

Recibido: 01-06-2016 Open peer review
Aceptado con modificaciones: 26-08-2016 <http://revistas.ucm.es/index.php/TEKN/pages/view/opr-52847>
Aceptado finalmente: 17-11-2016

An Introduction to Generative Justice

Una introducción a la justicia generativa

Ron Eglash

Rensselaer Polytechnic Institute
eglash@rpi.edu

ABSTRACT

Marx proposed that capitalism's destructive force is caused, at root, by the alienation of labor value from its generators. Environmentalists have added the concept of unalienated ecological value, and rights activists added the unalienated expressive value of free speech, sexuality, spirituality, etc. Marx's vision for restoring an unalienated world by top-down economic governance was never fulfilled. But in the last 30 years, new forms of social justice have emerged that operate as "bottom-up". Peer-to-peer production such as open source software or wikipedia has challenged the corporate grip on IP in a "gift exchange" of labor value; community based agroecology establishes a kind of gift exchange with our nonhuman allies in nature. DIY citizenship from feminist makerspaces to queer biohacking has profound implications for a new materialism of the "knowledge commons"; and restorative approaches to civil rights can challenge the prison-industrial complex. In contrast to top-down "distributive justice," all of the above are cases of bottom-up or "generative justice".

KEYWORDS

DIY; indigenous; queer ecology; maker; peer-to-peer.

RESUMEN

Marx propuso que las fuerzas destructivas del capitalismo están causadas, en el fondo, por la alienación del valor del trabajo, que es extraído de sus productores. Los ecologistas han desarrollado el concepto de valor ecológico no alienado y los activistas han aplicado el mismo concepto a la libertad de expresión, la sexualidad, la espiritualidad, etc. La propuesta de Marx de restaurar un mundo no alienado a través de una gobernanza económica de arriba-abajo no ha llegado a cumplirse nunca. Sin embargo, en los últimos 30 años han emergido nuevas formas de justicia social, caracterizadas por operar de abajo-arriba. La producción peer-to-peer, propia de las comunidades de software libre o de la Wikipedia han desafiado el control corporativo sobre la Propiedad Intelectual a través del intercambio libre y gratuito del valor trabajo; asimismo, las comunidades basadas en la agroecología establecen un tipo de intercambio de regalos con sus aliados no humanos en la naturaleza. Además, la ciudadanía *Do It Yourself*, desde los *makerspaces* feministas al *biohacking* queer, ha tenido profundas implicaciones para el desarrollo de un nuevo materialismo del conocimiento común; e incluso, la recuperación de los derechos civiles ha llegado a desafiar el complejo industrial carcelario desde estos nuevos enfoques. Así, en contraste con la "justicia distributiva" que funciona de arriba-abajo, todos los casos mencionados son ejemplos de "Justicia Generativa" (JG) que emerge desde las prácticas cotidianas, de abajo-arriba.

PALABRAS CLAVE

DIY; peer-to-peer; maker; indígena; ecología queer.

CONTENTS

1. Generating unalienated value
2. Arduino: a case study in generative justice
3. Generative Justice as a Transformative Process
4. Conclusion
5. References

CONTENIDOS

1. La generación de valor no alienado
2. Arduino: un estudio de caso de justicia generativa
3. Justicia Generativa como proceso de transformación
4. Conclusión
5. Referencias

Acknowledgement

The author would like to acknowledge National Science Foundation grant DGE-0947980 in support of this work.

It is common to hear conservative politicians declare that “liberals just argue over who got a smaller piece of the pie—but we want to make a bigger pie for everyone.” While this characterization is often misleading rhetoric, it reveals an uncomfortable truth about the political left: they have historically focused on the “distributive justice” of top-down government intervention. But in the last 30 years, new forms of social justice have emerged that are better described as “bottom-up”. Open source computing is perhaps the best known of these trends: the bloated, proprietary software of giant corporations is increasingly replaced by code that was generated in a kind of “gift exchange” of labor value: free distribution inspires free contributions. Another example is the food justice movement: the networks of community composting, urban gardens, “farm to fork” organics, and other means to establish a gift exchange with our non-human allies in nature. A third is the “maker” movement—a kind of open source network for the material world—which puts technologies ranging from 3D printing to “DIY bio” in the hands of lay citizens. Bottom-up value generation is not only a framework to address wealth inequality and environmental degradation; it also characterizes liberation from authoritarian control over free expression: peer-to-peer distribution of music, arts and other media; grassroots activism for sexual diversity across the globe; and so on. The time has come for a framework to describe these bottom-up alternatives to distributive justice: hence the need for this collection on generative justice.

Generative justice is more than just a list of helpful activities; it is a fundamentally different way of thinking about economics, politics, technology, ethics, and other categories that make up our vision for how societies should be arranged. If we think of the spectrum running from capitalism to communism, generative justice would be orthogonal to that line: open source software, composted soil, and reproductive rights have been just as much a struggle in the context of state ownership as they have been under private ownership. As isolated examples of bottom-up organization we already have “peer to peer economy” movements, “eco-utopia” movements, “restorative justice” movements, etc. But there is no cohesive framework for understanding what they have in common. Generative justice defines that common principle as *the bottom-up circulation of unalienated value*. This essay will provide a basic understanding of generative justice; a means to recognize its presence and potentials as it emerges; and a vision for how we might nurture its growth from these isolated examples to systems that can encompass an entire technosocial landscape.

1. Generating unalienated value

In Marx's original formulation of "alienated labor value", he contrasted the meaningful work of traditional skilled artisans, taking pleasure in their craft and earning respect from their community, with the dull repetition, low pay and enervating conditions of factory labor under capitalism. There are at least four challenges to making the alienation concept useful today. First, corporate marketing schemes are increasingly appropriating the artisanal allure: my Starbucks coffee is served by an underpaid "barista"; my cookies claim they were hand-made by Keebler elves. I can buy Domino's Artisan Pizzas, Tostitos' Artisan Recipes Tortilla Chips, Burger King's Artisan bun, and Dunkin' Donuts' Artisan Bagels. If artisanal labor is so easily simulated, what chance do we have for making it a basis of social critique? Second, evoking older, pre-capitalist forms could be read to imply that artisanal labor is better because it is more natural. But as I will outline below, some of the best examples of unalienated craft labor today are in highly "unnatural" realms of open source hardware and software. And romantic organicist notions of what constitutes "natural" labor are notoriously tied to stereotype gender roles; homophobic claims that only heterosexuality is natural; nationalist claims that "nature did not intend the races to mix" and so on. Third, older production forms may be a poor fit to contemporary population densities and needs. And finally, the stress on artisanal production often overlooks the gender, race and ecological dimensions of economies of care and histories of colonialism. To address these problems, we need a deeper look at what the concept of "generating unalienated value" could mean if liberated from some of this unwelcomed baggage.

