply and demand but which have no direct relation to sustainable material realities, in other words, the price signals do not give sufficient information about the sustainable use of the represented resources. Two alternatives for currencies are, on the one hand, asset-backed currencies which give information about the stocks and flows of a resource, so that it reflects sustainable use (Fishcoin, Mangrove Coin, SolarCoin). The other are mutual-credit currencies which in our opinion can reflect human contributions to common projects. Trustlines brings such a mutual credit function within the distributed ledger environment.

Trustlines[78] is an Ethereum-based platform that allows the issuance of IOUs on a P2P basis. Its design is inspired by the original idea of the decentralized currency network "Ripple" (Fugger, 2004). Trustlines Network essentially enables users to create money by providing credit for an amount they deem fair for people they trust. A Trustline is a smart contract that represents an agreement between two people to connect with a bilateral line of credit. These lines can be translated into purchasing power among the trusted nodes of the network.

The Trustlines Network has no single native token. Money in the network can be denominated in fiat currencies, commodities, crypto-tokens or other units of account, based on rules agreed upon all the nodes participating in a certain network of trustlines denominated in the same form of currency. For instance, a credit line has been agreed between user A and user B. This credit can be directly translated into valid money for either user in their direct trustees. But, simultaneously, user A may also make a purchase from user C, provided that there is trust between users B and C. This relation may be further expanded as more users participate in the network and create

78. Based on Kalmi, T. (2018). Comparison of Blockchain-based Technologies for Implementing Community Currencies. MSc Thesis in Computer Science, School of Science, Aalto University. Available at: https://aaltodoc.aalto.fi/bitstream/handle/123456789/34702/master_Kalmi_Tomi_2018.pdf;jsessionid=5195D17665B54793FF65F2C3D6AD231C?sequence=1.

trustlines between them. As long as a line of trust can be established, valid transactions can occur in the network.

The Trustlines Network is functionally not very different from our current credit-based monetary system. Money is a form of credit that becomes valid for anyone who trusts the creditor, which is usually a trusted third party, such as a central or commercial bank. In this sense, Trustlines leverages P2P trust relations to allow potentially anyone to become a creditor, within given limits. Moreover, the credit system becomes more efficient[79] as it scales, by depending on well-connected users. A small fee is charged on every transaction and is paid to the users providing trusted connections in transactions, thus providing incentives for users to establish as many connections as possible.

An important aspect of Trustlines is that the users can determine the level of credit they provide to others, according to how they feel comfortable. An agreed upon balance tracks how much the users owe to each other and the users' spending power is limited by this balance. Subsequently, the network of all trustlines is managed through smart contracts, and functions as a notary for all credit lines and balances. In case a user is unable to pay back their debt, the dispute is privately settled between the involved parties.

Trustlines, as a monetary solution, admittedly presents many of the deficiencies of our current credit-based monetary and accounting system. Moreover, to the extent that credits are denominated in fiat currency, it remains limited by the power dynamics of the current financial institutions. Nevertheless, it still presents an interesting application of blockchain technology to enable mutual credit in a P2P fashion, based on smart contracts enforcing socially determined criteria. This way, even though the actual trust relations among people become abstracted as the network scales, it is still possible to enforce and extend their agreed upon rules and values to their respective network. Additionally, the possibility to use different types of monies as denominators may provide greater degree of flexibility and resilience in the system, while it also allows the use of cryptocurrencies that reflect the values of the respective network.

79. Efficiency here refers solely to the function of the credit system. In terms of the infrastructure, with Ethereum blockchain being part of it, efficiency claims with scalability may vary.

Circles: A decentralized basic income

Circles is a cooperative project developing a P2P basic income using the Ethereum blockchain. It aims to explore money as a commons where communities can govern how the currency functions. A "bottom-up" basic income, Circles promotes cooperation and economic interaction by encouraging local trade networks. The more connected community members are to each other, the more valuable their network becomes.

Circles is a P2P, social currency wherein individuals can exchange one-to-one once they trust each other in the system. These relationships form a web of trust, which helps protect the system from Sybil attacks or people trying to claim more than one basic income. Similar to Trustlines, the Circles currency can be exchanged via transitive trust, wherein individuals can exchange with anyone in each other's trusted networks. Circles recipients can also validate their currency with an intermediary in order to extend their trust network.

The system mints an equal number of Circles coins to all participants, like a universal basic income. It is a demurrage currency, with a decay rate on all issued coins, creating a hoarding resistant and post-accumulation economy. The monetary policy of Circles is determined by a community governance process, undertaken at each regional Circles hub. Community members collectively agree on parameters of the system like issuance rate, demurrage rate, and trust limits. Because human trust is a core component of the Circles system, the community governance process will not and is not intended to scale beyond a regional level. That said, once multiple regional Circles hubs are established, there will likely be opportunities for them to trade and connect.

Circles runs via a series of smart contracts on the Ethereum blockchain, but it is a blockchain-agnostic protocol – and could easily run on another chain, or as its own protocol. There is a user-facing mobile app for iOS and Android, but Circles tokens can also be viewed on and interacted with on any other ERC20-compatible interface. Finally, for ease of use and low latency, the Circles team maintains a series of off-chain services to host non-critical components of

the system, like user profile photos and cached recent transactions.

The project will be undertaking a research pilot in Berlin in 2019. The aim of the pilot is to test assumptions about the system, including user engagement, and for these purposes they have partnered with a Radical Young Mothers collective, Prinzessinnengarten (a community garden and farmer's market) and Ola's Cafe, among other organizations. The team is also bootstrapping their own cafe, Cafe Grundeinkommen, which will accept the currency as well as serving as a community hub for Circles governance. Finally, the app will include a 'listing' feature for individuals and organizations to post goods and services they are willing to exchange for Circles, fostering a peer to peer marketplace.

Envienta: An integrated environment for open-source manufacturing

Envienta is establishing an integrated environment for integrated open-source manufacturing.

Envienta is a platform aiming to assist open design and distributed manufacturing. Its vision is to provide a framework to connect innovators, creators and designers with makerspace communities and eventually users, consumers and the existing supply chains. The Envienta framework is composed of: a) a platform, as a unique interface for the management of user accounts and projects; b) an innovation hub, mapping a global network of makerspaces and their respective capabilities; and c) an education system, oriented towards the sharing of knowledge and solutions in an online-facilitated environment.

Any user in the Envienta ecosystem may initiate a project and find interested parties with which to collaborate. After forming a team and an initial plan they can broadcast it to the network in order to attract investments for the design and prototyping of the idea. The prototypes are then shared under Creative Commons licences, so that others may download the blueprints, examine, modify and improve the products, and share them back with the rest of the

network. Finally, once products reach maturity, they can be introduced in the market through a network of manufacturers, while the platform provides assistance with marketing and legal and IP issues, in alignment with the CBPP principles.[80]

The interaction in the Envienta ecosystem is also facilitated by the ENV crypto-token, generated by the Ethereum network. The ENV token serves to record and manage the data flows in the ecosystem, by providing access to the produced services, rewards and reputation for contributors, while tracking the value flows among projects and supporting internal crowdsourcing.

The main goal of the ENV token system is to strengthen cooperation within the network and support its economic model. It allows the agents in the ecosystem to decide the types of contributions and resources that are sought, such as labor, renewable energy, land, tools, and machinery, and distribute rewards in ENV tokens. Simultaneously, the distribution of tokens is also connected with voting rights, while reputation reflects voting power. Furthermore, insofar as they represent the value produced in the network, they may also be circulated outside the network to engage external agents and acquire services.

Ultimately, the ENV token system envisions to support a resource-based economic model. It is understood as a transition step towards a representation of a diverse set of economic activities, including innovation, manufacturing and contributions, that is tightly connected with the tangible and intangible resources involved. The ENV tokens help to monitor the value streams across different stakeholders and create a real-time record of the available means and resources.

At its initial stages Envienta is focusing on areas related to sustainable living, home automation, green energy and food production. Its approach is explicitly oriented to foster sustainability and commons-based economic production. It is inspired by the concept of "cosmolocalism"[81] (Ramos et al., 2017), which builds on the potential of globally shared knowledge, information and design, in confluence with localized distributed manufacturing, ideally entailing the mutualization of technological tools and manufacturing facilities. Cosmo-localism fosters a shared morality through the commons, in the sense of co-creating and co-managing shared resources.

80. Envienta is currently aiming to use Creative Commons licences for the sharing of designs and prototypes, however its instigators are examining the use of hybrid licences (e.g., CopyFair) to support the open source producers in their market exposure.
81. https://theconversation.com/design-global-manufacture-local-a-new-industrial-revolution-82591.

FabChain: Linking advanced research to urban metabolisms and mainstream production and manufacturing

FabChain is uniquely positioned to correlate the advances of the pioneering Fab Lab ecosystem, which is focused on 3D printing and relocalized manufacturing, as R&D laboratories connected with both a league of engaged cities as well as manufacturing organizations.

FabChain[82] is envisioned as a token-based system to solve the problems of fragmentation and value flows among local distributed, commons-oriented design and manufacturing capacities. It builds upon the vibrant community of Fab Labs, a global network of digital fabrication laboratories with over 1300 members extending to more than 100 countries. Simultaneously, it advances the idea of the Fab Cities, a concept scaling the Fab Lab culture on city level, promoting a model for urban transformation based on the sustainable use of local resources and materials and the sharing of cultures. The specific importance of FabChain is that it aims to connect an existing network of advanced research laboratories, with an alliance of cities and with the existing logistical networks of industry.

The main goal of FabChain is to engage stakeholders in sustainable and (open-source) circular economy production practices, including the recycling, reuse and relocalization of supply chains at a city level, while enabling interaction and synchronization with other cities. This would need a confederated blockchain infrastructure that could facilitate the trans-local allocation of knowledge and productive capacities, while monitoring material flows in local, transparent supply chains. In this process, local makerspaces would be instrumental in mobilizing and allocating material resources and means of production. These relations would be agreed upon and enforced through smart contracts that would secure the automatic execution of the terms with the distribution of tokens.

82. At the time of writing the FabChain initiative is still on the initial stages of preparation. All the information reflects the instigators' intentions at this particular point.

The design of FabChain tokens encapsulates various functions for different stakeholders across the supply chain. They can provide certification; ensure transparency and alignment to ethical conditions (e.g., fair trade, provenance, organic production); stimulate cooperation and synergy among different stakeholders; incentivize circular economic activities; distribute rewards to contributors; regulate the use of mutualized resources and facilities; support the network's sustainability by creating links with the external market economy; encourage participation; and establish reputation-based decision-making.

The token model of FabChain is intended to offer two different types of tokens: a) a non-transferable reputation token (FabRep); and b) a transferable utility token (FabCoin). The reputation token will represent the value that an agent, either an individual, a group or an organization, has contributed to the network, as perceived within their respective communities. Each community is allowed to determine its own rules to attribute reputation, as it also affects the power relations in its decision-making.

FabCoins may be transferred among entities in the ecosystem to reward or encourage contributions, promote localized production and incentivize collaboration among different actors. Furthermore, different actors may provide products and services in exchange of either FabCoins or other currency. The value of the tokens will reflect their usability in these relations and their recognition as a mechanism of reciprocity. In principle, FabCoins could be used for the remuneration of contributions in the network, insofar as they provide access to useful services in the global FabChain community or eventually the possibility to be exchanged for fiat currency.

Additionally, FabChain aims to issue a series of ad-hoc certification tokens to determine the level of skills and competences for individuals or groups; the quality of services, tools and learning, as well as security standards for Fab Labs; the quality of designs and other relevant uses. Finally, FabChain also foresees proper attribution to the designers and their creations.

