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Multiple Geographies of Commons-Based Peer Production

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Abstract

This article engages from a geographical perspective with commons-based peer production (CBPP), an emerging socio-economic activity based on sharing resources and outputs among individuals who collaborate in a non-hierarchical manner. CBPP was initially used to describe the intangible production of knowledge and information through online cooperation. More recently, this practice grew to include other sectors of production, like hardware development, manufacturing, or agriculture, and has spread in various geographical settings, connecting Global North and Global South, rural and urban places, and digital and physical collaborations. The combination of intangible and tangible production has been described through the concept of cosmolocalism and the principle of "design global, manufacture local," and has been analyzed through practices observed in communal spaces, like makerspaces. While CBPP has been discussed as a more sustainable and convivial mode of production in social science literature, the phenomenon remains under-researched from a geographical perspective. This article aims to contribute to the CBPP literature and current geographical debates by exploring this emerging activity from a geographical lens. By using "multiple geographies" as a methodological tool, we argue that geographical approaches can help CBPP engage more with the materiality of production, as well as identify, problematize, and potentially address power relations on multiple scales. Likewise, the CBPP literature can contribute to geographical literature that is concerned about practices for more liveable worlds.

Keywords

commons-based peer production; cosmolocalism; local manufacturing; multiple geographies

1. Introduction

This article addresses the emerging and growing phenomenon of commons-based peer production (CBPP). The development of the digital economy, initially with projects related to open-source software and collaborative content creation such as Wikipedia, Linux, or LibreOffice, allowed some of the most prominent examples of this new economic activity to emerge. CBPP is "based on sharing resources and outputs among widely distributed, loosely connected individuals who cooperate with each other without relying on either market signals or managerial commands" (Benkler, 2006, p. 60). This mode of production and valuation is considered to deviate from the current hegemonic mode of production and to demonstrate a new trajectory for economy and society (Bauwens et al., 2019) beyond the dichotomy of state and market. In recent decades, CBPP activities were catalyzed by the technological progress that made it possible for large networks to innovate and produce in a decentralized, collaborative way. Gradually, CBPP grew to include other sectors of production, like hardware development, manufacturing, and agriculture. CBPP seems to have the potential to radically transform our understanding of economy and economic relations, and shift our perceptions of value, motivation, and collaboration, leading to new perspectives within geographical literature, as well as spatial planning and policy making.

The CBPP literature has been growing in recent years, drawing interest from various disciplines, like organizational studies, economics, legal studies, and others. Nevertheless, it has gone almost unnoticed in the field of human geography, with only a few exceptions (see, for example, Gerhardt, 2019). We argue that in the light of the social, environmental, and economic problems related to how global production is currently organized (Brand & Wissen, 2021), the search for alternative modes of living, working, and producing together (and in relation to nature) is urgent, and these are actually being practiced more than one would expect. CBPP exemplifies a radically different understanding of economy, and its exploration by human geography is needed to both understand this emerging phenomenon and question to what extent it contributes to more just economic, social, and environmental futures. More specifically, we argue that rethinking CBPP from a geographical lens would benefit both discourses on alternative local futures from geography and on alternative economies from commons-perspectives. The CBPP literature can contribute to geographical literature that conceptualizes practices that can support more liveable worlds. In parallel, geographical approaches can help CBPP engage more with the multi-sited materiality of production as well as further identify, problematize, and potentially address power relations and knowledge dynamics on multiple scales.

This article aims to contribute to this mutual benefit, by (a) providing a glimpse of the literature of CBPP and underlying research gaps that a geographical analysis would potentially address; (b) connecting the main ideas and practices of CBPP with theories and concepts coming from human and economic geography, especially a "multiple geographies" perspective (Liodaki et al., 2024); and (c) presenting some initial lines of thought that come from the combination of those literatures and could potentially lead to pioneering future research. Overall, we argue that a spatial perspective is promising as digital and physical nodes of CBPP are interlinked through concrete places and communities (Schulz et al., 2020, p. 20). More specifically, by coupling the CBPP literature and practice with concerns derived from a "multiple geographies" perspective and the relevant strains of literature, we outline a framework for future research on CBPP that can shed more light on the spatiality and materiality of its relevant practices, its potential to strengthen place-based developmental logics, and its expansion to include more reproductive activities. This framework, although

not strictly bounded, contributes to the CBPP literature by highlighting trajectories for more just and sustainable developmental futures.

The remainder of this article is structured as follows. In Section 2, we present a non-exhaustive literature review on CBPP and related concepts that are important for a geographical perspective on it. In Section 3, we briefly present the multiple geographies perspective and show how we use it as a methodological tool to rethink CBPP from a geographical perspective. In Section 4, we present our main strains of thought as a result of the combination of CBPP and geographical literatures, using concepts and theories as well as secondary literature on prominent and concrete cases of CBPP practice. Finally, in Section 5, we discuss some main contributions and conclusions.

2. CBPP: A Critical Literature Review

The purpose of this section is not to provide a systematic literature review that maps the entire field of research on CBPP (for this, see Bollier & Helfrich, 2012, 2015; Broumas, 2017; Kostakis et al., 2021; Morell et al., 2016; Papadimitropoulos, 2020) but instead to identify some of the most significant issues in the field. This section draws on key strands of the existing literature to highlight issues related to the diverse geographies of socio-economic practices within this field. These issues will be coupled with a "multiple geographies" perspective to explore the complex interrelations between the material and immaterial spatialities of CBPP, and the power relations that unfold across various scales—global and local, rural and urban, central and peripheral, digital and physical—in the sections that follow. This section specifically aims to identify core features of CBPP and assist geographers in understanding its spatial dynamics. It puts forth a reconceptualization of key terms such as innovation, the commons, and both material and immaterial production. In doing so, we contrast mainstream approaches to innovation with the notion of convivial innovation (Robra et al., 2023) as expressed in the economic and social practices of user communities engaged in commons-oriented production. Finally, we illustrate how convivial innovation is embodied in the framework of cosmolocalism, which links material and immaterial production through digital commons, 3D printing technologies, open-source hardware, computer numerical control (CNC) machines, and other shared technologies. These tools are typically utilized in open co-working spaces such as Fab Labs and makerspaces, fostering diverse economies driven by open innovation communities.