The phrase "generating value" is implicitly referring to the power of "self-generation." In his 1944 book *What is Life?* physicist Erwin Schrödinger noted the mysterious way organisms seemed to defy the second law of thermodynamics: "It is by avoiding the rapid decay into the inert state of 'equilibrium' that an organism appears so enigmatic; so much so, that from the earliest times of human thought some special non-physical or supernatural force... was claimed to be operative" (p. 70). He characterized this self-generative property of life as "negative entropy" (later shortened to "negentropy"). Terms for this phenomenon can now be found at every scale: "autocatalysis" for cycles in which biomolecules produced themselves; "autopoiesis" for an organism's self-reproduction; "sympoiesis" for ecosystem self-assembly, and so on. When we grow living organisms for food, we tap into this self-generating power; that is to say, some of the value that is normally circulated can be diverted for our own use. It

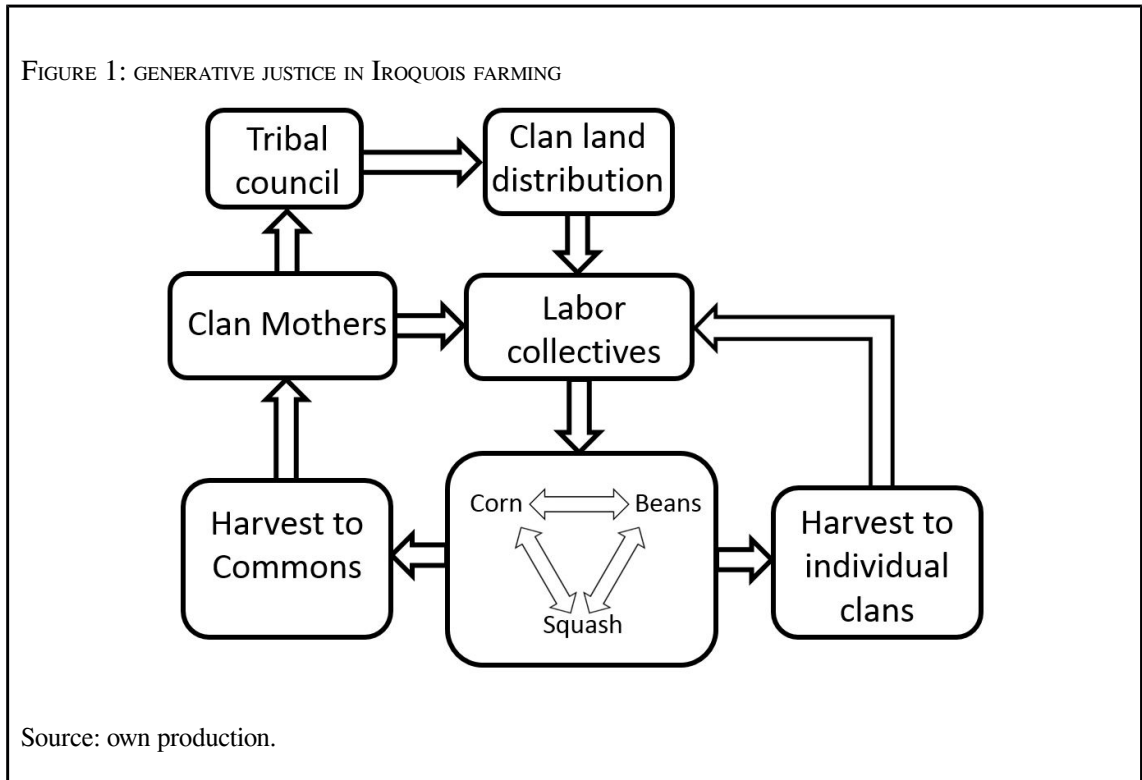
is here that we must choose between either becoming part of the circulation, or extracting—i.e. alienating—that value. Soils for example can be easily depleted of nutrients. Yet traditional farmers and horticulturalists have avoided this problem for thousands of years simply by returning our waste to the soil, and thus becoming part of the circulation of value through a broader array of sustainable practices called agroecology.

Marx made an analogy between unalienated labor and agroecology in *Capital* volume 1, where he stated that capitalist farming “prevents the return to the soil of its constituent elements consumed by man in the form of food and clothing... All progress in capitalist agriculture is a progress in the art, not only of robbing the worker, but of robbing the soil...” (Marx 1976, pp. 637-638). Recalling Schrödinger’s comment that the negentropic character of life is often attributed to a supernatural force, it is no surprise that Marx’s inspiration for this insight, German chemist Justus von Liebig, originally justified recycling sewage back to farm lands because of a “vital force” that gave living soils their generative power.

Marx was dedicated to eliminating “mystification”, but when he invokes the “living labor” of unalienated production, it sounds suspiciously like the vitalist “living soil” of von Liebig. This is not necessarily a flaw. Granted, it does pose the dangers of any organicist or naturalizing discourse, as noted above. But one can also interpret vitalism as humility; as a way of saying “there is something complex and wonderful in the generative force that we do not fully understand”. Indeed that was Schrödinger’s final conclusion¹. Today we know that the “living soil” concept was not far off: ordinary dirt is a complex ecosystem of bacteria, fungi, nematodes, decaying matter, water percolation, minerals and other features that form a dynamic, evolving network which still challenges our understanding. Analogous complex, self-sustaining networks in the social domain—not the simulation of artisanal labor in the Starbucks barista or Keebler elf—are necessary for real unalienated labor. We will now turn to one exemplar for such a network.

Figure 1 shows a schematic for the flow of unalienated value in the case of Iroquois (*Haudenosaunee*) farming around the time of the first European colonists. Each Iroquois nation

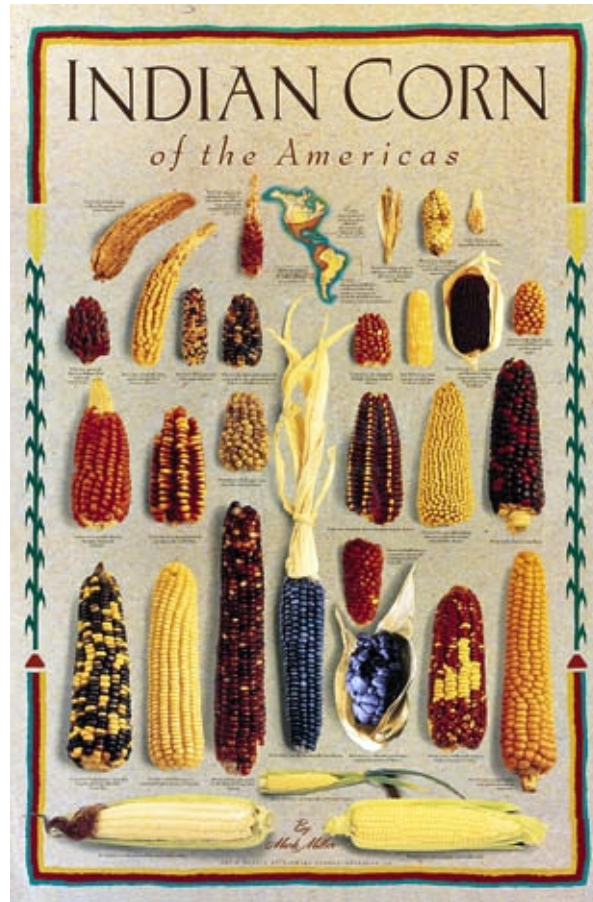
¹ In David Graeber’s *Anthropological Theory of Value* (2001) he associates this embrace of the elusive aspects of generative forces with a philosophical tradition extending from Heraclitus to Bhaskar (more recent examples would be Barad and other “new materialists”).



(in older terminology “tribe”) was divided into clans, and each had a council of clan mothers in charge of farming (Stites, 1905). The all-male tribal council distributed land to clans, but clan mothers chose the tribal council members, and could have them recalled (“knocking off the horns”) if their decisions were deemed biased (Wagner, 1993). Clan mothers also organized labor collectives, so that each family farm could benefit from the full labor force and avoid creating feelings of jealousy or envy (Seaver, 1992). In figure 1 we can follow this flow of social value from clan mothers, to tribal council, to land distribution, to the farm labor organized by the clan mothers. The farm itself shows a network within the network; the “three sisters” of corn, beans and squash. This traditional agroecology benefited by value circulated between non-humans: nitrogen-fixing bacteria on bean roots improves the soil for corn; corn provides stalks for bean vines to climb; and squash—benefitting from the nitrogen as well—reduces weed growth, evaporation and pests with its broad spiny leaves. Most harvests went to the individual families making up a labor collective, but those grown in the commons

(“*kěndiū'gwǎ'ge' hodi'yěn'tho*”) were used for public events (Parker, 1910), acting as both a symbolic and material manifestation of this communitarian circulation of value².