The FabChain model makes significant contributions in the development of accountability systems apt for sustainable and inclusive production. It illustrates an employment of distributed ledger technology to simultaneously coordinate social production on a global level, while keeping local material flows in check. This can be crucial especially at the city level, where a critical capacity for circular economic activities is concentrated, due to population density, the existence of diverse skills and capabilities and available materials

for reuse. It has been argued before (Bauwens & Niaros, 2018) that cities offer a favorable context for commons transitions. The FabChain confederated infrastructure could be instrumental in supporting the generalization of this potential at the global level by creating trans-local bridges of knowledge-sharing and political organization.

Terra0: Giving DAO agency to natural resources

Terra0 is aimed to create a capacity for natural resource systems, like forests, to develop their own technological and legal agency, by becoming DAO's. Several countries, such as Ecuador, Bolivia and New Zealand, have started to give legal personhood status to forests and rivers. But until now, human organizations need to go to court in order to realize this agency on behalf of the natural resource entities. The terra0 project goes a radical step further, by linking the resource entity to sensors, wallets, and making it into a DAO which can initiate actions on its own.

Terra0 is a framework built on Ethereum and aims to provide automated resilience for natural ecosystems. It envisions the creation of DAOs-employing rules that would enable natural ecosystems, including pieces of land or forests, to self-manage the resources they encapsulate. The terra0 goal is to create technologically-augmented ecosystems that can be more resilient, and acquire agency to enforce predetermined rules in economic relations.

One of the initial scenarios of terra0 envisions a technologically-augmented forest that may calculate and regulate its output in terms of raw materials, and in particular wood, but also other services that it may offer to both human and non-human agents, including quality relaxation for visitors, a protected ecosystem for diverse species and contributions to the overall ecological balance. The terra0 scenario imagines a shift from a situation where third parties exploit the forest's elements, to a situation where the forest is able to engage in transactions and claim control of the exchange value generated by its assets.

To this end, a smart contract would be created on the Ethereum blockchain to control the inputs and outputs of the forest by utilizing data from external (e.g., satellite images) or embedded sources (e.g., preconfigured databases, sensors) to determine the number, age and current status of the trees. A first crowdsale event would distribute terra0 tokens to the (human) shareholders of the project, in the form of debenture.[83] These tokens are non-transferable and represent a share of the property of the smart contract, whereas the forest is signed over to itself in exchange for debentures. This means that at the initial stage the forest owns itself, but is indebted to its shareholders.

The forest may then manage the exploitation of its resources through a separate smart contract that issues Woodtokens to grant licenses for the logging of certain trees. The Woodtoken reflects an agreed amount of wood in accordance with predetermined economic and ecologic parameters, such as tree age and density necessary for the preservation of a certain level of tree population or growth rate.

Using the revenue of these licenses the forest can redeem its terra0 tokens by paying its creditors. Once all the terra0 tokens have been redeemed, the forest is the sole shareholder of its own economic unit. It can then continue to regulate its resources by controlling the issue of woodtokens and according to varying levels of preservation or needs.

There are several drawbacks that can be identified in the terra0 model. To begin with, like Regen Network, it focuses on reconfiguring market forces by monetizing certain elements of the natural ecosystem. Furthermore, unless the trees are able to design and implement the rules of the smart contracts themselves, it is still humans that have principal agency on them. On a broader level, the very idea of forests gaining economic agency is somewhat trivial. In fact, much of the struggle in ecological movements seems to be on the opposite direction, that is, alleviating natural ecosystems from market functions, let alone enabling them to mimic humans and participate under similar terms.

But still, terra0 remains an interesting experiment that attempts to enable different technological opportunities for governance of the commons. It builds on a potential combination of remote sensing, machine learning, and distributed ledger technologies to develop tools that may facilitate diverse

83. The definition of a debenture by Merriam-Webster dictionary is “a bond backed by the general credit of the issuer rather than a specific lien on particular assets” (available at: https://www.merriam-webster.com/dictionary/debenture).

outcomes in the collective management of natural ecosystems and resources, informed by the interaction of meshes of DAOs, which may deploy certain collective rules and norms.

Ostrom Contracts: commons governance for the evolution of smart contracts

Ostrom Contracts build on a promising convergence of smart contract design with the Elinor Ostrom's principles for successful governance of the commons. It offers a useful trajectory for the development of blockchain technology to enable and support self-governance and sustainability.

The idea of Ostrom Contracts is inspired by the work of Elinor Ostrom (1990) on governing the commons. It is about AI-powered smart contracts coupled with intelligent environmental monitoring, informed by Ostrom's design principles[84] for successful commons. It builds upon a set of, arguably, untapped opportunities of smart contracts, which can offer accessible tools to engineer economic incentives in a cheap and scalable manner, and thus democratize the design of governance mechanisms.

More specifically, Ostrom Contracts envisions the possibility of smart contracts to allow the treatment of economic functions in the fashion of software. This means prototyping, testing and iterating on "economies," by embedding different motives and incentives into software code.[85] This way, by compiling Ostrom's principles into a software product, we provide insights on how to successfully enforce commons-based economic cooperation.

Some possible interpretations of Ostrom's principles in smart contract-related functions could be the following:[86]

84. For a concise overview of Ostrom's design principles by David Bollier see: *https://blog.P2Pfoundation.net/eight-design-principles-for-successful-commons/2016/10/27*.
85. For more details see: *https://medium.com/@daviddao/decentralized-sustainability-9a53223d3001*.
86. Discussion with David Dao, the instigator of Ostrom Contracts, documented in: *https://wiki.P2Pfoundation.net/Ostrom_Contracts*.

Principle 1: Clearly defined boundaries through token-based membership

The agents that benefit from – and care for – shared resources must be clearly defined, and so must the boundaries of the resources themselves. Digital membership can help determine clear group boundaries and can be implemented by simply owning a token. Membership models motivate people to cooperate with each other by increasing trust and reducing the risk of being exploited, especially when they can always opt out by selling or transferring their token(s). In this sense, incentives to stay in the group are linked to access rights to either natural common resources and/or valuable group benefits (e.g., a shared and easy-to-access marketplace, more decision power, additional income).

Principles 2 & 3: Blockchain governance for collective decision-making with local conditions at check

Successful commons-based governance require the restriction of the rules and norms in terms of time, place, technology, and/or quantity of resource units, based on local biophysical conditions, including natural resources, labor, material, and/or money. Moreover, the majority of the individuals affected by the operational rules can participate in modifying and enforcing them. Smart contracts enable fast decision making with low overhead. Members of the group can interactively propose guidelines and actions and vote on all proposals, thus determining their own rules and adapting them in a quick manner. Blockchain governance can allow the development of novel decision making methods, which is based on predefined rules. These are informed by local and global concerns.

Principle 4: Intelligent machine monitoring & learning

In self-governed systems, monitoring on the conditions of the shared resources and the behavior of individuals is implemented either by the members of the group themselves and/or by authorities accountable to them. However, in large natural ecosystems, like the Amazon rainforests or the vast landscape of the African Sahel region, it is almost impossible for a group of humans to constantly monitor such a large amount of territory. Scalable automation can offer great possibilities to effectively monitor larger commons, while maintaining trust through collective institutions and accountability to the members of the community. A number of research projects in wildlife monitoring, patrol planning and prediction, such as GainForest[87] and The

87. For more details see: *http://gainforest.org*.

Great Elephant Census,[88] already offer promising empirical evidence on the feasibility of such models.

Principles 5 & 6: Graduated sanctions and easy-to-enforce conflict-resolution mechanisms through increasing stakes and smart-contract judge

Self-governed groups often foresee graduated sanctions for violators of the operational rules to prevent repeated rule breaking. These sanctions depend on the seriousness and context of the offense and are assessed by other peers and/ or officials accountable to these peers. Low-cost platforms for rapid conflict resolution provide efficiency and resilience. In case of a smart contract, if a rule violation is detected a self-enforcing function can be invoked, which may, for instance, subtract a fee from a deposit of a certain agent. Similarly, different levels of sanctions can be decided upon either through voting or automatically.

For more complicated disputes, a smart contract can also play the role of the judge. Challenge/ response games can additionally be implemented, where one group of actors will be given the opportunity to submit evidence to falsify a certain set of facts, and if no convincing evidence is submitted over a period of time, then the truth can be assumed.

Principles 7 & 8: Higher-level recognition and nested design by programmable censorship resistance and complexity

For larger systems, the rights of commoners to devise their own rules of governance should not be challenged by external formal authorities. Similarly, the provision, monitoring, enforcement, conflict resolution, and governance should be organized in multiple nested layers to allow for resilience at greater scale. The decentralized and self-enforcing nature of blockchain-based smart contracts formally guarantees that decisions, made within this framework, are executed without censorship or control from higher-level authorities. Furthermore, smart contract architectures can be arbitrarily complex, allowing the development of intricate governance structures without limits in granularity.

Ostrom contracts aim to encourage cooperation and self-governance. Smart contracts serve as a transaction and governance medium for people to self-organize and collectively decide on common matters. For this reason, there

88. For more details see: *https://elephant-atlas.org/home*.

should be different levels of commitment to the deployment of smart contracts. Loosely coupled Ostrom contracts merely serve as media for self-organization, while the community remains the principal agent to enforce and implement their rules of governance and sanctions. Tightly coupled contracts can go one step further and automatically enforce execution. Automation can offer promising solutions by transferring the level of trust from the users to the system. However, automated systems also have many potentially dangerous implications as they are not immune from biases and adversarial attacks.

The emergence of blockchain governance has inspired a broad array of experimentations to implement complex political and economic affairs through code. There are claims over the possibility to pilot and implement different systems and apply methods to evaluate, reiterate and potentially improve different variations of economic outcomes. For instance, P2P Models[89] is another research project building on the potential of collaborative economy platforms harnessing blockchain technology. Building on the main outcomes of the P2P Value project,[90] it envisions a similar combination of commons-based rules for a new generation of self-governed and more economically sustainable collaborative economy communities. Finally, Artificial Intelligence, forms of which are already deployed in many of our daily applications, can also be implemented to augment smart contracts. Such iterations of the development of these emerging technologies entail many promises in providing better information on potential alignment of human self-interest with common good.

89. For more details see: *https://P2Pmodels.eu*. Also, see documentation in Appendix.
90. For more details see: *https://P2Pvalue.eu*.

Evolution of Accounting

Chapter 3
Evolution of Accounting

Carlota Perez (2002) has defined a framework for technological evolution based on a series of recurring technological revolutions. Each one of these comprises two phases: an installation phase, where new technological innovations are gradually introduced and diffused in the economy; and a deployment phase, where their dynamics are actually harnessed and optimized. Between the two phases lies a turning point, usually triggered by a financial breakdown (e.g., 1929 crash; 2002/2007 crash), and it is followed by a period of economic recession. This turning point provides a vital space for the necessary institutional reforms to take place for the deployment of the new technologies.

Blockchains are broadly discussed as disruptive technologies with the potential to change the way societies function. However, that is a rather superficial use of the term and not substantially connected to actual disruption, i.e., causing discontinuities in the trajectory of technological development. It is often compared to the internet and the profound changes that it has brought about. In the Perezian framework, the internet has been one of the key technologies that were widely diffused in the installation phase of the ICT revolution. This process was indeed disruptive and has profoundly changed the ways people connect, communicate and collaborate on a global scale.