2.1. Rethinking Innovation Beyond Organizational Boundaries

To present the main ideas around CBPP, we take the concept of innovation as a starting point. This concept has most often been related to the work of Schumpeter (1934), who conceived of it as the motor of capitalism. Innovation is a dynamic process of "creative destruction" driven by technological change and competition among entrepreneurs and firms, leading to business cycles that help capitalism to progress to the next evolutionary stage. Schumpeter (1934, p. 65) placed producers (entrepreneurs and firms) at the center of innovation, enabled by intellectual property rights, centralized product design, and technologies of mass production. Until the late 1980s, much innovation-related research was similarly based on firms as the central unit of analysis, in which new economic ideas and knowledge were to be created. Since then, many scholars and practitioners have acknowledged influences from external sources, exploring innovation that does not necessarily develop through the closed model of the enterprise innovating within its R&D department.

Moreover, recent decades have witnessed a paradigm shift in market economies, driven mainly by low-cost information and communication technologies (ICTs), leading to effects such as cost reduction, decentralization, modularity, and openness (Bauwens et al., 2019). This shift is coupled with sustainability transitions (Markard et al., 2012; Ostrom, 1990) and the rise of the prosumer (Toffler, 1980) that have disrupted centralized capitalist production by introducing peer production as an alternative organizational model anchored in the decentralized collaboration of peers on the internet and beyond. In organizational studies, we can see differences between the "private investment" model of innovation, that assumes returns on investment in the production of private goods protected by intellectual property rights, and the "collective action" model that assumes the collaboration of innovators to produce a public good in cases of market failure (Benkler, 2006; von Hippel & von Krogh, 2003). Several authors (Bauwens et al., 2019; Benkler, 2006; von Hippel & von Krogh, 2003) have described a hybrid model of peer production that combines elements of the private investment model and the collective action model, as evidenced in the cases of Google, IBM, and Microsoft heavily investing in open-source software production.

The literature (Bauwens et al., 2019; Morell & Espelt, 2018; Scholz, 2016; von Hippel & von Krogh, 2003; Wolf & Troxler, 2016) has thus far documented two main streams of peer production: (a) firm-hosted peer production, related to the term "platform capitalism" (Srnicek, 2017); and (b) CBPP. Whereas firm-hosted peer production is grounded in a techno-deterministic, productivist, centralized, and profit-driven model of economic growth, enclosing and privatizing knowledge, CBPP promotes beyond-growth models of convivial innovation. The concept of conviviality (see Illich, 2001) has previously been used to describe the aspects of sustainable technology (Vetter, 2018) and innovation (Pansera & Fressoli, 2021). Post-growth models question the necessity of continued economic growth for prosperity, without directly signifying negative economic growth per se. Conviviality thus translates into use-value creation, openness, sharing, solidarity, cooperation, self-governance, equitable value distribution, and sustainability. CBPP introduces alternative forms of ownership and governance to promote sustainability and empower individuals and communities against pervasive economic inequalities and power asymmetries (Bauwens et al., 2019; Benkler, 2006; Scholz, 2016). While firm-hosted peer production is hierarchical, extractive, closed, and proprietary, CBPP is conceptualized as collaborative problem-solving rooted in openness, accessibility, and sharing cultures. These changes are increasingly reflected in enterprise practices, where firms adopt open innovation strategies and source knowledge from external actors—signaling a shift toward translocal collaboration over competition.

Moreover, the concept of open innovation has been applied to explore how peripheral regions might leverage translocal knowledge partnerships to sustain competitiveness in a global economy (Vonnahme & Lang, 2019, 2021). As Benkler (2017, p. 266) argues, innovation is inherently "a collective, not individual process"—one that "depends crucially on communication" and unfolds through social interaction, making it "sticky, local, and social." Despite the conceptual potential of the open innovation paradigm, much of the related geographical scholarship continues to frame collaborative practices narrowly within a firm-centric perspective. Methodologically, many studies still privilege the single enterprise, asking how firms can extract value from mass collaboration, rather than exploring how such collaboration might give rise to alternative, more equitable modes of economic organization. Collaboration is often instrumentalized to enhance firm competitiveness, rather than being seen as a foundational principle for reimagining the economy along more cooperative and distributive lines (Sattler, 2024). Furthermore, the concept of "open innovation" may obscure underlying asymmetries of power and value capture. As Rikap and Lundvall (2022) argue, the

current landscape increasingly reflects a form of "knowledge predation," where large technology corporations convert open knowledge sourcing into mechanisms for accumulating intellectual rents and consolidating monopolistic control.

2.2. Peer Production and the Commons

CBPP blends peer production with the concept of the commons. The commons refers to distributed or shared resources and infrastructures—such as natural resources, technology, knowledge, capital, and culture—self-governed by user communities according to shared rules or norms (Bollier & Helfrich, 2012; Ostrom, 1990). As such, commons are composed of bridging elements, like a shared resource, but also a community and a commoning activity (Bollier & Helfrich, 2015; De Angelis, 2017). Over recent decades, the concept has been widely applied across disciplines, including economics, political science, and geography. As Clement et al. (2019, p. 7) note, "early commons studies have explored the ability of communities to collectively manage natural resources in a sustainable manner." Ostrom's (1990) foundational work examined numerous successful examples of collective resource management—such as forests, fisheries, and irrigation systems—highlighting how communities address environmental scarcity and degradation while supporting local livelihoods (Clement et al., 2019). Scholars have increasingly focused on the social relations related to the commons, analyzing the networks and forms of governance of the commoners (Bollier & Helfrich, 2015; Federici, 2018) and underscoring their transformative political potential (Azzellini, 2018; De Angelis, 2017).