FIGURE 2, “INDIAN CORN OF THE AMERICAS”



Source: Mark Miller. Reproduced with his permission.

In sum: relations of open reciprocity, communal sharing, gift-giving and voluntary collaboration allowed value to circulate in its unalienated forms, including labor power, political expression and interspecies ecological exchanges. Centuries before European nations recognized women's right to vote, or Marx theorized a classless society, or John Muir campaigned for environmental preservation, the Iroquois had accomplished all three. The

² Many thanks to Onondaga clan mother Freida Jacques for her help in understanding the role of *Ganigonhi:oh*, “the good mind,” in both ancient and contemporary Iroquois communitarian ecology.

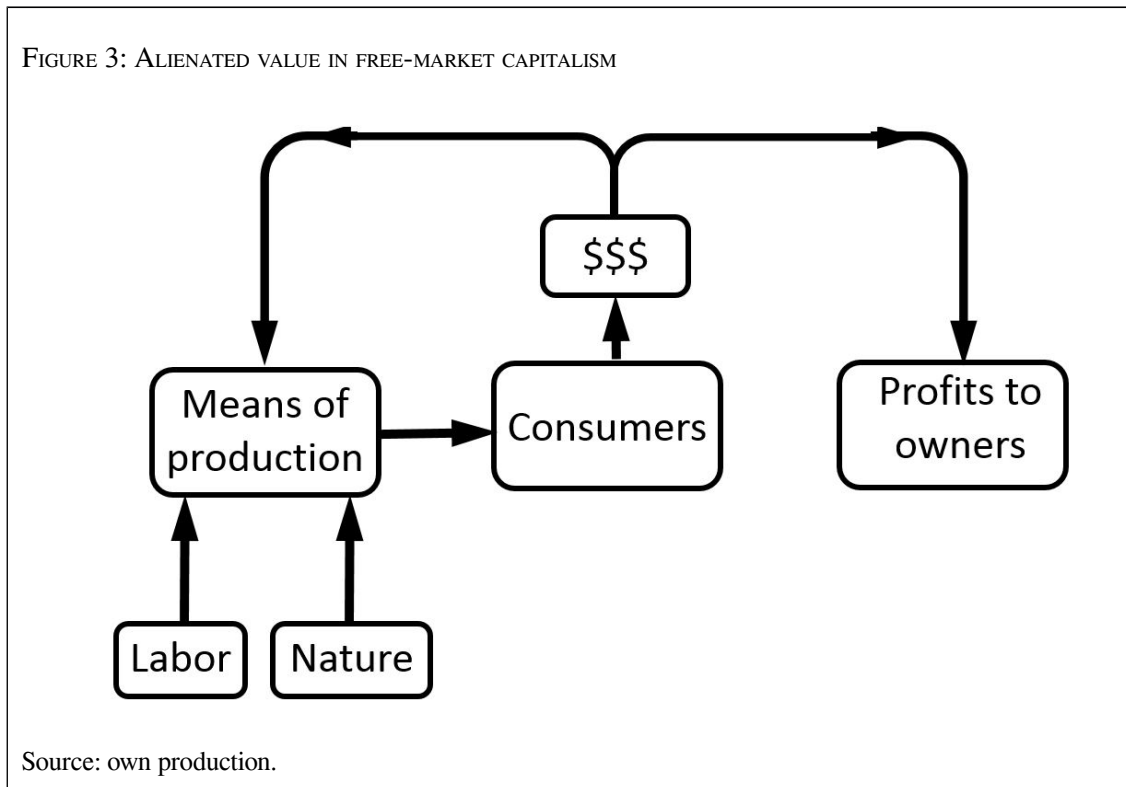
system could even “scale up” as the 5 nations created a democratic confederation; one which had at least an inspirational influence, if not an outright model, for constitutional founders such as Thomas Jefferson and Benjamin Franklin (Grinde & Johansen, 1991).

From the view of romantic organicists this was only possible because indigenous culture was “concrete”, lacking in the abstractions of science and technology. Any serious exploration of indigenous ethnobotany, ethnomedicine, ethnomathematics, etc. will show that these systems did not lack in abstraction and complexity. But even Latour (1993), who admits to their symbolic sophistication, dooms them to stasis: “By saturating the mixes of divine, human and natural elements with concepts, the premoderns limit the practical expansion of these mixes” (p. 42). This portrait fails to account for the enormous degree to which indigenous groups modified their environments. Various terms—“ecosystem engineering”, “anthropogenic environment”, or other phrases—Smith (2011) lists 25 different terms—these humanized landscapes ranged from stream sculpting for salmon and rock gardens for clams (Campbell & Butler, 2010), to controlled fires and quasi-orchards. The impact on plant genetics in the Americas was overwhelming. Figure 2, for example, shows the extraordinary variety of Native American corn prior to European arrival.

The modification began about 10,000 years ago in what is today central Mexico, where the barely edible head of the wild grass *teosinte*—about the size of a little finger—was gradually transformed³ to minimize seed scattering, and—as native cultivation brought it across different environments—to achieve greater size, starch content, drought resistance, pest resistance, and other advantageous characteristics (da Fonseca et al., 2015). Contrary to Latour’s characterization, it was precisely the network of cosmological significations and embodiments—an emphasis on gambling games; randomization in divination; and trickster narratives—which framed the need to counter the diversity of random events in nature (floods, droughts, infestations) with an equal diversity of crops (some of which would be resistant to the event), enabling this explosion in cultigen variety (Eglash, 2002). Rather than cultures frozen by categories of “the natural,” these indigenous groups and their non-human partners (Haraway 2008) had an innovative power which rivaled that of the industrial revolution: where would the Irish, Germans and Russians be without potatoes? Italians without tomatoes?

³ The usual assumption is that either this was deliberate breeding identical to western science, or completely unconscious and therefore without any epistemological status. But more accurate alternative frameworks place the intersections of indigenous cultural abstractions and material practices in their own context (Zimmerer, 1996; Aikenhead & Ogawa, 2007; Eglash, 2013).

Industry without rubber? Maritime trade without the indigenous knowledge of cinchona tree bark to treat malaria? The impact of corn, squash, beans, peanuts, peppers, melons, pineapple, avocado, blueberries, strawberries, tobacco, vanilla, cocoa, and other plants from the indigenous New World are overwhelming to contemplate. Unalienated value does not mean an unproductive system⁴.



Marx and Engels were not entirely unaware of these points: Engels (1902, p. 197) wrote that the potato bested even iron in its “revolutionary role in history”, and Marx wrote specifically

⁴ Three comments are necessary here. First, in response to the critique that this disproves the relation of justice to generative production, it should be clear that extraction from the “generative context” (Lyles *et al.*, 2016) creates alienated value which is then available for colonialism and other exploitative purposes. Second, in response to the critique that except for corn these are all wild plants, we should note that similar cultural impact on New World biodiversity is well documented for many plants; that in other cases there are subtle, long-term interactions (Allaby *et al.*, 2015); and in all cases the unalienated value is as much the indigenous *knowledge* of plant utilization as any genetic changes. Finally, against the critique that this should not count as innovation because it is simply the unconscious, universal impact of any human habitation, we note that the set of cultural abstractions are not in fact universal, which is why African indigenous contributions have had a very different impact than those of Native Americans (May, 2013; Eglash, 2013).

about the egalitarian nature of the Iroquois. But they could not adapt these insights to their vision: instead of generative justice—of circulating value in unalienated form—they developed a theory of distributive justice, that is, for how value should *continue* to be extracted and alienated, but afterwards centralized and redistributed. In a prior essay in this journal (Eglash, 2016) I have laid out the details for how and why that failure occurred; here I will only summarize the implications.