To date, blockchain technology has not effectuated any further disruptions in these patterns. However, we believe that the generic concept of distributed ledgers, enabling an internet of verified transactions in the context of physical production, holds great potential for various desirable outcomes for societies. It can thus shape new institutions that will allow us to deploy the full potential of the ICT revolution.

In earlier work, Kostakis & Bauwens (2014) distinguish three potential scenarios for the deployment phase of the ICT revolution:

The first scenario sees a regression towards traditional proprietary capitalism. Blockchain technology can be instrumental in this scenario, by enabling the enforcement of strict property rights, especially in the areas of information and knowledge.

The second scenario concerns the rise of cognitive capitalism, where

knowledge, software and culture are commodified and serve as the driving forces for profit creation. This scenario is reflected in the powerful netarchical platforms, like Facebook, Amazon and Uber, where a layer of P2P sociality is enabled and generalized, but is also manipulated and monetized in a rent-seeking pattern. Here again, blockchains may serve to optimize this process of accumulation, focusing on efficiency gains in slashing transaction costs, data integrity and security.

The third scenario envisions mature CBPP, emancipated from the prescriptions of profit maximization and perpetual growth. Here, P2P communities have acquired the means to form the types of institutions that can foster sustainable forms of social production. This is the trajectory that underpins our analysis and interpretation of the tools covered in chapter 2. Even though they may not be explicitly oriented towards the abolition of capitalism, they offer post-capitalist aspirations on different levels.

As we explained in chapter 1, double-entry bookkeeping has historically served this key function with regards to capitalism. The German historical economist and reputed analyst of capitalism Werner Sombart (1902), has been one of the leading scholars identifying this function of scientific accounting in stimulating and unleashing the rationality that thrusts the pursuit of economic profit, an essential element of the capitalist spirit. It was developed by the proto-capitalist merchants of the medieval city-states, and allowed them to procure the institutions that would configure their relation to the feudal order. The effectiveness and coordination of their practices enabled a dynamic force that would eventually form the future of societies. This is best reflected in the analysis of the mercantilist scholar Giovanni Botero (1590) on why the world's gold ended up accumulating in Venice, where there were no gold mines.

Polanyi (Bockman et al, 2016) unveils a similar relation between accounting and economic theory. We often place the birth of the capitalist economic theory and practice in 1776, when Adam Smith published the *Wealth of Nations*. However, Polanyi argued that economic theory develops systematically through the analysis and interpretation of accounting concepts, which in the case of capitalism predate the 18th century altogether. From a different angle, the lack of a basic economic theory for socialism has been one of the key weaknesses for Polanyi concerning socialist practices to transcend capitalism. Karl Marx has created an elaborate theory for the capitalist economy but consciously avoided working on a rigorous theory of the socialist economy. Therefore, if

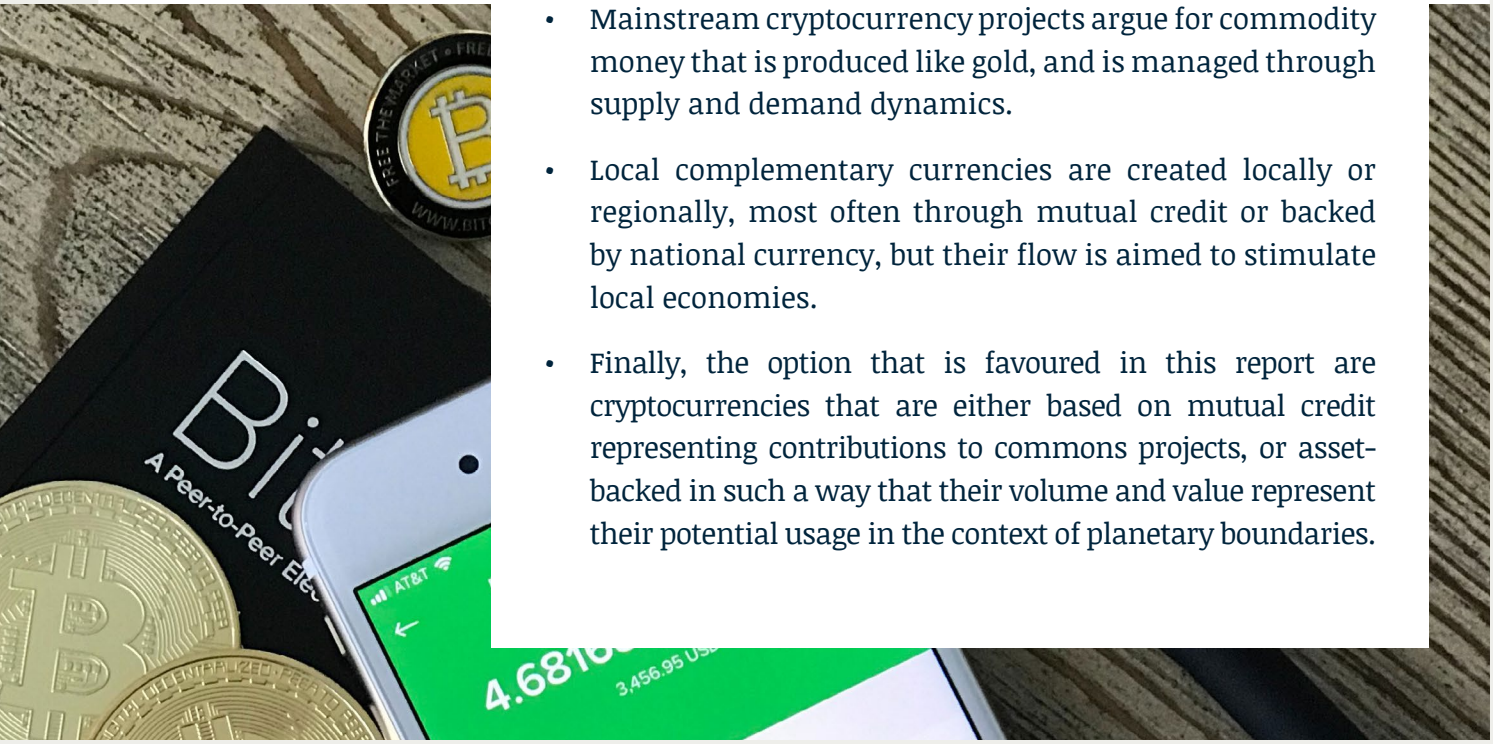
WHICH KIND OF MONEY DO WE NEED?

First, a reminder: How is money created today? Brett Scott writes:

"Our money system is underpinned by national central banks and treasuries that issue foundational 'base' money. This includes the physical cash in our wallets and also reserves, the special forms of digital money that commercial banks hold in their central bank accounts, which are inaccessible to us. These commercial banks then boost the money supply by issuing a second layer of money on top of the central bank money layer, through a process called credit creation of money (sometimes called 'fractional reserve banking') to create commercial bank money, which we see as bank deposits in our bank accounts."

Five monetary movements exist that want to improve different aspects of this process:

- The Modern Monetary Theory movement tackles the government creation of money. The main idea is that the government can create money for productive investments, and recuperate these investments through taxation without creating inflation. There is no such thing as government deficits in this context.
- Positive Money (UK) tackles the private creation of money through bank credit. They argue that only a democratic sovereign governing body can create new money, under their own terms and on behalf of the people.
- Mainstream cryptocurrency projects argue for commodity money that is produced like gold, and is managed through supply and demand dynamics.
- Local complementary currencies are created locally or regionally, most often through mutual credit or backed by national currency, but their flow is aimed to stimulate local economies.
- Finally, the option that is favoured in this report are cryptocurrencies that are either based on mutual credit representing contributions to commons projects, or asset-backed in such a way that their volume and value represent their potential usage in the context of planetary boundaries.



we are to theorize and promote the conceptualization of a P2P and commons-centric economy, we need to understand, interpret and integrate the nascent systematic practices that represent and assess economic facts.

Thus, the function of accounting practices arguably goes beyond measurement of debts and credits. This is merely a process, which serves to coordinate the steering of economic activities through a shared rationality among agents. In capitalism, this rationality includes the relentless pursuit of profit and is facilitated by the abstraction of economic objects to numerical representations. Elsewhere (Pazaitis et al., 2017), we have identified a different rationality in mutual coordination that is observed in CBPP. It is centered around contributory activity, shared capacities and aggregated integration of outputs.

Our argument is that a constellation of the necessary tools and technologies is already in place in the practice of CBPP. This means that we have the technological capabilities and the emergent socio-economic practices to accumulate a critical portion of human and natural wealth in the commons.

Crucial for our argumentation in this report is that the current crop and technologies must be looked at, in their integrative capacity to create a new system of sustainable production. This is the topic of our chapter, but first, we will now complement our overview of tools by looking at accounting and planning frameworks.

New Accounting and Planning Frameworks

Contributive accounting is a form of accounting that takes into account all kinds of contributions, not just waged labor that is recognized by the market.

As Tiberius Brastaviceanu of Sensorica's Open Value Network explains (see infra in our section on REA accounting):

"Our thesis is that in order to reward all the participants in P2P economic activity, and thus to incentivise contributions and make participation sustainable for everyone, we need to do contribution accounting: record everyone's contribution, evaluate these contributions, and calculate every participant's fair share. This method for redistribution of benefits must be established at the beginning of the economic process, in a transparent way. It constitutes a contract among participants, and it allows them to estimate their rewards in relation with their efforts. We call this the contribution accounting system."[91]

Guerrilla Translation: Multi-flow accounting for commons-based, open-value cooperativism

Guerrilla Translation (GT) is a commons-oriented communications collective using P2P accounting for value sovereignty. Their governance/economic model tracks and rewards value in three complementary streams: Livelihood Work (work paid by clients), Love Work (pro bono translation work which creates a knowledge commons), and Care Work (affective and reproductive labour for the collective and its members). GT is a pilot project for Open Value Cooperativism and Distributed Cooperative Organizations (or DisCOs)

Guerrilla Translation was created in 2013 as a livelihood vehicle for activist translators. Influenced by the Occupy and 15-M movements, the collective built social capital with progressive authors and readers by offering pro

91. Tiberius Brastaviceanu *https://wiki.P2Pfoundation.net/Tiberius_Brastaviceanu_on_Why_We_Need_a_Contribution_Accounting_System*

bono translations of articles dealing with the Commons and P2P, activism, environmentalism, intersectional feminism and other interrelated movements. Their work as a general communications agency is complemented by the pro bono work, which is diffused through the collective's English and Spanish webpages.

Inspired by the P2P Foundation's work on Open Cooperativism, as well as by Open Value Accounting and Feminist Economics[92], Over the course of five years, Guerrilla Translation substantially reworked their Open Source governance model to arrive at the "Distributed Cooperative Organization (DisCO) Governance Model,"[93] a framework for purpose-oriented and DLT-enabled, but not dependent, cooperative organizations. The model allows workers to mutualize their skills while identifying value flows, making care work visible, and creating plurilingual commons.

The governance model has interdependent provisions for levels of membership, decision-making and value-tracking, we will concentrate on the latter. The best way to visualise how value is created and distributed among the members of the collective is by understanding each of its three value streams (Livelihood, Love and Care) as shares. The first two (Livelihood and Love) are considered **productive work** and are tracked in credits, typically in relation to wordcount or other easily tokenized deliverables. Although externally the collective uses a sliding scale to set prices for paying clients, internally both Livelihood and Love credits are valued at the same rate. All members accrue credits in both value streams, increasing their relative shares. On a monthly basis, the shares are divested for agency and pro bono work, at a ratio of, 75 and 25% respectively. The collective's net holdings[94] in a given month are to be fully paid out, with each member receiving their salary according to their shares rather than their direct labour over the course of that month. In this way, the DisCO model functions much like an income-sharing commune, but with clearly bounded ratios for both types of productive work.