While Ostrom's work on the commons was initially intended to illustrate the self-governance of natural resources, Benkler also mobilized the concept to describe the self-governance of knowledge creation. The results of those activities are usually used according to an open-access logic: Products are common resources that favor reproducibility and derivativeness (Morell et al., 2016, p. 28). Like the innovation communities literature, CBPP embraces the predominance of social motivations rather than monetary incentives, but moreover recognizes the centrality of the commons rather than private property, and considers alternative organizational forms (networks, communities) as equally important and valid as the predominant centrality of firms in much economic theorizing (Benkler, 2017). In this line of thought, the commons often signify an alternative property rights structure, distinct from market-based systems, emphasizing decentralized governance, non-monetary motivations, and a hybrid form of organization between the state and the market (Benkler, 2017).

CBPP has been defined as "a new modality of organizing production: radically decentralized, collaborative, and nonproprietary; based on sharing resources and outputs among widely distributed, loosely connected individuals who cooperate with each other without relying on either market signals or managerial commands" (Benkler, 2006, p. 60). Over the past decades, largely unnoticed by the general public, this mode of knowledge creation and interconnected production has spread and thrived. As Benkler (2017, p. 267) further explains, "peer production combines three core characteristics: (a) decentralization of conception and execution of problems and solutions, (b) harnessing diverse motivations, and (c) separation of governance and management from property and contract." The practices of CBPP are carried out by individuals connected through peer-to-peer networks, operating outside the traditional hierarchical and contractual frameworks of the market.

Initially, CBPP emerged in the digital economy, exemplified by open-source software and collaborative platforms like Wikipedia, OpenStreetMap, Linux, and LibreOffice. Benkler specifically draws on the work of the sociologist Manuel Castells to connect the emergence of CBPP with the development of a networked information economy. The most prominent examples of CBPP have been information-sharing ventures, forms of online entrepreneurialism, and open-source activism. As Benkler argues, CBPP can flourish in a digital environment that has low costs of reproduction, decentralized human–computer interaction, and low communication costs (Papadimitropoulos, 2018, p. 840). Some scholars, however, argue that early CBPP scholarship focused too narrowly on digital commons and immaterial production, thus neglecting the material dimension of the commons (Papadimitropoulos, 2018). For CBPP to serve as a foundation for a broader economic model, it must also encompass material production. Therefore, it is an open question how "the immaterial production of the digital commons can replicate into material production" (Papadimitropoulos, 2018, p. 832).

2.3. Cosmolocalism, a Partner State, and Diverse Economies

The potential merge of the digital commons with material production aligns with Manzini's (2015) notion of "cosmopolitan localism" or "cosmolocalism," which advocates for locally grounded systems that remain intelligible and controllable by communities, while also drawing upon global flows of knowledge and innovation. Manzini envisions a distributed production paradigm where a network of interconnected local initiatives balances autonomy with interdependence. Within these networks, the exchange extends beyond technical knowledge to include cultural values and social practices. As such, the cosmolocal model promotes principles of open collaboration, ecological stewardship, and decentralized innovation, advancing CBPP as a framework for both sustainable production and democratic participation.

The monolithic emphasis on online services within open innovation communities and CBPP is increasingly being challenged by the concept of "design global, manufacture local." This approach bridges the gap between immaterial and material production in CBPP frameworks (Kostakis et al., 2016). It aligns with broader scholarly interest in collective and collaborative production and consumption practices (e.g., Buxbaum-Conradi, 2024, on the Fab City movement). The push to incorporate materiality is not merely theoretical; it also reflects practical trends in applying CBPP principles to domains such as wind turbine development and agricultural technologies (Robra et al., 2023). This shift toward a production-oriented model is sometimes discussed under the term "open production," signaling a broader scope than the traditional open-source software movement. As Kostakis et al. (2015) argue, commons-oriented communities ideally operate at the intersection of local embedding and global connectivity. Understanding the complex dynamics between globally distributed open design and locally embedded manufacturing is therefore essential to fully grasp the evolving landscape of CBPP.

Concerning this shift, scholars have emphasized the need to better understand the relationship between CBPP, the market, and the state, while much attention has been given to the political and legal dimensions of the commons. Kostakis and Bauwens (2014), for instance, propose a transition toward a peer-to-peer mode of production in which the state plays a proactive role by establishing foundational infrastructures to support this transformation. They advocate for a "partner state" that facilitates CBPP through public funding, legal frameworks, educational programs, and technological infrastructure. On the other hand, De Angelis (2017), while recognizing the potential for strategic collaboration with various actors, including the state,

when such engagement serves the broader goal of contributing to the commonwealth, envisions CBPP as part of a post-capitalist trajectory that seeks greater autonomy from both state and market institutions. Further, CBPP as an emerging mode of production can be understood through the lens of diverse economies. This approach reframes the economy not as a system limited to markets, commodities, and for-profit enterprises, but as a heterogeneous terrain composed of forms of labor (e.g., informal or unpaid work), enterprise (e.g., cooperatives, community businesses), property (e.g., commons), transactions (e.g., gifts), and finance (e.g., interest-free loans; Gibson-Graham & Dombroski, 2020). Crucially, the diverse economies framework recognizes that all wealth creation ultimately depends on the labor-mediated appropriation of nature to meet human needs, wants, and desires. It not only highlights the co-existence of a wide range of economic practices—formal and informal, paid and unpaid, capitalist and non-capitalist—but also offers analytical tools to explore how these practices interact and shape one another (Smith & Stenning, 2006). This multiplicity and "messiness" of economic interactions leads to what Naylor (2022) conceptualizes as "multiple developments," acknowledging that economic change does not follow a singular or linear path.