In figure 3 we see a schematic for the flow of alienated value in capitalism. Figure 1 used double lines to show how the flow of unalienated value—in energetic forms like labor power, material forms like ears of corn, expressive forms like council votes—circulated through interlocking self-generative cycles. Figure 3 uses single lines to show that value has now been extracted, that is, alienated from its source. While there are definitely self-generative processes *inside* the boxes labeled “labor” and “nature” they are kept out of sight: the gendered “caring economy” carried out largely by women to maintain a workforce; the ecological resources stressed by extraction and pollution—all remain invisible. The reason for that is obvious: how could you give someone a box of chocolates if they could see the exploitation that produced it? Compare that to the deliberate visibility of labor embedded in the artifacts of indigenous societies (figure 4).

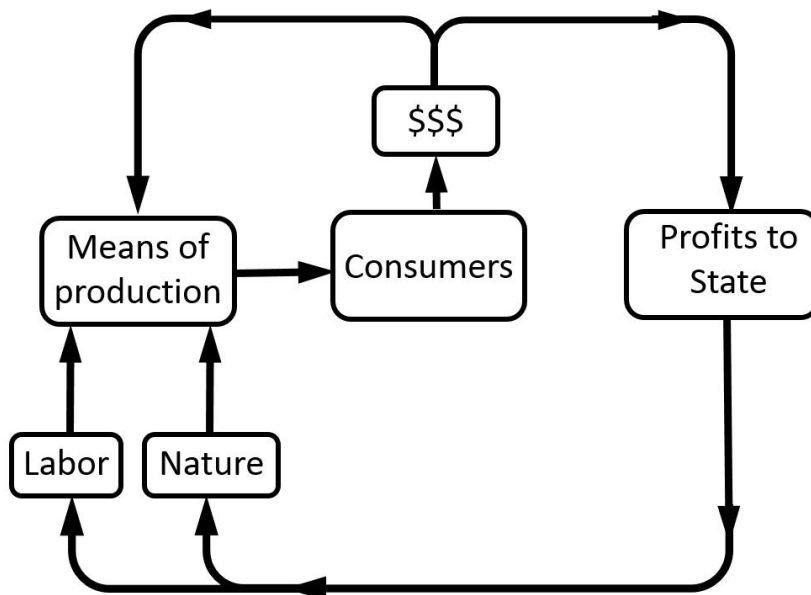
FIGURE 4: A. SHOSHONE BEADED PURSE; B. HAIDA CEDAR BOX; C. AFRICAN CORNROW HAIRSTYLE



Sources: figures a and b by the author; figure c courtesy Dr. Elze Bruyninx and the Museum for African Art, NY.

The high amount of detail--hundreds of tiny beads, intricate carving strokes or braided plaits—renders labor value in a visible form that is interwoven with social relations⁵: “my friend showed me some love today; check out the braiding in my hair.” Capitalism’s emphasis on keeping the original source of value generation invisible creates the illusion that money itself generates value: hence we hear phrases like "earnings are booming ahead" or "your investments can go to work for you" as if it was money itself doing the labor (Taussig 1977).

FIGURE 5: FLOW OF VALUE IN STATE PLANNED COMMUNISM



Source: own production.

A schematic for value flow in centralized state communism (figure 5) does not look much different than that of capitalism (figure 3). The pathways are still the single lines of abstracted value, and thus the promised returns are in alienated forms such as chemical fertilizers for nature and mass consumption⁶ for labor. In nations as diverse as the USSR, Cambodia, China,

⁵ I do not mean to imply that there is one uniform way that indigenous cultures treat this relationship. Graeber (2011) documents the profound diversity. See also footnote #4.

⁶ For example, Gronow (2003) describes the distinctive types of mass consumption under communism in the USSR: party-sanctioned magazines like *Rabomitsa* ("The Working Woman") attempted to create illusions of central planning's success in making fine fashion available to all (despite widespread shortages), in a kind of inversion of capitalism's attempt to create the illusion that elite designs are only available to a few (despite the widespread dissemination of knock-offs shortly after they debuted).

and Venezuela, government-owned systems of value extraction still produced the kinds of problems we see in many privately owned systems of value extraction: poverty, pollution and human rights violations. While abstracted categories are always suspect for academics (Latour, 1993; Barad, 2012), those three phenomena are a good way to define what we look for in a generative system: unalienated labor value instead of poverty; unalienated ecological value instead of pollution, and unalienated expressive value instead of human rights violations.

Marx believed that the levels of productivity needed to free humanity from the whims of Nature and toil could only come at the price of alienated value. Generative justice takes an opposing stance. Adopting the language of human rights activists, but keeping in mind non-humans as well, we can define generative justice as follows: *The universal right to generate unalienated value and directly participate in its benefits; the rights of value generators to create their own conditions of production; and the rights of communities of value generation to nurture self-sustaining paths for its circulation.*

2. Arduino: a case study in generative justice

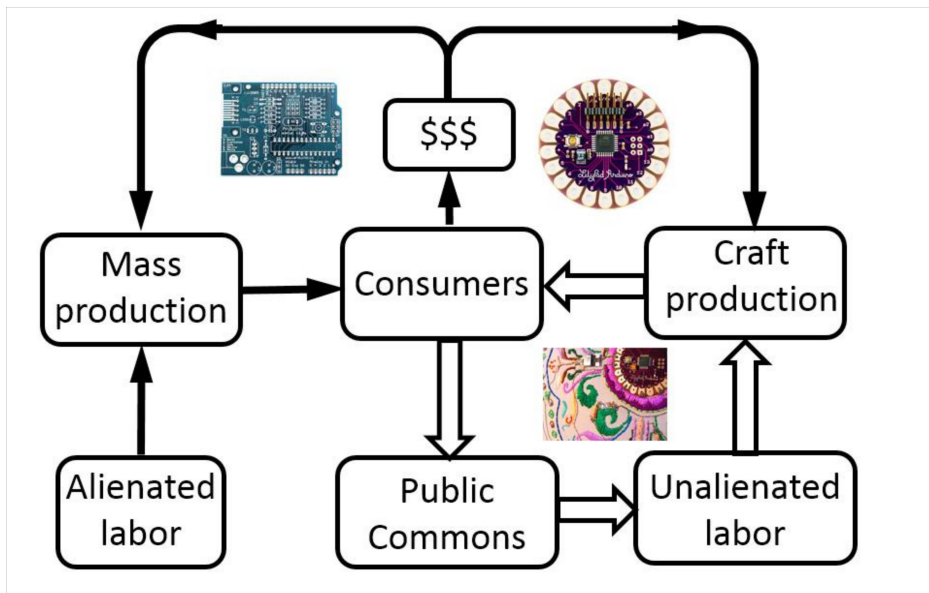
Having mapped out generative justice for the Iroquois past (figure 1), it is all too easy to imagine a flow chart for generative justice in some utopian future, so figure 6 provides one in its current, messy, compromised state in the real world. As with previous diagrams this is enormously simplified. This particular chart is for the case of Arduino, an open-source, microprocessor-equipped prototyping platform that has inspired a wide range of “maker” or “DIY” innovations created in an artisanal, unalienated mode of production. In contrast to the idea of patents or copyright, open source generally allows anyone with the right to distribute, modify and make use of the intellectual property⁷. In the case of Arduino it means I can download a blueprint of the circuit, make whatever changes I like, manufacture my version and sell it⁸. And the code these circuits run is also open source, and thus similarly shared by peers, both lay and professional. Code is shared through a “public commons,” hence the phrase “commons-based peer production” (Benkler, 2013). Thus the lower right part of the

⁷ According to BlackDuck (a common resource for open source statistics), about 90% of the software with open source licenses in 2015 is “free software,” meaning they allow both distribution and modification. There are other open sources licenses possible: for example some differentiate between for-profit and nonprofit rights.