Reproductive work is tracked in hours, not credits. These "care hours" account for two types of care work: for **the health** of the collective where

92. According to Guerrilla Translation, Open Value Cooperativism expands on the practices of Open Cooperativism by explicitly adding Open Value Accounting and Feminist Economics. Open Value Cooperativism is also the theory informing the DisCO Framework. See: *https://wiki.guerrillamediacollective.org/index.php/Open_Value_Cooperativism*
93. An introduction to the model can be read at: *https://www.guerrillatranslation.org/our-governance-model/* . The full text model can be found at: *https://wiki.guerrillamediacollective.org/index.php/Distributed_Cooperative_Organization_(DisCO)_Governance_Model_V_3.0*
94. Understood as available liquidity once taxes and infrastructural costs are paid have been addressed but before payment is disbursed to members.

the collective is seen as a living entity that needs commitment, material inputs and fidelity to its social mission; and for **the people** within the collective who build mutual trust and intimacy support structures. In the former the collective itself is seen as a trust. Similar to how a Community Land Trust (CLT) perpetuates specific social values through shared ownership structures, Guerrilla Translation's on-chain dimension upholds and enables the collective's consent to a set of voluntary, self-organised rules. A DisCO's algorithms, whether encoded on a blockchain or not, support the collective in overseeing, simplifying and carrying out the human-level agreements and rules. Once the community's care-orientation is entrusted to the on-chain entity, it is described as a **Community Algorithmic Trust** (or CAT) which oversees the health of the collective. A DisCO is considered healthy when its administrative and human requirements are taken care of, i.e., all members ensure that both Livelihood and Love work are done at the agreed-upon ratios, that payments are received, relationships maintained, websites updated, etc., a lot of what is typically considered administrative work.

In contrast to self-executing Decentralized Autonomous Organizations (DAOs), which can be excessively centered on quantifiable ("tokenized") aspects, a Distributed Cooperative Organization or DisCO like Guerrilla Translation stresses human mutual support, cooperativism and care work. Its *on-chain* dimension is a perpetual prototype influenced by the *off-chain*, lived experience of the collective. DisCOs track three types of work to clarify difficult conversations, and so as not to be algorithmically subjected to an unappealable set of figures.

The second type of care work is caring for the people within the collective. Guerrilla Translation has developed on the mutual support practices of Enspiral and other commons- and feminist-oriented collectives to ensure that all members are heard, respected and empowered to express themselves, thus ensuring true equipotentiality. Hours tallied for this type of work can then either be paid down monetarily as a different set of shares when a DisCO has start-up funding, or are simply fully decommodified and used as indicators to adjust share ratios in the two productive streams as well as work allocations and needs[95].

Guerrilla Translation is part of the Guerrilla Media Collective, a Distributed

95. This dual stage approach to Care Hour usage is described in the Care Work Value section of the governance model: *https://wiki.guerrillamediacollective.org/index.php/Distributed_Cooperative_Organization_(DisCO)_Governance_Model_V_3.0#Contribution_Tracking*

Cooperative Organization also working on web design, illustration, coding and other communications. As such, it is a pilot project for DisCOs, testing strategies for value sovereignty in the real world. The case of Guerrilla Translation is important because it adopted DLT technologies and peer-to-peer accounting as an already existing, viable collective working in markets and creating commons. Their commons-oriented feminist critique of contributive accounting is unusual in the blockchain space and, as such, provides an alternative framework to build on the practices of Platform and Open Cooperativism for other sectors and publics.

Resources - Events - Agents (REA): An accounting system for networked cooperation and shared supply chains[96]

Resources-Events-Agents (REA) is a radical innovation for accounting which hitherto has been based on double-entry bookkeeping, which takes an individualistic or corporate point of view, and it is aimed at increasing the capital base of a commercial entity. REA, on the contrary, offers an 'independent' ecosystemic view of the flows between participants in an ecosystem and evolved in the context of integrated supply chains. Metaphorically speaking, this abandonment of double entry is, in our opinion, symptomatic of a shift from a capitalist point of view, based on competing corporations or nations, to a cooperative point of view, based on networks of cooperation in joint ecosystems.

REA is a model for an accounting system re-engineered for the information age. It was originally presented by William McCarthy (1982) as a generalised framework designed to cover certain needs for information management that traditional accounting could not adequately address. The main motivation behind the development of REA has been the limitations of double-entry bookkeeping in providing the necessary information to facilitate decision-making in business entities.

96. This section is based on a forthcoming paper by Alex Pazaitis, tentatively titled: *Capturing Value in Open Innovation: The Case of Sensorica*.

Double-entry is generally limited to monetary representations and dates and is overall alienated from the most functional areas of an enterprise, other than accounting. In most cases, the type of information and the classification systems used in traditional accounting are of little use to non-accountants, and offer limited ability for decision makers to utilise the raw data from the actual economic activities. These limitations result in low integration of the information across the various functional areas of an enterprise, which often leads to inconsistencies and overlaps (McCarthy, 1980; Dunn et al, 2016).

These limitations are addressed by the REA framework through a semantic approach that aims to reflect real-world business activities rather than double-entry accounting objects. As the name implies, the model creates computer objects that represent: a) Resources (e.g., goods, services, cash, assets); b) Events (e.g., processes, transactions, agreements, contracts); and c) Agents (e.g., individuals, groups of individuals, entities, machines). REA preserved the duality of economic events that is typical of double-entry, retaining the causal relationship between inflows and outflows. For instance, in a productive process, several resources (e.g., components, labor time, machine time) are employed as input, and produce in turn other resources (e.g., products, parts). Simultaneously, REA identifies the agents involved in these events and connects the activities with stock flows, which represent resources moving from one activity to another (Haugen & McCarthy, 2000). This way, it integrates all the planning, monitoring and communication functions, providing greater granularity of data to effectively track the economic activities and inform decision-making (Dunn et al, 2016).

Research on REA has progressed in recent years and the model has gradually evolved from a generalised framework to a design theory for enterprise systems. It is the basis for the International Organization for Standardization/ International Electrotechnical Commission standard on economic exchanges (ISO/IEC 15944-4:2007), while it has been argued that the implementation of the model in enterprise systems, like Enterprise Resource Planning (ERP) systems, can have significant advantages in terms of cost reduction and user experience. Recently developed enterprise systems, such as Workday and REA Technology, have applied the core of the model in their architecture, while many ERP systems that do not fully embrace the REA accounting model are still largely consistent with the design theory.

Even though REA exists as a model from 1982, it is not yet widely adopted in business, due to path dependencies with the traditional accounting practices.

Most ERP systems are consistent with double-entry bookkeeping artefacts in the way they provide information for their applications and thus include general ledger modules for the relevant accounting tasks (Vandenbossche & Wortmann, 2006). As this type of information is mainly handled by accountants and financial managers, they in turn prefer ERP systems to be designed in a way with which they are more familiar.

On the contrary, network-based organizations could benefit from the logic of semantic representation of their reality to a greater degree than by relying on artificial accounting constructs. Furthermore, it enables the recognition of interactions that are not guided by price signals, or trust-based intra-organizational integration, which is reminiscent of the forms of clusters (Porter, 1990; 2000) or strategic alliances (Teece, 1992), which are already challenging the definition of the boundaries of "the firm."

REA enables new organizational and business models, such as the open enterprise Sensorica, which builds on the REA model to support its operation as an "Open Value Network," allowing diverse agents, individuals and entities to contribute to common projects and build open-hardware solutions. As a design theory, REA envisions to provide a common vocabulary that enables the coordination of all involved parties in integrated systems. It poses as a discontinuity in the design paradigm of electronic accounting systems, where instead of focusing on the automation of traditional accounting artefacts, it conceptualises a new way of representing the complex economic reality.

An emerging universe of projects is building on the REA potential, such as Mikorizal Software, which is building accounting and open supply chains solutions along with communities that work on alternative economic models. In the same direction, ValueFlows poses as a collective effort to capture and systematize these learnings and work towards the creation of a set of common vocabularies to describe flows of economic resources of all kinds within distributed economic ecosystems. A concise overview of these developments is presented in the Appendix, offered by Bob Haugen who, along with Lynn Foster, is one of the key engineers of REA implementations.

Reporting 3.0: Direct access to a representation of matter and energy flows in interconnected supply chains

Reporting 3.0 proposes a multi-capital framework, in which resource flows are directly accessible without translation into price signals. The proposal of this ambitious but vital project is to create a Global Thresholds and Allocations Council as a depository of resource availability, including the biocircularity quotients (how much of a resource can be iteratively reused after each cycle of use). Considered as global commons, agreements can be made about the justified use and distribution of a resource within planetary boundaries, which can be used for planning context-based sustainability, i.e., how much of a resource can be used at the local-territorial level (bioregional), or at the level of entreprise or ecosystem of production.

Reporting 3.0 is an R&D platform working on the development of reporting solutions to support a regenerative and inclusive economy. It engages diverse stakeholders from the broader reporting sector in a collaborative environment to co-create and pilot tools and recommendations for emerging economic and business ecosystems. Its motivation is to build on the potential of reporting to increase transparency and, thus, accountability in more informed decision-making to amend degenerative practices and proactively activate regenerative ones.

Reporting encapsulates different clusters of information that concern a company's decision-making and sustainability, from performance metrics, impact on capital, and compensation and incentives, to risk and innovation, strategy and governance, and business models. Additionally, Reporting 3.0 also takes into account the long-term view on the value created for the company and its shareholders, but also the value flows in the broader systems in which a company operates.

To fulfill this role, reporting practices have to evolve[97] and allow the inclusion

97. Reporting 3.0, as the name implies, presents the 3rd consecutive step in this trajectory. For a brief overview see: https://reporting3.org/wp-content/uploads/2018/07/r3.0-Information-Brochure-2018.pdf.

of non-financial aspects such as social and ecological ones. In the early 1990s these attempts began to be examined under the term "Triple-Bottom-Line" (TBL),[98] where the three dimensions of business sustainability, social, ecological and financial, were combined. Yet, the TBL approach still fell short in capturing the broader business context, in terms of social and environmental limits and demands at the sectoral, local, regional or global level.

Reporting 3.0 aims to fill these gaps by setting data and information in the proper context of various limits. It aspires to enable and coordinate a stream of transformations, starting from the micro level of the individual company, moving to the meso level of sectoral and regional systems, and finally to the macro level of global economic, social, and ecological systems. These build around the identification of environmental and social *thresholds*, i.e., upper and lower limits based on ecological boundaries and social foundations, and *allocations*, i.e., proportionate shares of the full stock of a resource.[99]

Reporting 3.0 asserts to enhance the viability of the use and sharing of resources through a conscious process that employs thresholds and allocations, given that resources always have upper or lower limits of viability, while the use of shared resources always require some system of allocation. Thresholds and allocations can, thereby, tie impacts from micro-level organization with macro-level economic, social, and ecological viability. Ideally, this would inspire, but also provide, the necessary practical tools for companies to integrate this vital micro/macro link in their management, performance and reporting to foster system-level sustainability.

The above concepts are compiled by Reporting 3.0 in the form of practical blueprints, which provide guidelines and principles to assess company strategies. The reporting blueprints define a desirable trajectory that is then integrated in different domains, including accounting, data and business models. Furthermore, Reporting 3.0 coordinates the pilot implementation of these blueprints to examine their viability and scaling-up potential, as well as a series of support activities for dissemination, exchange, feedback and cross-pollination.