2.4. Open-Source Hardware, Makerspaces, and Material Production

In recent years, the scope of CBPP has expanded beyond the digital domain, increasingly encompassing physical production. The expiration of key 3D printing patents, coupled with advances in CNC machines, microprocessors, and sensors, has expanded the scope of open-source software into hardware. Following the copyleft logic of open-source software (Gay, 2002), open-source hardware production is built on the legal premise that designs, assembly instructions, and bills of material are made publicly available for anyone to study, replicate, modify, and sell, including the hardware created (Thomas, 2019, pp. 35–36). The term "hardware" applies to any type of tangible artifact, for instance, whether electronic, mechanical, or textile. Additive manufacturing technologies programmed with open code interconnect the production of intangible goods, such as designs, information, and knowledge, with tangible goods such as agricultural tools, windmills, and prosthetics (Bonvoisin et al., 2021). Arduino, for instance, applied open collaboration and shared knowledge principles to the development of physical hardware (Ramos, 2021). Other initiatives have emerged across sectors such as agriculture—e.g., Bioleft, the Open Source Seed Initiative, and L'Atelier Paysan—and manufacturing—e.g., OpenBike, Tzoumakers, Enspiral, and Las Indias. Some of these ventures reflect broader systemic efforts: The Open Source Pharma movement, for example, aims to transform drug discovery and development into a more collaborative, transparent, and socially oriented process. Its mission is to provide affordable, accessible medicines through commons-based innovation rather than profit-driven models.

A key aspect of tangible CBPP is the material space where collaborative production occurs. To support this, communities have established makerspaces—publicly accessible workshops equipped with digital fabrication tools like 3D printers and CNC machines. Makerspaces can potentially promote alternative economic models and foster community engagement (Liodaki, 2024a, 2024b; Simons et al., 2016). Rooted in CBPP principles, they emphasize shared resources, open access to tools and knowledge, and a "do-it-together" ethos that blurs the line between producer and consumer. By enabling encounters among people from diverse backgrounds, makerspaces become hubs of inclusion, sustainability, and creative autonomy (see also Moritz et al., 2024). They challenge traditional production models by democratizing access to industrial technologies, supporting global design and local manufacturing (Kostakis et al., 2015), and advancing sustainability through localized, collaborative innovation. Makerspaces variously aim to contribute to

ecological sustainability by reducing transportation and related carbon footprints, encouraging reuse, customization, and knowledge sharing, extending product lifespans, reducing waste, and supporting a circular economy overall. A sustainability index has already been developed in recent research, including a Digital Product Passport for hardware (Roio et al., 2024; Santander et al., 2020). However, while the marginal cost of producing one unit in software nears zero, hardware incurs multiple costs (materials, machines, personnel, overheads, physical space, energy). Open-source hardware production may also include long and often-intertwined supply chains and sophisticated product certification (Thomas, 2019, p. 105). Therefore, open-source hardware production is more costly and complex compared to open-source software production.

Beyond enabling sustainable and decentralized production, makerspaces have also emerged as educational hubs that promote lifelong learning and informal skill-building. Emphasizing knowledge as a shared resource, these spaces reflect CBPP principles by facilitating open access to tools and learning opportunities. Most are organized as associations or public entities with minimal profit orientation, allowing them to prioritize community access and collective ownership over revenue generation (Kurzeja et al., 2021). Their reliance on open-source software and hardware further supports inclusivity and aligns with CBPP's commitment to the free exchange of knowledge. As counterspaces to dominant, profit-driven production models, makerspaces foster environments that emphasize use value over exchange value, quality over quantity, and diversity over uniformity (Liodaki, 2024a; Nicolosi, 2020), while connecting with like-minded alternative initiatives at local and non-local levels (Liodaki & Stockdale, 2025). By supporting local, small-scale manufacturing, they aim to produce sustainable alternatives to mass production while embodying the collaborative ethos of CBPP.

The literature (Morell & Espelt, 2018; Thomas, 2019; Wolf & Troxler, 2016) has thus far documented a diversity of open-source hardware business models featuring a wide spectrum of value propositions, revenue streams, stakeholder interactions, incentives, and licenses. Stakeholders interacting with Fab Labs/makerspaces may include universities, students, firms, experts and freelancers. Incentives may vary considerably, from generating income or building human capital to the joy of participating in a common cause, altruism, peer-to-peer learning, sharing, socializing, and so on. Thomas (2019) has identified different logics for open-source hardware production, including the community level that corresponds to communities that manufacture products from the bottom-up (e.g., Farm Hack, L' Atelier Paysan), the inter-organizational level that corresponds to firms collaborating with communities (e.g., Renault, Volkswagen, Kreatize), and the ecosystem level that corresponds to all stakeholder interactions including the state, municipalities, universities, organizations, and start-ups. The Maker Movement has shifted from a DIY-bricolage phenomenon to a global ecosystem with thousands of spaces (Fab Labs, makerspaces, and open workshops) spread across more than 100 countries (Diez et al., 2018; R. Mies et al., 2024; Moritz et al., 2024).

Eventually, CBPP, both in its immaterial and material dimensions, provides unique opportunities for many-to-many innovation and the development of a more ethical, sustainable, and inclusive economy. At the same time, CBPP is rife with numerous tensions, contradictions, and obstacles, such as the "tragedy" of the (digital) commons (Hardin, 1968; Sharma, 2023), capitalist cooptation (Birkinbine, 2020; Kostakis & Bauwens, 2014), asymmetric competition versus incumbents, volunteerism and precariousness, hidden hierarchies and patriarchy, a lack of funding, a lack of sustainable business models, a lack of relevant cultural and institutional contexts, a lack of proper branding and marketing, a lack of well-designed incentive mechanisms and protective licenses, and so on (Papadimitropoulos, 2020, 2022). Given these complexities,

as well as the multiple potentials of CBPP and the implications this emerging mode of production may have in spatial planning and policy making, a more nuanced geographical perspective is needed to critically assess the strengths and limitations of CBPP and to explore its future potential.