⁸ Arduino carries a Creative Commons Attribution Share-Alike license, which allows commercial derivative works, as long as they credit Arduino and release their designs under the same license (the last clause being “copyleft”).

flowchart is a kind of virtuous cycle of unalienated value. For that reason, I have used “unalienated” double arrows for that part of the cycle, although we should caution that this is just to emphasize the bulk of the flow, not to make invisible those whose labor is extracted (Aaronson, 2010).

FIGURE 6: GENERATIVE JUSTICE IN THE VALUE FLOW FOR ARDUINO:



Sources: Upper left, an Arduino printed circuit board mass-produced in China by Gold Phoenix; Upper right, a circular LilyPad Arduino from artisanal production in the US by SparkFun; Lower left, a LilyPad electronic textile handmade by Becky Stern.

It’s not hard to see how peer production works for unpaid labor such as “recreational sharing”: it is everywhere today from YouTube videos to fanfiction, and has blurred the lines between production and consumption; the results of what Zittrain (2008) calls “generative technologies”. It’s a bit more complicated for paid labor, because it is coupled with a not-so-virtuous cycle on the upper left, involving people working on an ordinary factory assembly line. Many of my skeptical colleagues will cry “gotcha!” at this point, because they maintain that the whole public commons structure of the lower right simply masks the labor exploitation of this upper left cycle. But that skeptical reduction ignores the crucial and potentially liberating features of these systems.

In the eyes of skeptical Marxists such as Chopra and Dexter (2006), this extraction of labor value on the assembly line is the only significant aspect. The fact that there might be some “anti-capitalist tendencies”—such as a return to the unalienated labor of a craftsperson—is dismissed as merely a symptom of “late capitalism”; a postmodern mode based on precarization and flexibilization. In short they see it as a means by which labor is duped into working without resistance or rebellion: open source as the new opiate of the people. It does not take a Marxist to express such skepticism, liberal scholars such as Morozov (2013) ridicule the idea that open source platforms can offer anything more than self-delusion in comparison to more traditional politics.

It is true that many examples of crowdsourced labor in the digital economy are exploitative. Critics such as McRobbie (2002) and Ross (2007) were right in that “celebratory accounts of 'participatory culture,' 'peer production,' and the like valorize labor relations in which enterprises extract free or low cost labor for their own benefit” (Ekbia & Nardi 2014). However we are not helpless in determining how bottom-up agency is structured. For example, in contrast to Uber, whose replacement of taxis with independent workers is often cited as an example of crowdsourced exploitation, two similar app-based ride sharing systems, Green Taxi (Colorado) and Transunion Car Service (New Jersey) are unionized worker-owned cooperatives. While Arduino has not achieved that degree of labor ownership, its characteristics are still quite remarkable.

Arduino divided in May 2015 (ironically due to a dispute over trademark on the name) into a “Genuino” made in China, and “Arduino” made in Italy and the US. Arduino in Italy—the original location of the innovation—boasts an impressive combination of mass production and artisanal appeal. Its production machinery is all made locally; the work environment is beautifully and humanely designed (DesignBoom, 2013). Economists Piore and Sabel (1984) highlighted this area of Italy for the rise of “flexible economic networks” in which production by artisanal (skilled and self-directed) workers was sustained by rapidly reconfiguring collaborations across small companies. However Arduino’s US manufacturer, SparkFun, takes the concept of unalienated labor to even deeper levels. While the copper printed circuit boards (the image inside the cycle on the upper left of figure 6) used by SparkFun are imported from ordinary mass production⁹, the remainder of their production system, from hand-soldering to coding to Intellectual Property (IP), has been greatly influenced by open-source philosophy.

⁹ Primarily the Chinese company Gold Phoenix, among others. In 2014 SparkFun toured the Chinese factories and documented their impressions online: <https://learn.sparkfun.com/tutorials/how-chip-on-boards-are-made>.

Prior to my academic position I worked in two different levels of Silicon valley corporations, one hand-soldering boards (low pay) and the other coding software for integrated circuit design (high pay), so I am familiar with the ways that highly paid employees can boast about their hippie-esque creative workplace while assembly line labor is ghettoized in the building next door. Paranoia over IP theft is one excuse for creating those separations. Inspired by open source and its opposition to IP privatization¹⁰, SparkFun, to the contrary, has created an extraordinary workplace in which even low-level labor benefits from a creative environment. For example:

I started at SparkFun in September of 2007 as an assembly technician. My experience in electronics had consisted of only running sound equipment for my band and fixing the occasional broken guitar cord. After only a few days on the production floor, my skills with a soldering iron improved dramatically, and I was building beautiful little widgets. It wasn't too long before I started wondering how all these circuit boards actually worked. Whenever I had the chance, I would walk across the hallway to the engineers and ask for 5 minutes of their time.... In the last few years I have focused my energy at SparkFun to designing more efficient testing equipment and providing feedback to the engineers on how we can better design for manufacturing and testing. I can hardly call it a job, because I love it so much.¹¹

(SparkFun, 2009, para. 1)

Thus the flowchart of figure 6 reveals a third category of labor: between the usual alienated assembly line at upper left, and the unpaid public peer production of lower right lies the extraordinary potential of generative justice: well-paid, unalienated labor. Granted, it only exists in a messy, compromised form: still dependent on mass-produced PCBs, ic chips and other components; still locked into a world of bosses and hierarchies. But the stubborn

¹⁰ See SparkFun CEO Nathan Seidle's August 1, 2013 testimony to congress (available at http://judiciary.house.gov/_files/hearings/113th/08012013/080113%20Testimony%20-%20Seidle.pdf) for an eloquent account of their logic: they use open source, despite the constant copies of their innovations in China and elsewhere, in part because their relatively small size cannot go up against the legal apparatus of giant corporations, and in part because its philosophy enables innovation, collaborations with user communities and other benefits.

¹¹ <https://www.sparkfun.com/users/59173>. See <https://www.sparkfun.com/news/1654> for a similar example; in this case a female worker inspired to learn coding due to her employment at SparkFun, and her critique of mainstream gender stereotypes. Some of the comments by readers objected to posting "political" statements, but the vast majority was strongly supportive, suggesting that SparkFun's deliberate efforts to use open source to establish continuity with its consumer base has also helped establish a continuity with the democratizing character of their workplace. Their outreach also includes local maker workshops for girls and donations of their Arduino-based "Inventor's Kit" to HBCUs and African makerspaces.

evolution of open source over the last 30 years—from the solitary GNU manifesto to the code undergirding half the world’s software—makes generative justice one of the most promising paths to social change.