Reporting 3.0 represents a broader trend in business practices, where the elements of social and ecological sustainability gain prominence through

98. Elkington, J. (1994). Towards the Sustainable Corporation: Win-Win-Win Business Strategies for Sustainable Development. *California Management Review*, 36(2): 90–100
99. Authors' interpretation from: https://medium.com/@ralphthurm/what-are-thresholds-allocations-and-why-are-they-necessary-for-sustainable-system-value-fe127483c407.

the recognition of (re)generative activity towards both dimensions. Marjorie Kelly (2012) introduces a taxonomy of generative enterprises,[100] which imply a historical break with markets and "the market economy," i.e., an economic system that is exclusively controlled, regulated and directed by markets (Polanyi, 1957). It illustrates a potential for market-oriented agents, with collective forms of ownership and control, to operate and invest for social and environmental goals before profits.

Nevertheless, it is always useful to also look for new categories to surpass the deadlocks of our current economic reality. The notion of entrepreneurship has also many historical interpretations that are almost inseparable from profit making and exploitation (including self-exploitation). Of course, there is a constant evolution and metamorphosis of those categories, as different groups of people look to challenge and deploy their potential. But we also need to acknowledge the limitations of the various solutions that rely on existing processes, like monetization and quantification, to enable new ones.

At any rate, the vision of generative forms of entrepreneurship is aligned with the practice of CBPP. Generative, commons-oriented enterprises are embedded in the social and ecological context they operate. They create added value around the social and ecological capacities upon which they depend, and enrich them by creating livelihoods for the productive communities, while contributing to the commons. The generated surplus is reinvested for the well-being of the communities and of the broader ecosystem.

MuSIASEM: Accounting for material/energy flows and their limits

MuSIASEM, standing for "Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism,"[101] is an important set of tools for biophysical accountability. As current price signals do not reflect the need to conserve

100. Kelly's diagram can be found here: *https://wiki.P2Pfoundation.net/Emerging_Ownership_Revolution#Characteristics_of_Generative_Ownership_Forms*
101. See also the treatment here at *https://wiki.P2Pfoundation.net/Multi-Scale_Integrated_Analysis_of_Societal_and_Ecosystem_Metabolism*

resources for long-term sustainability, regions, corporate entities or networks of cooperation need direct access to the flows of matter and energy that they require for operating, and to the possible limits of that use in view of sustainability. To answer this challenge, the project has developed systemic tools that can be utilized for maintaining sustainable production.

MuSIASEM is an accounting method aiming to analyze socio-ecosystems and simulate certain possible or required patterns of development. It integrates biophysical and socioeconomic variables to establish a link between the metabolism of socio-economic systems, i.e., the processes of energy and material transformation that are necessary for the continued existence; sustainability and reproduction of those systems; and the potential constraints imposed by the natural environment in which they are embedded.

MuSIASEM integrates data from various levels (e.g., national, regional, local and household); from various issues such as time use, land use and energy consumption; and from various activities and production sectors. An in-depth analysis of the MuSIASEM framework exceeds the confines of the current article, as this would require a fundamental explanation of several concepts from different scientific domains, including Complex Systems Theory and Bioeconomics. Nevertheless, it serves the purposes of the current research to briefly present some of the main features.

MuSIASEM focuses on the patterns that make socio-economic systems work, and enables a deeper understanding and an assessment of their sustainability. Two fundamental categories in this process are *funds* and *flows*. Flows are the elements that come into or out the system, e.g., energy, food, or water, whereas funds are the agents that are preserved in the system and transform input flows into output flows, e.g., capital, people, or land. In other words, flows are the elements that keep the society alive, while funds are the elements that have to be sustained and reproduced in the process.

Two other useful categories are those of *endosomatic* and *exosomatic metabolism*. Endosomatic metabolism is related to food, i.e., energy transformation that takes place inside the human body to maintain its activity and development. Exosomatic metabolism refers to energy converted outside of the human body, that will be converted to applied power under human control, in order to facilitate work associated with human activity.

Using these categories MuSIASEM enables the connection of two non-equivalent views of the metabolic pattern of a given society: a) the external

view, which concerns potential environmental constraints, such as the availability of resources, waste generation and absorption capacity; and b) the internal view, which deals with potential technical and economic constraints, such as the technical coefficients and the requirement of production factors. In other words, the first view assesses the feasibility of the metabolic pattern according to the characteristics of processes that lie outside of human control, whereas the second view focuses on the viability of the metabolic pattern according to the characteristics of human-controlled processes.

The MuSIASEM approach can be used to analyze environmental constraints of a socio-economic system by generating an Environmental Impact Matrix. To this end, the flows metabolized by a society are mapped in spatial terms (using GIS) in order to study their impact on the metabolic pattern of the embedding ecosystems. Mapping flows against ecological funds in spatial terms allows us to check whether the density of the metabolized flows is harmful for the stability of environmental processes.

Respectively, MuSIASEM can be used to analyse socio-economic constraints. In this case, biophysical variables are combined with monetary ones to characterize the different activities that constitute the economy. This provides a biophysical overview of economic processes through quantitative representations of society's metabolic patterns. These patterns are then described in relation to the profile of allocation of human activity in the different compartments of society.

This analysis shows the interrelationships between demographic, economic and environmental constraints. In this direction, MuSIASEM can be used to integrate data referring to different levels of organization and scales (national, regional, local and household) and different dimensions of analysis.

This combination of biophysical and monetary variables generate a record of time use and exosomatic energy consumption in the different activities that make up the economy. This provides a biophysical overview of the economic process in the form of a quantitative representation of a metabolic pattern, showing the interrelationships between demographic, economic and environmental constraints.

MuSIASEM is a unique framework that can be applied in different contexts and under various assumptions. It enables the development of tools that can analyze patterns of energy consumption on different levels and create linkages with social and economic indicators, such as monetary flows, employment

and output. It may be used to compare the performance in relation to specific desired outcomes across different countries, sectors or regions on various levels of analysis, and to study the effects of these outcomes. It holds great potential in the design of socio-economic systems, either communities, organizations or supply systems, that are socially and environmentally embedded.

Accounting for Impact and Externalities

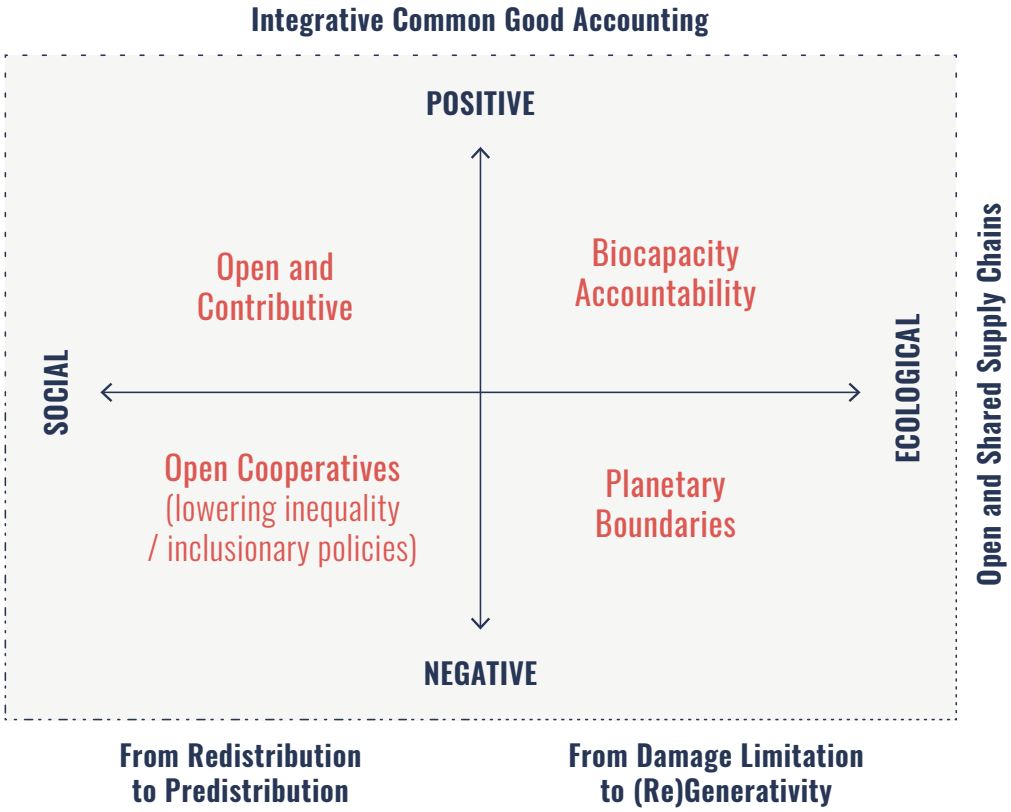


Figure 7: Four kinds of externalities

As Peter Barnes has explained: "EXTERNALITIES are a better-known concept than commonwealth. They're the costs businesses impose on others — workers, communities, nature and future generations — but don't pay themselves. The classic example is pollution. Almost all economists accept the need to "internalize externalities," by which they mean making businesses pay the full costs of their activities. What they don't often discuss are the cash flows that would arise if we actually did this. If businesses pay more money, how much more, and to whom should the checks be made out? These aren't

trivial questions. In fact, they're among the most momentous questions we must address in the twenty-first century. The sums involved can, and indeed should, be very large: after all, to diminish harms to nature and society we must internalize as many unpaid costs as possible. But how should we collect the money, and whose money is it?"[102]

In the above graph, we distinguish between the four kinds of externalities that are not recognized in the current political economy. Positive social externalities are contributions that bring value to a productive project and that are generally not recognized, for example, domestic and care work is not recognized as 'valuable' by market society, and Facebook does not share any of its profits with the co-creators of its value, i.e., its users and their communication work.

Negative social externalities are the multitude of social issues that are negatively impacted by economic injustices and that are currently taken up as issues by the state function or philanthropy, or not at all.

Positive environmental externalities result from activity that benefits ecological outcomes but are not recognized and rewarded. For example, a Community Land Trust movement like the French 'Terre des Liens' helps generative organic farmers with access to the land, and these in turn have a major positive impact on decreasing water depollution costs by public authorities, but these presently are not rewarded or financed in any specific way.

Negative environmental externalities are the unrecognized damage done by economic entities.

There is presently no systemic way to finance such generative activities, i.e., those that produce positive outcomes or help repair or undo negative ones, except for financing through taxation and philanthropy, which are not structurally integrated in the production process itself.

At the P2P Foundation we believe that a shift must be made from 'repairing' negative externalities after the fact, or 'outside of the process of production,' to a system that integrates the accounting and financing of such externalities, i.e., that can systematically reward and finance generative work.

We introduce here two approaches that go in the right direction:

102. Source: *http://evonomics.com/dont-ditch-capitalism-tax-extractive-side-effects-fuel-growth-barnes/*

The Regen Network proposes a way to directly finance generative activity, by recognizing impacts on a ledger, tokenizing these activities, and finding ways to finance them in a structural way.

The Common Good Economy approach focuses on impact accounting in terms of achieving recognized Common Good aims, and having firms and productive entities compete to achieve positive impact.

Regen Network: 'Ecological state protocols' to verify advances in sustainability and regenerativity

The Regen Network has developed the crucial concept of 'ecological state protocols,' which can be both used to verify the attainment of ecological (and social) impacts, and put on a ledger for tokenization and possible financing.