3. A Geographical Perspective as a Methodological Tool

As stated in the introduction of this article, CBPP has so far not attracted much attention from geographers (cf. Gerhardt, 2019). However, geographers have a longstanding interest in researching alternatives to capitalist organizing and development from a spatial perspective. Following the non-exhaustive literature review above, in which we attempted to address some main topics regarding CBPP, we now outline our methodological insights in order to make a geographical perspective to CBPP fruitful. More specifically, in order to rethink CBPP from a geographical lens, we will further conceptualize it using the multiple geographies perspective (Liodaki et al., 2024). The term "multiple geographies" has gained increasing attention in recent decades. It reflects a growing recognition that space is not homogenous, bounded, or uniform, but encompasses multiple layers of meaning, power dynamics, and social constructions embedded in historically and geographically specific sociospatial and ecological configurations (Chhabria, 2019; Dionisio & Carr, 2022; Kabachnik et al., 2014; Papatzani et al., 2022; Toly et al., 2012; Van Sant et al., 2023). Recent research (Liodaki et al., 2024) shows that this approach is strongly embedded in ongoing debates within political, urban, postcolonial, and feminist geographies that aim to advance a radically different perception of the production of space. This perception may equip geographers to better understand how contemporary crises, such as rising economic and housing inequality, climate change, social injustices, neocolonial exploitation, and war, are deeply intertwined with sociospatial dynamics and manifest unevenly across different spatial contexts. This article is an attempt to use the theoretical underpinnings of "multiple geographies" as a methodological framework for further research, in order to deepen understandings of CBPP and highlight under-researched topics related to it.

More specifically, a multiple geographies theoretical approach follows a threefold conceptual underpinning: (a) paying attention to the multiple exclusions of the Global South (as key ventures and relationally connected sites) while bringing to light alternative visions of the world and subaltern practices that challenge the singularity of the one-truth Western narrative and embrace pluriversal thinking; (b) intersecting with theories of uneven geographical development and highlighting how spatially uneven processes give rise to a multiplicity of experiences or—in other instances—how the multiple geographies of specific processes result in spatially uneven outcomes; (c) engaging with feminist and intersectional literatures to demonstrate how various social groups and individuals, with diverse identities, navigate multiple socio-spatial exclusions and express a spectrum of experiences within space. Overall, following these three theoretical strains in human geography, without overlooking their overlaps and tensions, a multiple geographies approach: denotes plurality, illustrating the coexistence of diverse worlds; signifies unevenness, elucidating the power dynamics and conflicts among different places within economy; and connotes diversity, emphasizing the varied spatial experiences among different social groups and the emergence of counter-examples and counter-practices in the here and now.

A multiple geographies perspective can recalibrate the question of how to study the impacts of CBPP economic activities. We assume that CBPP has implications both on the local level of survival (e.g., for its contributors and their communities) as well as for a wide range of users, places, and communities. Given the

assumed, spatial non-boundedness of CBPP activity, it is mandatory to view this process as occurring unevenly throughout space, creating synergies, conflicts, and collaborations in a plethora of places. The proposed conceptual framework sees socioeconomic activity as a spectrum of diversity, and it allows us to ask which role "place" plays in CBPP-related practices. Overall, we assume that a reconceptualization of CBPP following a multiple geographies framework brings the question of space into the relevant discussions and sees CBPP practices as activities coexisting with a multitude of actors in a multitude of sites that affect their implementation. More specifically, in the following section, we attempt to rethink CBPP by analyzing it anew using literature from the three theoretical strains of human geography proposed in the "multiple geographies" theoretical framework: post-colonial, uneven development, and feminist geographical thought. We thus outline three subsections that aim to address some leading arguments that emerge from the relevant literature and CBPP scholarship and practice. Unraveling this geographical multiplicity of CBPP can contribute to a deeper understanding of this emerging phenomenon and its potential to transform the economic relations of our time, while opening up questions and directions for future research.

4. Three Insights for the Multiple Geographies of CBPP

In this section, we present our conceptual suggestions and avenues for future inquiry based on our effort to combine the insights from multiple geographies with CBPP. We highlight three insights from this engagement, shedding light on major geographical issues that emerge from the literature. More specifically, the three strains of geographical literature highlighted in the multiple geographies framework have unraveled some basic pathways for rethinking CBPP as a practice that can expand the relevant literature. In the three following sub-sections, we show how post-colonial, uneven development, and feminist geographical concerns can fuel CBPP thought and further deepen its endeavors, while renewing geographical thought with new empirical insights. These pathways, although inspired by empirical insights documented in the CBPP literature, illustrate potential directions for further research that can bridge the multiple geographies framework and CBPP practice.

4.1. Spatiality and Materiality of Production in CBPP

The first concern for a multiple geographies perspective on CBPP would be the issue of the underrepresentation of the Global South in CBPP-related research so far, despite recognition in the literature that the Global South has a paramount role to play. We start with the observation that most cases in the CBPP literature are derived from the Global North, with only a few cases emerging in the Global South, such as Bioleft, an open-source seeds initiative—similar to other initiatives in the Global North (Louwaars, 2019)—which collaboratively develops and distributes seeds within community networks in Latin America (Cremaschi & van Zwanenberg, 2020). Even within allegedly global initiatives such as Wikipedia, many groups and especially the Global South remain underrepresented (Graham et al., 2014). Despite the aspirations for global design and local manufacturing, it seems that within the documented and analyzed examples of CBPP, both design and manufacturing primarily take place in the Global North. One option, therefore, is to put more energy into identifying hitherto unknown or emerging instances of CBPP without problematizing its current conceptualization. This approach might bring similar ventures, such as Bioleft, to the fore.