The sheer size of the Arduino “gift economy” would put any leftist commune of the 1960s to shame: as of 2014 about 1.2 million boards had been sold (Orsini, 2014); double that counting independent “clones” (Medea 2013). Over a million visitors to the website each month are recurring users. But more impressive is the range of projects that users have developed. While it is true that many Arduino applications are simply whimsical, others have serious humanitarian applications: for example innovations for disability (McAllister et al., 2012); citizen science for pollution detection (Gertz & Di Justo, 2012); mapping and communications for disaster relief (Libby, 2012); and low-cost health electronics for developing nations (Monicka et al., 2014). José Gómez-Márquez at MIT has developed the “MakerNurse” program which supplies nurses in developing nations with online resources and hardware tools (such as “MEDIKit”, a low-cost Arduino based platform for DIY medical gadgets) for a growing collection of nurse-made innovations. Still others take on social change issues: for example the Arduino “Geiger shield” was the start of what eventually became a hybrid of DIY and scientific-grade instrumentation, the BGeigie, which offered activists an affordable means to contest Japanese government claims of radiation safety during the Fukushima disaster (Murillo 2013).

In some cases these social issues are addressed in the form of what we might call Arduino’s “protest technologies”: often from media artists such as Cayla McCrae’s “glitter bomb” for gay rights activists, or Constantine Zlatev’s anti-war shotguns (converted into flutes). In the potent category of “activist fashion designers” we can find Arduino’s political lines of wearable media ranging from feminist critique to counter-surveillance. However it is important to reflect on how social protest articulates with generative justice. We can think of the code, blueprints and technical knowledge of such projects as one part of the circulating value, and equally important are the affective ties of solidarity; including what Natalie Kouri-Towe (2015) calls the “circulation of new resonances and new affinities that invites transformational possibilities” (p. 32). Since these protests can change policies to better foster conditions for bottom-up production, multiple generative cycles are clearly present (Ratto et al, 2014; Boler & Phillips, 2015). However there is a tendency for some scholars examining bottom-up protest technologies to reduce the significance strictly to its impact on top-down institutions: for example implying that DIY textile collectives are *only* significant when “yarn

bombing” or knitting protest signs. Any sense that such bottom-up collective practices have significance in themselves is immediately dismissed as neoliberalism. This is simply a mirror reversal of the conservative analysis of “social entrepreneurship” which reduces any bottom-up production to a victory of the free market. As an alternative model to either pitfall—and nicely illustrating Arduino use—we might consider the Textiles Environment Design group, featuring activist researchers such as Kay Politowicz, Melanie Bowles, and Rebecca Earley. Together with other groups such as Zoe Romano’s Openwear collaborative, they have developed theories and practice for creating a “circular economy” of textile production which includes recycling, sustainable sourcing, collaborations with traditional designers in India, sensor networks for materials tracking and other platforms that mix social critique and non-human (ecological) collaboration as forms of generative justice.

Generative justice can help us understand how open source technologies like Arduino can foster such innovations: addressing unmet social needs, offering new means of social critique and new tools for resistance to intrusion or exploitation. Contrary to both free-market and Marxist expectations, these ethical advantages can accrue equally well in socialist or capitalist systems. The Seeed Studio company in the People’s Republic of China (creators of the Seeeduino) is remarkable for its similarity to open source startups in New York or San Francisco: they sponsor hackathons, post interviews with other Makers from around the world, etc. Their foosball tables and colorful offices stand out against surrounding drab factories. They are part of the same Arduino public commons as anywhere else in the world; a global network of non-profit contributors and modest for-profit enterprises. While avoiding any overt opposition to the communist government¹², they do encourage activities such as air quality measurement, which has recently become a sore spot for Chinese government officials, and, like other startups in the Shenzhen area, are forced to contend with a growing government control over the internet (Grundy, 2015).

However Seeed must not only fend off the problem of communist censorship but also capitalist strategies for market exclusion: in 2015 Arduino’s former manufacturing partner claimed ownership of the brand, launched its own Arduino product line and created a legal case to bar distributors from buying “Arduino” labeled products from anyone else. Since it

¹² Lindtner (2015) describes the period from 2009 to 2011 when Chinese communities forming around the maker movement were vocal in espousing open culture, but government actions against activists such as Isaac Mao blunted any direct movement. Lindtner stresses the resulting differences from Western hacker orientations, but the fact that maker movements can be anti-hegemonic in both communist and capitalist contexts is an important example of how generative justice can occupy an orthogonal political dimension.

was still open source, they could only restricted the name and not the hardware design or software, so Massimo Banzi, co-founder of Arduino, and Eric Pan, founder of Seeedstudio, announced a strategic partnership to create the “Genuino” brand sold through their own sites as well as others such as Adafruit. Thus open source allowed them to survive the kind of conflict of that often destroys companies, and does not seem to have hurt their abilities to bring in more liberating social forms: for example Limor Fried, the founder of Adafruit (one of the most successful of these Arduino-associated companies), reports that their freedom from large corporate structures allows them to move their products in the direction of “fair trade” practices, even to the extent of avoiding components based on tantalum (since it is mined in Central African conflict areas; see Cicero 2013).

Less exploitative than typical large scale corporations, and more self-sustaining than charity or government programs, these small scale open source companies recall the Jeffersonian democratic vision of a nation of independent farmers and innovators¹³. Jefferson, himself an inventor, was also an early critic of patents, opposing them along the lines of generative justice¹⁴. That is not to say generative justice can only be manifested in the Jeffersonian vision—there are many possible paths, some more likely as a modification of socialism than as a variant of capitalism--but the comparison is illuminating. In the case of proprietary technology, continued growth of a small company will eventually lead to a big corporation; typically less democratic and more prone to exploitative practices. In contrast, open source technology can facilitate more beneficial kinds of growth. For example, Arduino’s combination of an easily understood hardware platform, open source and simplified software (“Processing”), and “crowdsourced” libraries and sample projects was key to its ability to make microcomputing accessible to laypeople; but thanks to the open source status of its circuit layout, innovator Leah Buechley was able to redesign that into an even more accessible form, the LilyPad: a board that makes the integration of electronics into textiles much easier. Her company—although small in scale—was able to show a statistically significant increase in the number of female electronic hobbyists in the Arduino community (Buechley & Hill 2010).

¹³ The negative implications must also be accounted for: Jefferson’s vision clearly had white males in mind, and race, gender and class diversity in today’s bottom-up forms are still an unsolved problem, as discussed below.

¹⁴ Jefferson in 1813: “That ideas should freely spread from one to another over the globe, for the moral and mutual instruction of man... seems to have been peculiarly and benevolently designed by nature, when she made them, like fire, expansible over all space, without lessening their density in any point, and like the air in which we breathe, move, and have our physical being, incapable of confinement or exclusive appropriation.” He eventually conceded to patents, even becoming the first patent examiner, but never relinquished his skepticism (Walterscheid, 1999).

It is this kind of positive feedback loop—a broadened access that facilitates the kinds of innovations by which technological access is even further broadened—that constitutes a kind of second level of generative structure: the system’s evolution through time. If the first level is composed of systems like figure 6, the second level would be thousands of those systems linked together in a co-evolving ecosystem. Taking the evolutionary metaphor a bit further, what constitutes “mutation” in this population, and how can we deliberately drive the direction of that evolution such that the alienated components gradually diminish?

The increasing significance of women and feminist reflection in these Arduino networks gives a hint at how this second level of “directed mutation” might be possible. First, it’s important to understand that the forces resisting gender equity are considerable.

Computing has the worst gender diversity of any technical discipline, surpassing even math and physics. Menking and Erikson (2015) describe how the harassment (“trolling”) that discourages women in many online venues also affects their work in generative spaces such as Wikipedia; Terrell et al. (2016) describes similar problems in open source, and Toupin (2013) in physical makerspaces. Thus, given those challenges, Buechley’s success in “hacking” the Arduino in ways that increased female participation is all the more significant, and surely counts as one tool in the “directed mutation” portfolio. But equally important is what Fox et al. (2015) refer to as “hacking gender”. In their study of gender diversity in physical hackerspaces, they noted that excluding all males was a relatively rare strategy. More common was a kind of social analogue to DIY experimentation: some declared feminist hackerspaces that allowed all genders; there was a Hackermoms dedicated to “mothers of all genders”; and others using the term “inclusive” to denote a porous remix. LOL Oakland for example describes itself as “a people-of-color-led, gender-diverse, queer and trans inclusive hacker/maker space” (LOL Oakland, n.d.).