Regen Network is a global community and platform focused on ecological monitoring and regeneration. Regeneration is defined as a process of renewal, restoration, and growth that makes cells, organisms, and ecosystems resilient to natural fluctuations or events that cause disturbance or damage. In this framework, the primary goal of Regen Network is to regenerate the earth's ecosystems.

Its approach leverages distributed ledger technology to create a systemic multi-stakeholder, market-driven solution to facilitate verifiable ecological outcomes. It is built around the Regen Ledger, a domain-specific public permissioned blockchain. Its core feature is to provide secure functionality for end users into the blockchain itself, instead of a multi-purpose smart contracting language. For this it is based on Tendermint, a general purpose blockchain consensus engine that can host arbitrary application states.[103] Tendermint is said to offer several advantages in terms of resilience, interoperability and overall energy consumption, while ensuring high data integrity and federated governance.

103. For details about Tendermint see: *https://tendermint.com/docs/introduction/introduction.html*.

The core attribute of the Regen Ledger is the use of smart contracts to reward ecological regeneration. This is supported by a decentralized system that monitors and verifies ecological state and change of state. It contains three core ecological protocol frameworks: a) Ecological State Protocols (ESPs), which monitor the on-the-ground conditions, generate trusted data and define the algorithms and conditions that verify a certain ecological state or change of state; b) Ecological Contracts (ECs), a smart contract framework for funding and rewarding desired change in ecological state; and c) Supply Protocols (SPs), a framework built on top of the ESP framework to integrate supply chain tracking data in addition to land use.

The basic function of an ESP is to evaluate the state and change of state for the ecosystem of a specified area. For instance, an ESP could be used as a class of certification, like Organic or Fair Trade to promote sustainable and ethical land use practices. ECs in turn are smart contracts that can generate funding for specific ecological outcomes, either positive change in the ecological state or reparations for damage created. To specify the desired outcomes ECs may reference one or more ESPs to create indices and set thresholds for the results, and scale the rewards. Finally, the Supply Protocol (SP) framework may be used to tie the ESP framework into the supply chains, by combining different data sets.

The data for the verification protocols are gathered by various sources. From raw remote-sensing data and analyses using vegetative and water indices, GIS datasets and bioregional sensor networks, to user-collected data concerning information on the soil, the practices applied, handheld instruments, or other specific data required for the ESP.

Organizations with various roles may issue tokens on top of Regen Ledger when certain Ecological Contracts are fulfilled. This way, a new perception of value creation can be promoted that is tied with the resilience of the bioregions supporting human activity. The Regen token model aims to create economic incentives for investment on applications that support generative activity. The Regen Ledger will issue its native token, XRN, which will function as a mechanism for the accounting of ecological value.

Regen is oriented towards market-driven solutions to support regenerative outcomes. Nevertheless, it acknowledges the broad criticism of the current carbon trading system for its limited real world impact. To address this, Regen proposes the creation of a marketplace for verified regenerative carbon credits.

A potential application of the Regen model could be in regenerative agriculture, which encompasses a system of farming principles and practices that increase biodiversity, enrich the soil, improve watersheds, and enhance ecosystem services. For instance, no-till farming has been widely discussed as a farming practice that enhances soil quality and reduces the risk of erosion, by growing crops or pasture without the application of any form of soil preparation by mechanical agitation, such as digging, stirring or overturning. It has been estimated that no-till farming can be twice as effective as a carbon sequestration management practice[104] (i.e., a natural or artificial process to remove carbon dioxide from the atmosphere and gather it in solid or liquid form).

In this context, Regen can provide methods to differentiate between till and no-till farming, using remote sensing and GIS, to assess agricultural lands and monitor the long-term changes in soil health due to these management practices. These data can be embedded in different ESPs to determine desired ecological outcomes and linked to the use of these practices. In turn, farms that adhere to regenerative practices according to the sequestration results they yield can be financially rewarded using the XRN token system.

The ability to monitor and compare the impact of regenerative practices vis-à-vis non-regenerative ones can unlock vast opportunities as to predicting long-term shifts in carbon sequestration of land, before any changes are evident at the ground level. This is particularly relevant for the support of regenerative practices, as any detectable changes in soil carbon would otherwise take up to 10 years to become tangible. On the contrary, it is vital to encourage these types of practices in order to achieve global carbon drawdown.

From a more critical perspective, the tools and methods created by Regen Network are still operating largely in a logic to tilt market-based forces so as to make regenerative activity appear as "a good investment." To that effect, they are based on measurable data to coordinate outcome-based rewards, and are therefore still applying some form of abstraction to social and biophysical processes. However, Regen Network nevertheless provides a novel approach to encode ecological externalities on the production and distribution level.

From this angle, government or regulatory agencies, on any level, can leverage the Regen solutions to implement policies oriented towards certain environmental goals. Moreover, they may strengthen the current supply

104. More details at: *https://medium.com/regen-network/update-new-insights-into-till-no-till-monitoring-protocol-d36e21083e9d*.

system of certifications, by increasing transparency and efficiency and by reducing the costs of implementation, which can enhance the role of more and diverse actors in the process, including farmer communities and local stakeholders. This way, Regen Network takes a first step towards more inclusive and multi-stakeholder forms of governance in the critical domain of food provisioning.

The Common Good Accounting System: Competing for positive impact

ECONOMY FOR THE COMMON GOOD
An economic model for the future

The Common Good Accounting System describes the positive and negative impact of economic entities, by calculating the effects of economic activity in 17 clusters related to the Common Good. The system offers specific versions for productive entities (firms) and for territorial entities (cities and regions). Through this mechanism, firms and productive entities start competing for achieving these aims, and are rewarded for it with lower taxes and higher support, while those that fail to achieve these aims are subjected to higher taxes and less subsidies.

The Common Good Economy approach has been proposed by the Austrian economist Christian Felber[105] and a pan-European movement of about ten thousand members. In 2018, about 2,000 entities[106] experimented with the accounting tools developed by the project. Starting with a legal analysis of European democratic constitutions, Felber noticed that they all contain articles stating the economy must serve the common good, and that there is no constitutional basis for the fiduciary obligation to maximize shareholder profits. Hence, firms should be assessed on their capacity to achieve common good aims. Contrary to accepted opinion, the common good is not a fuzzy concept, but can be exemplified and measured by a cluster of 17 goals that have accrued wide social support, such as improving the environment and

105. For more on Christian Felber an the Common Welfare Economy, see the video via: *http://www.youtube.com/watch?v=D3Z2cXK5mhc*
106. See *http://www.lteconomy.it/en/topic-interviews-en/interviste/christian-felber-economy-for-the-common-good*

biodiversity, or improving social equity, gender balance, etc. Financial and economic sustainability are necessary, but are only a subset of why firms should be 'in business.' By accepting such a Common Good accounting scheme, which is voluntary for the moment, firms start competing with each other in an entirely different way, by actually improving their positive social and ecological impacts. They should be assessed in this way by society and public authorities, with incentive schemes, such as taxation and subsidies, that are geared towards rewarding those that achieve this type of positive impacts. At some point in the future, when the movement is confident that the accounting schemes function optimally, it will advocate for political measures to make such accounting mandatory, based on the existing constitutional clauses.

VALUE / STAKEHOLDER	HUMAN DIGNITY	SOLIDARITY AND SOCIAL JUSTICE	ENVIRONMENTAL SUSTAINABILITY	TRANSPARENCY AND CO-DETERMINATION
A: SUPPLIERS	**A1** Human dignity in the supply chain	**A2** Solidarity and social justice in the supply chain	**A3** Environmental sustainability in the supply chain	**A4** Transparency and co-determination in the supply chain
B: OWNERS, EQUITY- AND FINANCIAL SERVICE PROVIDERS	**B1** Ethical position in relation to financial resources	**B2** Social position in relation to financial resources	**B3** Use of funds in relation to the environment	**B4** Ownership and co-determination
C: EMPLOYEES	**C1** Human dignity in the workplace and working environment	**C2** Self-determined working arrangements	**C3** Environmentally friendly behaviour of staff	**C4** Co-determination and transparency within the organisation
D: CUSTOMERS AND BUSINESS PARTNERS	**D1** Ethical customer relations	**D2** Cooperation and solidarity with other companies	**D3** Impact on the environment of the use and disposal of products and services	**D4** Customer participation and product transparency
E: SOCIAL ENVIRONMENT	**E1** Purpose of products and services and their effects on society	**E2** Contribution to the community	**E3** Reduction of environmental impact	**E4** Social co-determination and transparency

Figure 7.5: Common Good Matrix

Multi-layer integration: How the new technologies fit together

The tools presented in chapters 2 and 3 comprise only a small part of the overall landscape, but are illustrative of a possible and necessary set of techno-social solutions for a fair and environmentally sustainable mode of production and distribution. There is in fact an ever growing number of projects evolving as we speak that are not necessarily less important than the ones presented. However, an all-inclusive documentation would not only be an almost impossible task, it would also hinder the comprehension of this text. In the following sections, we briefly explain the rationale behind our selection,

which simultaneously delineates the main trajectory of our argument on how these emerging tools fit together. Our aim is thus to draw the contours of a common vision to, hopefully, increase awareness and alignment among the various dispersed efforts.

Earlier, we summarized the main lines of criticism on the limitations of the design of blockchain technology, while acknowledging the useful and necessary advances currently discussed under the topic of distributed ledgers. In other words, we believe it is necessary to move towards post-blockchain ledgers.

This is where the Holochain project comes in. In the blockchain, every transaction needs to be verified against the whole ledger, which requires an exponential increase in resource use to validate new blocks. Moreover, the idea of a "world computer" has strong oligarchic elements in its design. Both proof-of-work and proof-of-stake protocols do not present fair mechanisms for the distribution of power in decision-making. Proof-of-work creates soaring demands in energy and processing power, which requires access to ever-increasing amounts of capital. Even more, proof-of-stake is explicitly based on ownership of stakes, which represents the outcome of the very same unequally-distributed underlying dynamics.

There are various attempts to remedy this through alternative designs of the consensus protocols or the rules of verification, but with limited success. On the contrary, Holochain reimagines distributed ledgers altogether based on principles derived from biomimicry. It fundamentally changes the dominant narrative from "trustlessness" to a "web of trust" principle: if A trusts B, and B trusts C, then trust can be ensured among all the peers. Holochain makes it possible for various context-based distributed ledgers to become interoperable and interconnected, thereby creating a universal distributed-ledger mechanism, rather than a universal ledger.

It has therefore significantly lower requirements in energy use for verification; it is potentially more scalable at lower cost; and does not automatically create oligarchic processes. Moreover, it uses mutual credit as its main mechanism for exchange of value, and its first native token, Holo, is based on the representation of the server space made available to the system. Its Initial Community Offering had also foreseen specific measures to limit the power of big investors against smaller ones.

Likewise, the infrastructure technology of ECSA, Gravity, provides an alternative

architecture to bitcoin's universal ledger or Ethereum's World Computer, by offering a platform for interoperating networks of decentralized computers. The Gravity design is modular and granular, and allows more possibilities for developers to create and run applications on it, based on different properties and consensus protocols.

ECSA thus enables a new approach for distributed ledger design. It relies on the mobilization of diverse capabilities to collectively contribute to, and maintain, the rules of cooperation in the network. It allows alternative economic spaces, with relative value sovereignty, to enforce their desired principles of cooperation and exchange, so as to devise a distributed mechanism for computer-mediated cooperative work capacities.