In parallel, multiple developments across diverse places are also related to the spatiality and materiality of production that so far have not been sufficiently addressed in literature. Generally, we argue that CBPP can

benefit from a more geographically informed vision around the spatiality and materiality of both knowledge and physical production. CBPP literature has problematized the assumption that global knowledge flows can be understood as entirely immaterial, while only local manufacturing relates to material production. Instead, it recognizes that this understanding vastly underestimates the materiality of global knowledge flows and the digital economy in general (Kostakis et al., 2016). Nevertheless, issues of multiple developments are also related to the multiplicity of production places in "local manufacturing."

We will briefly illustrate our reasoning in relation to Arduino, an open-source venture whose main products are boards for electronic devices. Arduino has thrived on the contributions of a global community of enthusiasts, developers, and hobbyists (Pearce, 2012). While its knowledge dimension thus subscribes to the premises of global design, it is debatable whether its production can indeed be called "localized" and whether its effects on reproduction can also primarily be grasped at the local level. The majority of Arduino boards are assembled in Italy by Arduino's partner, Alba PCB Group. Only a small portion of boards are produced in makerspaces or other places. Wherever and however the boards are assembled "locally" (whether in a for-profit company or convivially in a makerspace), we want to emphasize that such boards transcend such local socio-material relations. A board can also be conceived as the sum of its constituent parts, embedded in specific labor processes and places elsewhere.

We know from other literature that electronic boards more generally rely on components sourced from various global locations, often with questionable labor conditions and social and environmental impacts (Clément et al., 2020; Moreau et al., 2021). Recent studies stress the importance of questioning where the metals and minerals for high-tech artefacts come from, and the implications for labor and the environment these have (Sovacool, 2019). Kostakis et al. (2023) propose a new category for technological artefacts that may offer more effective solutions, combining the low-tech—which tend to be cheap and easy to deploy—with the high-tech. They call this in-between zone "mid-tech," aiming to contribute to socio-technical imaginaries of the future and overcome the issues of geographical unevenness that arise from romanticizing high-tech solutions (Bihouix, 2020; Vetter, 2018).

Focusing on the spatiality and materiality of production, including its ramifications for people and planet, helps to address the variegated effects of CBPP on different places and communities. In the literature, we identify a debate around whether CBPP initiatives should be seen as embedded in the cycle of the market or the cycle of the commons (which is assumed to conflict with the market and capital). According to Bauwens in his interview with Gerhardt (2019, p.6), CBPP "has to be associated with value realisation and distribution. If you can't make a living and reproduce yourself, if you cannot produce the products and services needed for maintaining human communities, it is not yet a mode of production." An interesting concept that aims to resolve this tension is that of "transvestment," describing the process of taking funds from the cycle of the market and investing them into the cycle of the commons. To better understand the potential of transvestment, Bauwens himself suggests looking into geographical concepts, such as the new nomadism of the digital knowledge class. Future studies should look into the old and new supply chains and networks that manage to do more with less, following a cosmolocal model, which will be particularly relevant in the current polycrisis. However, it is also particularly insightful to rethink the spatiality of transvestments, exploring where the transvestments take place in particular and with what kind of effects.

4.2. Place and (Place-Based) Development in CBPP

We argue that the CBPP literature can benefit from a more fine-grained engagement with the concept of place, understood here as open to flows of ideas, beings, and objects (Massey, 1994), to assess its developmental implications. We assume that CBPP-induced activities have implications both on the local level of survival (e.g., for its contributors and their communities) as well as for a wide range of users, places, and communities. A geographically informed perspective can highlight nodes in the respective networks of CBPP ventures that are so far only partially illuminated, precisely because conventional economics—but also existing conceptualizations of CBPP—have rendered them outside the purview of "economic" analysis. This crucially relates to how the interplay of material and immaterial production affects not only the contributors themselves, but a wide range of relationally connected actors, ranging from suppliers, households, and nature as the basis of creating wealth, to broader communities of users, consumers, and prosumers.

Given the assumed spatial non-boundedness of the production activity, it is mandatory to view this process as occurring unevenly throughout space, creating synergies, conflicts, and collaborations in a plethora of places. A more geographically informed framework of CBPP sees economic activity in a spectrum of diversity and can potentially provide us with more insights about the motivations and collaborations of CBPP participants, the diversity of labor practices, the reasons people engage in CBPP projects without or beyond monetary motivations, and the role of the broader community in that process. Thus, it allows us to ask which role "place" plays in CBPP. Place is not peripheral to the discussion of what "surviving well together" entails, and how to satisfy social needs, but one of its preconditions. Place thus emerges as an alternative approach to tackle questions of survival and sustainability by weaving together prior forms of displacements, misplacements, replacements, and, analytically most important, emplacements (Barron et al., 2020). Emplacements here are understood as transformational processes through which survival can be re-organized to make places more survivable for the (more-than-human) communities that inhabit them. By positioning places center stage, CBPP can examine and tackle problematic and historically concrete forms of dis-, mis-, and replacements (of people, animals, plants, objects) that hinder the satisfaction of needs for current and future generations.

Moreover, as diverse economic practices interact with each other (Smith & Stenning, 2006), the CBPP literature could also shed more light on the variegated effects of its activities, e.g., if open-source hardware is assembled at a particular location, can we confine our analysis to the assembly place? Do we need to take into account the places in which sourcing of inputs occurs? How does CBPP affect places and cultures of consumption? Does interlinked re/production address problematic forms of dis- and misplacements in the respective nodes through forms of re- and emplacement, and if yes, how so? Such questions have the function of transcending a predominant and simplifying "universal development" versus "pluriversal alternatives to development" debate or ideal types of production modes such as "capitalist production" versus "commons-based peer production." The multiplicity and messiness of interacting economic practices can rather lead to a conceptualization of "multiple developments" (Naylor, 2022), potentially grounding CBPP more in its everyday messy entanglements in and between place, rather than as a normative foundation for an alternative mode of production. We draw on the emerging multiple geographies approach, also inspired by diverse economies thinking, because it allows us to better think through the multiplicity of economic activities and the multiplicity of places implicated in economic activities.