Gender is not the only domain with this evolutionary trend. An expansion into wider realms is a potential in many cases mentioned above: the MakerNurse collective of Gómez-Márquez, the socially responsible entrepreneurship of Limor Fried, the sustainability of the Textiles Environment Design group, and other intersections. The challenge is not simply a technical issue. Gómez-Márquez, for example, is up against a multibillion dollar healthcare industry that often makes “uncertified” health instruments illegal (Williams, 2013). It is only by coupling these efforts with social justice movements, national policy changes or other broad social forces that those technologies and practices can effect deep change. A Marxist theory which dismisses these efforts as “late capitalism” is no more help than free market libertarianism that rejects all state institutions out of hand, or a luddite organicism that rejects

all technology out of hand. Building a theory of generative justice requires understanding this second level in terms of social, technical and ecological co-evolution.

3. Generative Justice as a Transformative Process

To understand how generative co-evolution might work, consider Elizabeth Potter's (2001) account of gender in Robert Boyle's 17th century experiments. It is well known that Boyle's experiments, which were foundational for the origins of modern scientific practice, excluded women on the basis that witnesses to the experiment must be "modest": only upper class men had a reputation at stake (Shapin & Schafer, 1985; Haraway, 1997). Potter notes that we typically think of this kind of story as how science and technology become gendered; but we tend to miss how gender is constructed by science and technology. Prior to Boyle, the concept of "modesty" was primarily applied to women. Creating a form of male virility that was of the mind, rather than the body, introduced new ways of being male; in this case one that would exclude women from the laboratory. At the second level—a kind of generative *injustice*—this set of sociotechnical practices quickly propagated to create ties between sexism and science in labs across the world. Even today we find male programmers brandishing versions of mental virility online in ways that cause gender exclusion (Callahan 2016).

To have the reverse of Boyle's sexism spread—to have practices that actually *increase* democratic inclusion "go viral"—we need nested loops¹⁵ in which networks of generative cycles are linking social, technical and ecological value circulation at multiple scales, such that they increase the propagation of these sustainable technosocial structures. Or as Benkler (2013) puts it, mechanisms by which "expanding the domain of mutualism improves freedom and well-being under conditions of persistent market imperfection and an inevitably fallible state" (p. 213).

This is as much a social challenge as it is technical (Coleman, 2009). As Dunbar-Hester (2014) points out:

It is especially important that activists—and also scholars—be wary of advancing a romanticized notion of voluntarism or participation that celebrates the agency of peers or the cent-

¹⁵ Nested loops is essentially used here as a synonym for what is described in detail as "recursive depth" (Eglash & Banks, 2014).

ality of technology, without seeking to understand the difficult and elusive work of building and maintaining structures of participation, especially egalitarian participation”

(Dunbar-Hester, 2014, p. 86).

There are certainly case studies showing how the bait of creative autonomy is used to create “self-exploitation” (McRobbie, 2002; Ross, 2007; Irani, 2015). On the other hand, a significant literature on the “moral economy” (Banks, 2006; Hesmondhalgh & Baker, 2011; Jenkins et al., 2013) suggests that many workers in creative industries are not merely dupes, but are well aware of the potential for self-exploitation, and found that the rewards of doing socially significant work outweighs the negatives. In their study of 19 independent digital companies supplying production, software, web design and other services to the British Public Broadcasting System, Bennett et al. (2015) found that the emphasis on a collaborative or gift-economy approach “did not ... necessarily mean precarious employment and self-exploitation, but could also foster creative freedoms, potentialities and ethics within companies as a ‘two-way street’” (p. 154) as they made extraordinary commitments ranging from employee job security to humanitarian projects. The unusual circumstances—a plethora of small independent companies supplying a national broadcasting system—offers an intriguing model for the cultivation of generative justice. One must keep in mind that at least some of the activities of these small companies would still be restricted to the upper right loop in figure 6; an unalienated production cycle that has links to alienated forms. But most generative attempts must start from this limited scope. The open question is what mechanisms can be introduced—policy, legal structures, technical structures, intellectual developments, social movements, etc.—to nurture its growth.

Non-humans in the circulation of unalienated value

We have focused so far on Arduino and its social dimensions in part because it can help make the distinction between Generative Justice and concepts such as “circular economy”; “industrial ecology,” “cradle to cradle” and similar frameworks for sustainability. While the mechanisms they propose, such as systematically recycling all “waste” as positive resources, could well be part of the circulation of unalienated ecological value, it is also compatible with a “green dictatorship” of diminished human rights; or a society in which a small wealthy elite enjoy carbon-zero exploitation of labor, or other contradictions made possible by a definition of sustainability that maintains a nature/culture dualism. By devising a concept of “unalienated value” that can move between labor, ecosystems, and expressive forms, we put all

three domains on the same “ontological plane” (to paraphrase Pickering, 1995) and enhance our ability to envision them as a unified landscape without losing track of its morphology, including both peaks and pitfalls.

The similarity between certain strains of environmental discourse on the dangers of impurity in nature, nationalist discourse on the dangers of impurity in race (Haraway, 1984), and homophobic discourse on the “unnatural” sex of gays and lesbians (Sbicca, 2012) is an important reminder for why the concept of “unalienated value” has to be carefully crafted to avoid the traps of essentialism, organicism, authenticity, and other authoritarian forms. Similar risks occur with the term “generative” or its synonyms (“life force”) which are also used by “pro-life ecofeminists” who would restrict women’s reproductive freedom (O’Neil, 2009). On the other hand, Anglin (2015) rightly points out that we cannot solve the problem by simply “removing the queer from inclusion in vitalistic discourses.” One way to guard against such dilemmas is to mobilize our prior definition of generative justice regarding *the rights of value generators to create their own conditions of production*, thus including reproductive and sexual orientation rights¹⁶. For example, Haraway (1997) reframes breastfeeding from a “more natural” practice to a form of knowledge that requires intergenerational circulation (making complimentary moves with the speculum and other technologies); similarly Greene (2014) considers the communitarian dimensions of queer space. The misguided attempt by some scholars to exonerate homosexuality by pointing to examples in nature is particularly illuminating for thinking about the relationships of non-humans to generative justice.

Parry (2012), summarizing the work of Jennifer Terry, Stacy Alaimo, Donna Haraway and other critical theory scholars notes that “mobilizing the rhetoric of the “natural” in contemporary culture wars surrounding human sexuality... merely reinscribes new normative discourses of “natural” sexuality as well as reinforcing the theoretically untenable concept of culture-nature dualism” (p. 7). While rejecting naturalism, this body of literature also celebrates the powerful presence of what biologist Bruce Bagemihl calls “biological

¹⁶ I have been using the language of “rights” to make it easier to communicate these concepts, but it can give the misleading impression of dependence on top-down enforcement. Consider, in contrast, how gay activists during the AIDS epidemic achieved more generative scientific practices: through bottom-up mobilization, not top-down legislation (Epstein, 1996). Thus alternatives to rights discourse might be phrasing such as “establishing deeply embedded practices by which value generators to create their own conditions of production”. On the other hand, there is no reason to exclude government regulation from the list of things that can be helpful to generative justice, as long as it is clear that the two are orthogonal dimensions.

exuberance”: the dizzying array of sexual behaviors, multiple genders, hermaphroditism, transsexual morphs and features that refuse simplistic reduction to reproductive imperatives. As Alaimo (2010) puts it, they help us think about “deviation as an ethical ideal of openness to unexpected change” (p. 139). And we need not stop at biology: this endless creativity is in some sense what brought us non-euclidean geometry, atonal music, non-classical physics—the myriad alternative forms that mangles of human and non-human agency make available in every domain; in other words, the deeply generative nature of the universe itself (Barad 2007).