Furthermore, as we argued earlier, the new forms of mutual coordination need to be integrated in shared supply chains or networks through pluralistic forms of value accounting. DAOStack is building on a legacy of related projects, such as Backfeed,[107] in order to create a system of interchangeable tokens of value exchange. It is an important attempt to rethink a consistent system of value for a contribution-based economy and the rules of value circulation and governance. In a similar direction, REA represents an important shift from double-entry accounting to a network-based view which illustrates individual and collective contributions in the value flow. Finally, Guerrilla Translation's multi-flow accounting system is important for its explicit incorporation of both productive *and* reproductive work into the value equation. This shift beyond double-entry to a network vision of one's activities is necessary for the transition to an economic system which is able both to account for contributory activity and to integrate externalities.

In turn, Envienta and FabChain exemplify a potential path for this transition to take place for ecosystems of physical production. They are oriented towards the creation of cooperative ecosystems based on distributed manufacturing capacities, organized around makerspaces or Fab Labs as their innovation hubs. They emphasize the elements of openness and cooperation, keeping locally-determined socio-ecological conditions in mind, involving mutualization, circulation and reuse of resources and outputs in integrated systems. In this direction, Faircoin and Trustlines represent a potential contribution of blockchain-based systems to support the maintenance and further development of these capacities and cooperation, from a commons-oriented

107. Some of the instigators of DAOstack are the same with the Backfeed project. For details see: http://backfeed.cc.

point of view by focusing on currencies for more fair exchange. Terra0 is of experimental interest because it can integrate non-human agency in this web of cooperation.

Regen Network presents both a vision that allows for the recognition of the value of positive generative work, and a way to structure flows of 'circular finance.'

Finally, MuSIASEM and Reporting 3.0 provide the back-end layer of this process, by defining context-specific and global thresholds and allocations to assess and guide the overall sustainability of such ecosystems. They present a potential evolution in economic governance systems that are more aware and inclusive of the social and ecological aspects when it comes to informing decision-making and promoting more open and democratic approaches. They could and should evolve to fully thermodynamic accounting systems.

Production for social needs within planetary boundaries

What we have already observed in CBPP is that it is possible to create massive and complex technological infrastructures, essentially visible for all the actors, to coordinate self-identified contributory activity. These permissionless contributions are guided within an environment of shared transparency that allows potentially anyone to understand where contribution is needed. This capacity is often referred to as "Holoptism,"[108] whereas the capacity to coordinate work and production through signals is called "stigmergy," with reference to the signalling language of social insects. In the words of Jean-Francois Noubel, we are witnessing a shift from pyramidal collective intelligence to holomidal collective intelligence.[109] In other words, from competing hierarchies to cooperative networks, whis is to say, from competition between cooperating teams to collaboration, *including* potential

108. *Holoptism* (sometimes also referred to as *Holopticism*) is often contrasted to *Panoptism*. Panoptism is the way knowledge is distributed in hierarchical organisations. Only the top of the pyramid has a full view of what is going on in the organisation. Holoptism characterises the ability for any member to have horizontal knowledge of what the others are doing, but also the vertical knowledge related to the aims of the project. For more details see: *https://wiki.P2Pfoundation.net/Holoptism*.
109. "We name holomidal collective intelligence the new form of collective intelligence that emerges thanks to the Internet. Local and global, decentralized and distributed, agile, polymorphic, based on leadership, individuation, open source, integral wealth and mutualist economy, this young form of collective intelligence still lives through its infancy phase. However, we can already see its huge impact on humanity where more and more people in civil society self-organize in order to address societal issues that pyramidal collective intelligence cannot address, and even provokes Socialware and communityware to serve as the keystone on which collectives can rely on, in order to self-organize and scale up, locally and remotely. Holomidal collective intelligence will soon build advanced forms of Holopticism and augmented Holopticism." (http://cir.institute/holomidal-collective-intelligence/)

competition within these collaborative frameworks and ecosystems.[110]

Moreover, the sharing economy, with all its nuances and various interpretations, has demonstrated the effectiveness of large-scale allocation of idle resources through P2P signals that do not necessarily entail price signals. The sharing economy has showcased patterns to allocate massive amounts of unused capacities, from excess resource-processing power to rarely-used household appliances, in many cases more efficiently than by central planning or market operations. The internet has enabled a logic of mutualization for idle resources, which can lead to more efficient and sustainable consumption practices.

One of the common problems of CBPP has been the amount of unpaid work, because there were no easy mechanisms to recognize and reward contributions. It is in this direction that interest has been placed on distributed ledgers, insofar they can allow for large-scale integration of open and shared contributory accounting. Productive communities may, thereby, decide how to reward contributions and develop mechanisms for the recognition of multiple forms of value, thus enhancing their value sovereignty.

Simultaneously, these instruments can also be designed to maintain more fair and just distributions of value. Accounting objects are fundamentally representations of the world of physical-social interactions. Through such accounting systems, which embed the social dynamics of CBPP, the mutual coordination practices can shift from the immaterial world of knowledge, software and design, to the direct coordination of actual physical production. In other words, it is through shared accounting and shared logistics that physical production can become stigmergic, by following the examples of the patterns of signals that already work for immaterial production.

However, physical production requires access to depletable and capital-intensive resources, where stigmergic coordination alone does not suffice. Moreover, material resources need to be exchanged or purchased, often beyond local boundaries. Until now, global supply chains have been based on market mechanisms to coordinate these exchanges. A similar function may be regulated through the exchange of crypto-tokens. The difference is that price signals alone do not necessarily reflect the social and ecological

110. Think of current capitalism as sport: teams compete, but team members collaborate to win the competition. In post-capitalism, actors collaborate using commons and networks; they may still compete for projects or customers, but on the basis of joint resources that are also used by their potential competitors.

needs for sustainable allocation of resources, but merely the current tension between supply and demand. On the contrary, distributed ledgers can encode different rules into new forms of currencies whose design and supply may reflect and execute the use of certain biophysical outcomes.

As these techno-social solutions remain at the nascent stage, market pricing is expected to remain dominant. In this process, complementary currencies can still provide new possibilities to monitor, manage and explain the flow and allocation of material resources. For instance, mutual-credit tokens reflect human contributions, or contributions by humans to an ecosystem, which may include physical resources as contributions. Their issuance and distribution is linked with the available resources among the participants of the ecosystem, including their own labor. Moreover, asset-backed tokens reflect a given state of specified resources and can be designed to reflect the usable stocks and flows, based on certain sustainability concerns. Finally, utility tokens reflect the future usage of resources, also showing future availability, which can include sustainability planning. In this context, a potentially useful concept is that of "functional governance," i.e., a form of governance based on the direct management of matter-energy flows in a given system, including their use and exchange.

Finally, mutual coordination may be permissionless; however, it takes place within a sphere determined by planetary boundaries which must, to a certain degree, be coercive to ensure the survival of the planet and its beings.[111] These boundaries may be represented by a planning framework, determining the metabolic patterns of matter and energy for various agents on different geographical levels. It is possible to identify the amount of available resources and their respective rates of bio-circularity, i.e., the rate at which a form of certain resources remains available in the long term after each iteration of use. Subsequently, global thresholds and allocations can be determined at different levels, so that entities can operate within context-specific levels of sustainability.

Kate Raworth in her book *The Doughnut Economics* (2018),[112] provides a useful framework to integrate this approach (see the figure below). The outer ring of the doughnut shows the planetary boundaries that cannot be exceeded, which

111. On planetary boundaries, see also: William Catton's 'Overshoot' (1982) https://www.press.uillinois.edu/books/catalog/63fae3tq9780252008184.html
112. First introduced in Raworth, K. (2012). A Safe and Just Space for Humanity. Oxfam Discussion Paper. Available at: *https://www.oxfam.org/sites/www.oxfam.org/files/dp-a-safe-and-just-space-for-humanity-130212-en.pdf*.

include vital functions for the planet, such as the nitrogen cycle. The inner ring illustrates social priorities reflecting the human and social needs that should be covered. The inner ring necessarily remains within the resource limits set by the planetary boundaries. Democratic societal institutions can set the framework for funding these priorities and allow the contributory and problem-solving communities to verify their progress and impact. This framework provides a simplified overview of a mechanism that ensures both social fairness and biophysical accountability.

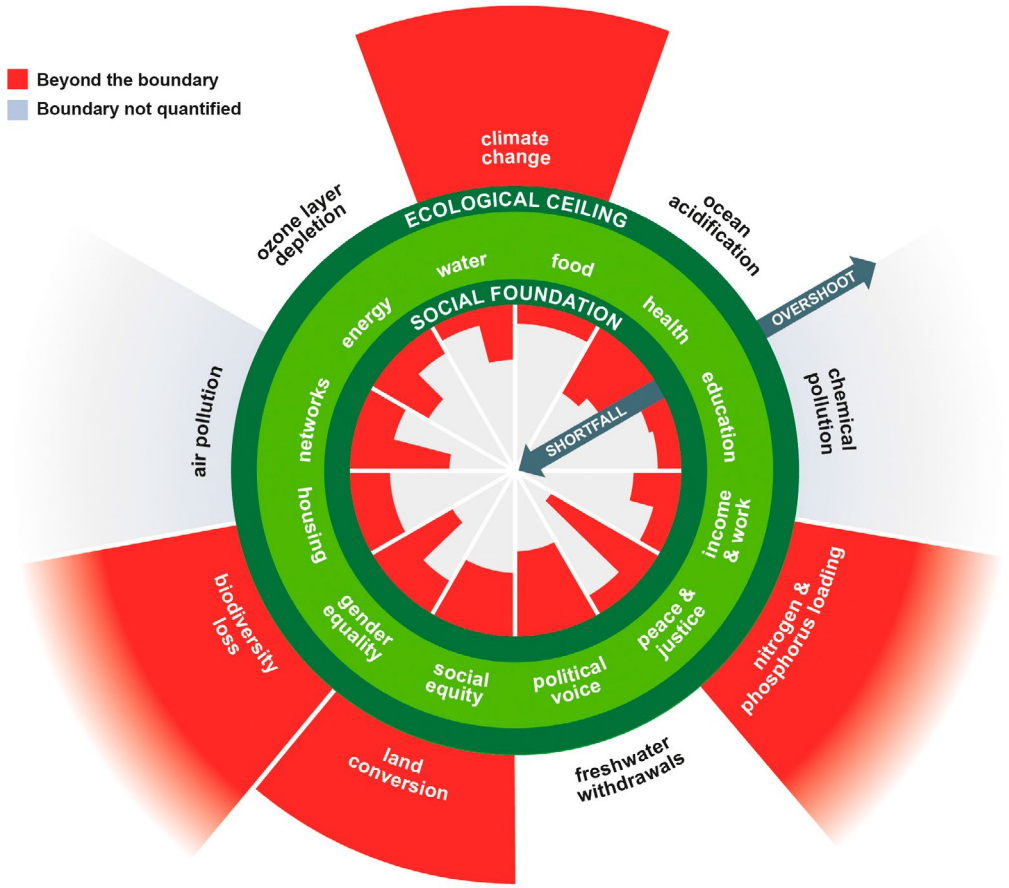


Figure 8: The doughnut of social and planetary boundaries by Kate Raworth

In this context, the projects presented in Chapter 2 and 3 can be seen in various combinations as mechanisms to determine contributory activity within planetary boundaries. These mechanisms would account for social requirements and ecological capacities and allow for context-specific sustainability. Simultaneously, they would inform a global layer of thresholds and allocations, by making the information concerning their sustainability

conditions universally available, while remaining locally binding. This necessitates that the relevant planning frameworks account for both mutual-coordination mechanisms and market mechanisms, eventually guiding the latter forms to shift towards the former; its feasibility will be based on the identified social needs. It nevertheless remains an agile, functional framework that would emerge from pluralistic mechanisms setting complementary and overlapping layers of biophysical rules, ideally set through participatory forms of governance.