4.3. What "Production" in Commons-Based Peer Production?

Finally, we attempt to rethink the concept of "production" in CBPP. By referring to the multiple geographies literature, we highlight how the dominant conceptualizations of production erase under-the-radar and invisibilized economic practices. To further integrate them into an analysis of CBPP has the potential to enlarge the phenomenon and make more visible contributions by subaltern actors, including actors from the Global South. We argue that the CBPP literature can benefit from this more feminist and postcolonial way of conceptualizing production. This can make possible a more cosmopolitan perspective in knowledge production that not only includes cases from the Global South but also destabilizes potential productivist epistemologies in CBPP.

Feminist geographers who inspired the multiple geographies approach can help to articulate the need to rethink production. By challenging the prevalent technology-centered production-centrism based on goods and services, feminist scholars highlight the crucial role of social reproduction as the condition of possibility for production. Reproduction is typically associated with feminized labor (e.g., care and emotional labor sustaining social ties) as the precondition of both more "productive" labor (Federici, 2004) and the production of life (M. Mies, 2014). This way of conceptualizing production—by asking questions about labor—has only begun to emerge within CBPP literatures (Deka, 2021; Schneider, 2022; Toupin, 2021). Developing it further requires more theoretical and empirical efforts. We argue for the need to also challenge the clear-cut distinction between production on the one hand, and reproduction on the other. Only in a capitalocentric reading, in which capitalism defines what is "normal," is it possible to define "the household as the space of 'consumption' (of capitalist commodities) and of 'reproduction' (of the capitalist workforce) rather than as a space of noncapitalist production and consumption" (Gibson-Graham, 2006, p. 8).

The same is true for all kinds of subsistence economies that feminist scholars associate with the production—and continuous reproduction—of life (M. Mies, 2014; Salleh, 2010). Especially in the (semi-subsistence) agricultural realm, collaborative, commons-based practices are well attested to in the Global South (Berkes & Davidson-Hunt, 2010; Cima, 2020). Reproduction, therefore, often comes with "productive" connotations (although such use values might not be traded or consumed by others, much in line with how CBPP connects to debates of prosumption). Production, too, has clear references to reproduction: of capitalist class relations; of households, including children; of nature through the labor process (Foster, 2000). Therefore, we propose that a multiple geographies-informed research agenda might more readily circumscribe its phenomenon as commons-based peer re/production, in which the emphasis is expanded to grasp the substance of "re/production" through an investigation of labor.

This reconstructed framework of commons-based peer re/production comes with a twofold contribution to CBPP literature. First, it extends potential cases in the Global South and the Global North, in which a variety of commons-based re/production processes are occurring in the here and now, but perhaps not in areas such as open-source hardware (Toupin, 2021). So far, many CBPP-aligned practices have fallen under the radar due to (often implicit) ways of theorizing production as related to manufacturing goods and services, but not necessarily to the re/production of life. Second, through a problematization of the "labor" underpinning re/production, it becomes possible to ask critical questions regarding the working conditions of contributors to CBPP, which so far are poorly investigated (cf. Bauwens & Niaros, 2017, for an exception). This also includes examining the so-far invisibilized emotional and care activities within such communities.

We would explicitly add consideration of the wider households and communities that sustain them to the analysis of contributors' re/production. Contributors need time, energy, and support to participate in CBPP. What is the role of reproductive labor by others (household and beyond) in this? Especially for pivotal CBPP cases such as Linux, whose contributors are predominantly men (Grzegorzewska, 2021), such analyses are so far relatively absent. Conversely, there is an understanding why women are underrepresented, including "increased caring responsibilities, which often limit the time they can spend on other paid and unpaid activities, including getting involved in open source communities" (Grzegorzewska, 2021).

5. Discussion

This article explores the intersections between CBPP and geographical thought, emphasizing how a geographical lens can provide critical insights into fostering productive localisms. CBPP, with its emphasis on shared resources, decentralized production, and collaborative networks, offers an alternative to traditional, centralized economic models that prioritize global efficiency and private ownership over local resilience and equity. CBPP should be more closely researched in relation to space and planning, as it has the potential to foster local economic development, reduce reliance on long-distance supply chains, and promote environmentally sustainable practices by maximizing the use of local resources.

As illustrated in Figure 1, by engaging with a multiple geographies perspective, we have highlighted the potential of CBPP to challenge conventional dualisms such as global/local and central/peripheral, while