The above framework is summarized in the figure below, in which some of the projects presented in the previous are placed. This integrates the various combinations operating on the three layers: a) mutual coordination of contributions; b) circulation and exchange of necessary resources; and c) planning frameworks indicating limits of use. The horizontal axis represents the tension between social and ecological capacities, which include, respectively, the available human and natural resources, and their relevant regulation. The vertical axis indicates positive contributions towards the top, and thresholds and allocations that are set in place to withhold negative implications to both the social and ecological sphere.

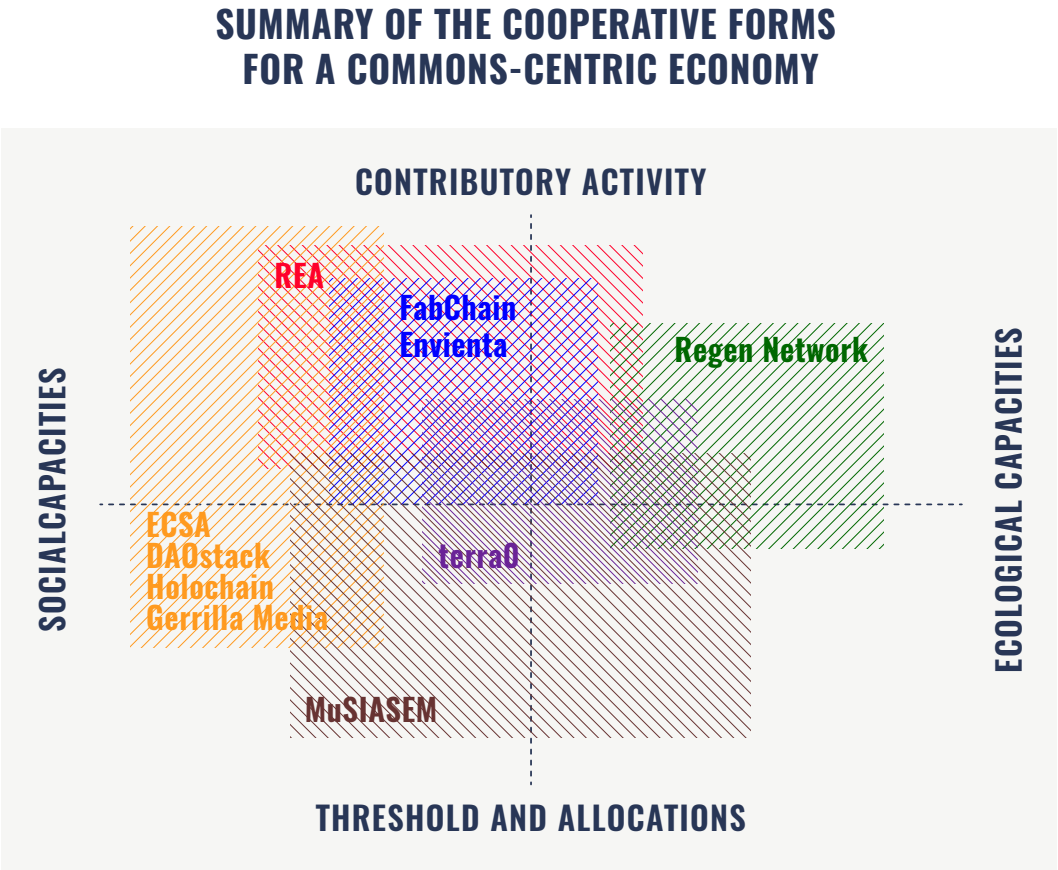


Figure 9: Contributory activity within social and ecological thresholds and allocations

Contributory activity may be relevant to both social and ecological capacities. For instance, ECSA DAOstack and Guerrilla Translation can stimulate contributory activity through P2P signaling and rewards systems, while allowing for a framework determining the lowest levels of necessary social work that needs to be allocated for the production of certain goods and services. Similarly, Regen Network can stimulate positive contributions to a certain ecological state of an ecosystem by rewarding regenerative activity, while designating a lower limit for the sustainability of the given state of the ecosystem. Simultaneously, FabChain and Envienta may coordinate the circulation of resources within and across ecosystems in order to cater for the necessary social needs, while encouraging positive ecological contributions through circular economy processes. Finally, the MuSIASEM framework can provide information on both social and environmental thresholds and thus guide contributory activity in the other layers.

Let's use an example to better explain the above relations. The French community land trust Terre des Liens[113] buys a piece of land to protect it from market speculation. They vest it in a trust and provide low-rent access for organic farmers through leases. The organic activity that takes place on this piece of land creates different types of positive externalities. For instance, the much lower (if not zero) use of pesticides contributes to the quality improvement of the local water horizon, which leads to lower depollution costs for the local public authorities and their water agencies. Simultaneously, it also incrementally benefits the health of the local population through the provision of organic food, thus reducing health-related costs in the long term.[114]

This means that both the state and the public are benefiting, but there is no mechanism to calculate the return, at least partially, of this investment. There are no financial means at hand to facilitate this transition towards more ecological and healthy models. Terre des Liens does not get rewarded for its generative activities and the positive externalities it creates, while the farmers and agribusiness that actively degenerate the quality of the soils and waters are rewarded by market income and state subsidies. There may be incentive mechanisms in place to motivate the adoption of less intensive and

113. https://terredeliens.org.
114. An example: Sole Food Street Farms (https://en.m.wikipedia.org/wiki/Sole_Food_Street_Farms; https://www.huffingtonpost.ca/2017/09/18/vancouvers-sole-food-street-farms-takes-on-poverty-with-urban-agriculture_a_23213211 'A 2013 MBA study done by a team at Queen's University determined that for every dollar paid to staff, there is a $2.25 savings to the health-care, social-assistance and prison and legal systems as well as the environment "

more environmentally-friendly farming techniques, but those mechanisms nonetheless fail to acknowledge and tackle the very foundations of an overall degenerative model of intensive agriculture. This is a clear illustration of the major weakness of the current system which rewards extractive activities, but not generative ones.

A potential solution can be provided by finance schemes, engaging stakeholders from state, private and civic entities, that acknowledge and reward these positive externalities. For instance, the official water agency, which can potentially save substantial funds from depollution expenditures, would agree to finance Terre de Liens, and any other actor achieving the same effects, in proportion to what it saves. Ecological State Protocols, based on the model of Regen Network, could be instituted to verify and log the ecological status of this particular piece of land and record its improvement. Positive results, such as lower carbon emissions, increased biodiversity, improved food quality, and higher degree of social inclusion through the provision of employment, could be coupled with the issuance of tokens. This way, a mechanism can be developed through which the verified savings of the agency could be used to buy-back the tokens, thereby initiating a virtuous cycle towards generative activity. We could call these sets of mechanisms "circular finance," as they reflect the necessary circularity of the physical economy.

Moreover, this scenario has arguably further advantages. It could be extended to an alternative scheme of competitive bidding for public procurement by the state agencies. For example, a general permissionless mechanism for regenerative contributions can be set up and guide multi-stakeholder forms of public-private and public-commons partnerships. This process can be further expanded to fund different forms of ecological and social outcomes. We are describing a mechanism that links permissionless contributions with income-generating market operations and which, instead of financializing nature, rewards regenerative work and contributions. It also provides a more integrated approach to replace or complement competitive bidding for narrowly-defined impact bonds, which may reduce certain externalities but create others, since competition on pricing by for-profit firms rewards those that succeed in externalizing other effects.

In conclusion, we have described here a new type of economy that is defined by:

1) an increasing importance of free (as in freedom) forms of mutual coordination mechanisms, enabled through shared infrastructures;

2) a sphere of circulation and exchange of matter and energy flows, informed by monetary signals which are connected to social and ecological constraints; and

3) a layer of planning frameworks determining biophysical thresholds and allocations.

It will perhaps be clear how this 'triarchy' also fits with our analysis of the forces at work in peer production, as well as our proposed model for a P2P society.

In short, the peer production communities practice contributory production through free mutual coordination. This illustrates a tentative social model where citizens participate freely in the commons of their choice as a means to build their identities, obtain recognition and participate in the efforts for the common good. In order to make a living from their contributions, peer producers, i.e., commoners, join an ethical and generative market sphere. In this sphere of the generative market, goods and services may be exchanged, but in a way that strengthens the commoners and their commons.

Finally, the 'commons of the commons' is the sphere of the common good proper, which requires the management and maintenance of all the common resources needed for societal life: this is the sphere of 'planning' and framework setting, in other words, here the broader rules and regulations are determined, so that the contributions and exchange can go on without upsetting the broader natural and social environment.

We move from a market society with a subservient state and weak and unproductive civil society (considered so because the non-market production of value remains unrecognized, i.e., the current Capital-State-Nation triarchy) to a new configuration where the commons of contributions is central, as a global interconnected network of productive and civic communities at various scales. This configuration is also surrounded and maintained by a regenerative market sphere. Finally, it is broadly regulated by a Partner State that enables personal and social autonomy while setting the boundaries in which free association can occur. This is achieved by protecting the limits needed for the common good of all humanity and other beings through a Commons - Generative Market - Partner State configuration.

This report has been a description of the kind of techno-social infrastructure that can facilitate this shift or transition.

Our contention is that many of the tools for setting up this configuration are already available or in the process of development and prototyping. However, in terms of a fully integrated ecosystem these attempts are currently fragmented and to a large extent still immature. On the positive side, the potential of the necessary technologies for more sustainable production has been identified and an increasing number of projects are investing in this direction. Even though there is a lack of alignment with regards to a shared socio-political vision, a few of the key actors are taking a more holistic view at the systemic level.

At any rate, we cannot of course suggest that the above framework is definitive or that it can include all the possible relevant scenarios in a vastly complex social and economic reality. It may, though, provide a useful basis for guiding technological design, especially in the domain of distributed ledgers and accounting tools. Furthermore, it may serve as the common ground to develop a more integrated vision to bring the various fragmented projects in alignment.

Acknowledgments

Dedicated to the memory of Robin Murray (1940-2017), Erik Olin Wright (1947-2019) and Bernard Lietaer (1942-2019). With gratitude for their engagement for the commons.

We are grateful to the people who actively engaged with the drafts of this report:

- James Gien Wong
- Alanna Irving
- Sharon Ede
- Matthew Slater
- Philippe Honigman
- Sarah Grace Manski
- Saraswathi Subbaraman
- Raji Ajwani
- George Anadiotis
- Moritz Bierling
- Stacco Troncoso

During the writing of this report, co-author Michel Bauwens was appointed as 'intellectual in residence' by the European 'labour mutual' SMart.coop. This support was important in creating the conditions for writing this report.

Finally, we are indebted Romy Krämer and Julia Gajewski (Guerrilla Foundation) Constanze Wehner (Schoepflin Foundation) and to Fiona Dove, (Transnational Institute) for working together with us to make this report possible.

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P2P Accounting for Planetary Survival

Towards a P2P Infrastructure for a Socially-Just Circular Society

How shared perma-circular supply chains, post-blockchain distributed ledgers, protocol cooperatives, and three new forms of post-capitalist accounting, could very well save the planet.

By **Michel Bauwens** and **Alex Pazaitis**

A joint publication between the P2P Foundation, Guerrilla Foundation and Schoepflin Foundation.

P2P Foundation · GUERRILLA FOUNDATION ACT. AFFECT. CHANGE · Schöpflin Stiftung