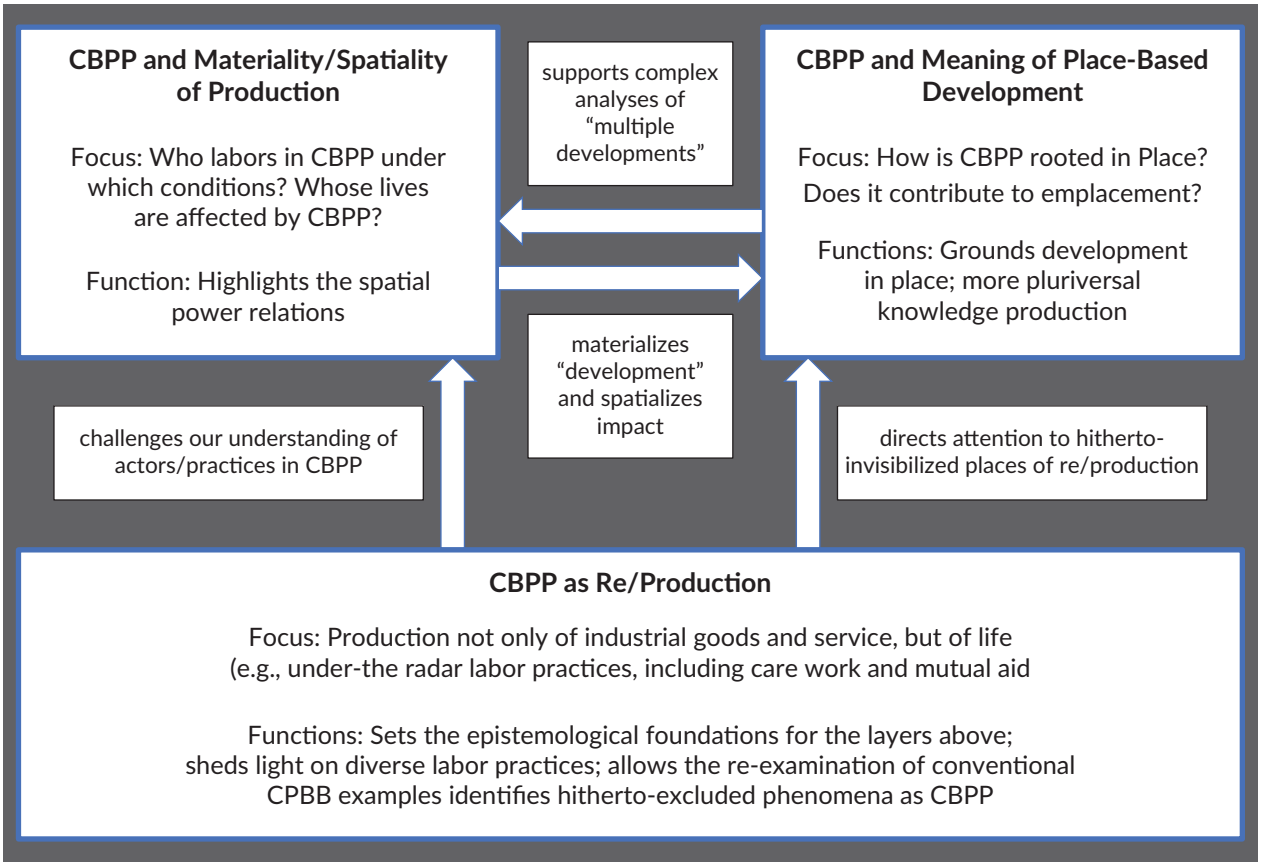

Figure 1. Rethinking CBPP through multiple geographies.

outlining pathways for further research. More specifically, issues raised by post-colonial geographies may shed light on the materiality and spatiality of CBPP; the geographical literature on uneven development leads us to concerns related to place-based developments; and feminist geographies can renew our understanding of what kind of production is highlighted in the CBPP literature. Of course, those strains of thought are not rigid and bounded, but overlap and connect to each other in diverse ways, leading us to some main concerns and pathways for future research on CBPP practice and outlining a renewed way to approach the phenomenon. A key point of this study is the recognition that while the digital realm facilitates global collaboration, the material conditions necessary for local manufacturing are unevenly distributed. Power relations, access to resources, and the materiality of production should be critically examined to ensure that CBPP does not inadvertently reproduce or exacerbate existing inequalities. The term "production" can be rethought from a feminist and post-colonial point of view to include invisibilized reproductive labor practices: emotional support and care work within CBPP communities, but also the supporting care work by households and/or other persons to sustain contributors' energy, time, and labor. A perspective informed by the insights of "multiple geographies" thinking moves beyond a simplistic localization of production and instead compels us to analyze how CBPP initiatives interact with place-specific socio-economic structures on multiple sites and scales. A critical engagement with power dynamics is essential to understanding how benefits and burdens are distributed within CBPP networks and how more marginalised communities, particularly in the Global South, can harness CBPP for socio-ecological reproduction and survival.

Given these insights, and without overlooking the previous efforts of CBPP scholars to touch upon the important issues we have presented in the previous section, this article shows that future research should shed more light on key areas. More specifically, comparative studies examining CBPP initiatives across different geographical contexts could offer valuable perspectives on the factors that contribute to their success and the challenges they face. These studies should investigate how CBPP ventures incorporate and value local knowledge, address power imbalances, and contribute to culturally revitalizing development pathways. Additionally, research on power dynamics within CBPP networks could illuminate the ways in which governance structures influence equity, particularly in relation to Global South–Global North relations and the rethinking of center–periphery dynamics. Another important area for future investigation is based on place-based (post-)development approaches that emphasize community-led initiatives experimenting with CBPP principles in locally grounded ways.

This study has certain limitations. First, the connections between CBPP and geographical literature are not exhaustive. Other overlaps could be highlighted between the two lines of thought, leading to other results. This article focuses on matters that are related to a "multiple geographies" perspective and thus leads us to specific claims regarding CBPP. Second, while it presents a conceptual engagement with CBPP and geographical thought, further empirical research is necessary to substantiate these theoretical claims. Future studies should focus on case-based and place-based (but not place-bound) analyses to better understand how CBPP operates in different geographical contexts. By doing so, scholars can provide deeper insights into the relationships between digital collaboration, material production, and socio-spatial inequalities, thereby advancing both CBPP and geographical research in meaningful ways. Nevertheless, by embracing a multiple geographies perspective, CBPP research can contribute to knowledge production that is more sensitive to feminist, decolonial, and "multiple developments" demands. Being attuned to these calls can help further unlock the transformative potential of CBPP. This approach thus aligns with broader calls for a

pluriversal understanding of development, where diverse, autonomous, but globally interlinked and digitally mediated pathways emerge. This requires a commitment to decolonizing knowledge production, empowering local communities to define their own well-being pathways, and rethinking the materiality and spatiality of CBPP. In this way, CBPP can foster more just, sustainable, and culturally diverse futures that move beyond the limitations of traditional development models.

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Conflict of Interests

The authors declare no conflict of interests.

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