While non-humans such as plants and bugs cannot form labor unions or run for office, they often vote with their feet (or other appendage): for that reason the material agency of the non-human world has increasingly been framed as a missing factor in social sciences analysis (Callon, 1986, Pickering, 1995; Bennett, 2010; Barad, 2012), and some scholars in the “community economy” school have focused on this need to change “peer-to-peer” so that it includes non-human peers (Hill 2015). Washick et al. (2015) warn that the work on new materialisms is sometimes so focused on celebrating agency and contingency that it loses sight of hegemonic forces such as class relations. In one example they cite the author delights in a Gap commercial in which clothing appears to animate itself, with the dubious claim that igniting a pagan sensibility in viewers will trump any damage from commodity fetishism. Our approach to resolving this conflict through generative justice—bringing attention to hegemonic forces while simultaneously accounting for non-deterministic material agency—has utilized concepts from self-organization and complexity theory. In the parlance of nonlinear dynamics, these hegemonic forces, as well as their opposite in collective resistance, can be modeled as a “basin of attraction” (Eglash & Garvey, 2014). These can be analyzed quantitatively: for instance as agricultural pests gain immunity to pesticides, and farmers apply it in greater amounts, ecological disaster becomes a basin of attraction. But the basin concept also works well as metaphor. For example when we see working class students struggling in a college environment, it’s like watching iron filings invisibly pulled in a magnetic field.

The opposite effect, basins of attraction for generative justice, require bottom-up circulation of nature’s agency in a “mangle” (as Pickering puts it) with human intentionality. This has been dramatically illustrated by Elinor Ostrom (2010) and her colleagues in studies of Common Pool Resources (CPR). In cases ranging from ancient Nepalese irrigation to contemporary Maine lobster fishing, they persistently demonstrate how bottom-up, self-organized governance systems, properly implemented, can offer gains in both human and ecological productivity, sustainability and biodiversity. While there are parallels to open source software (Eglash, 2002), CPR cases take on a harder challenge: software is not a “rival

good”—downloading software does not diminish our stock of the original—as would be the case for irrigation water, lobsters, and other natural resources. Her eight principles for implementation of a CPR—practices such as the right to modify conditions of production, the use of “nested” networks rather than centralized control, etc.—could well be the ground rules for generative justice. And yet Ostrom also cautions against an overly deterministic view: she notes that the diversity of social ecologies has to be respected and warns against simple panaceas that a literal or rigid interpretation of her eight principles might imply.

Altieri (2004) provides one such illustration, noting how the panacea of ecologically responsible agriculture can be manipulated. As large corporations such as Monsanto seek alternatives to commercially disappointing approaches such as genetic engineering, their replacement technologies are “greenwashed” under the name of “ecoagriculture.” But similar to Marx’s conviction that “nature’s paltriness” could not sustain the needed yields, they still insist that only fundamentally extractive practices—in particular large scale monocropping—can create significant yields. Altieri notes that the alternative practice of agroecology addresses both poverty and sustainability by promoting smallholder multicropping; a practice which increases biodiversity, which then allows natural pest control, more efficient use of nutrients, etc. That is to say, it establishes the nested loops of generative justice. Contrary to the “paltriness” thesis, yields can be increased without introducing value alienation. Nor is it necessary to spurn technology in such efforts; even further productivity can be gained, for example, by combining ICT with agroecology principles (Nelson & Coe, 2014).

4. Conclusion

In summary: At first glance, generative justice simply concerns the feature long noted about nature and labor: they are the fundamental generators of value, and there are advantages to respecting them as such. Contradictory to the capitalist view, this value can best serve human interests when it is allowed to remain in its unalienated state, and circulated by the human and non-human generators themselves. Contrary to Marxist traditions, direct transition to bottom-up circulation—not a temporary dictatorship of top-down extraction—is the best means to that end. Finally, contrary to the organicist view, unalienated value is not synonymous with categories of the natural or concrete, as it can be created with digital circuits as easily as it can with flesh and soil. This last point is crucial for an analysis of unalienated expressive value, as our autonomy over our own sexuality, creative media, spiritual practices, free thought and

other deeply personal (and collectively social) categories can be threatened by authoritarian control.

There are, of course, many unanswered questions. Given that corporations have long valorized the romantic notion of “homegrown” or “handmade” as a marketing strategy, how do we specifically delimit or define “non-alienated” or “non-extracted” forms of value without resorting to organicism (romantic notions of authenticity or concreteness)? Given that generative justice cannot utilize abstraction to delineate alienation, how might local exchange systems such as local currencies, time banks, or other forms of value representation (Werner 2008) be circulated in a generative network without creating barriers to the circulation of value from unalienated forms of production? What might be gained by incorporating non-monetary exchange; that is, the direct trading of goods and services (the US barter market is currently estimated at \$12 billion annually)? How might generative justice contribute to the analysis of frameworks already utilizing these concerns, such as “solidarity economy” (Kawano et al., 2010); “real utopias” (Wright, 2013); “community economy” (Cameron et al., 2014); “non-extractive economy” (Grady-Benson & Sarathy, 2015); “peer-to-peer economy” (Hamari et al., 2015); etc?

Thus the greatest challenges might be summarized as follows: given the traditional Marxist critique that bottom-up social entrepreneurship is simply too weak in the face of capitalist hegemony (McCabe, 2013), or more recent critiques such as those of Washick et al. (2015) regarding optimistic over-reach in the new materialism, how can generative justice distinguish between true democratization of economy—fundamental to the concept of “putting value generators in charge of value circulation”—and the neoliberalism or “precarity” in which capital utilizes bottom-up structures to divert critics from real change, dupes low-paid labor with the romance of “free agency”, valorizes the wealthy as “job creators,” and ignores “negative externalities” (Ross, 2007; Ekbja & Nardi, 2014)? As Noam Chomsky pointed out a recent critique of worker-owned cooperative Mondragon (Flanders, 2012), even financially stable cases of unalienated labor are not sufficient if they cannot move toward system-wide transformations.

Let us return to the contention that generative justice should be *orthogonal* to the socialist/capitalist spectrum. If successful, a generative perspective should not only contest barriers created by capitalist hegemony, but also the barriers of traditional Marxism: co-opted labor unions, vanguardism, authoritarian states, etc. Thus we can ask symmetrical and mutually-interrogating questions: what kinds of federal policies or practices would aid generative justice against the power of corporate forces? How can the sexism, racism and

other ideologies that often invade bottom-up collectives (Del Casino, 2009; Menking & Erikson, 2015; Toupin, 2013) be addressed by deliberate policies, technologies, and organizational forms? Should dependence on non-generative forms—like the dependence on mass production of silicon chips for artisanal production of Arduinos—be considered a “parasitic” relation that must be immediately eliminated, or can the relationship offer possibilities for transformation (why not fair trade silicon chips?). The following essays in this collection investigate these and other questions as we explore the landscape of generative justice.

5. References

- AARONSON, S. A. (2010). How China's Employment Problems Became Trade Problems: China, Labour Law, and the Rule of Law. *Institute for International Economic Policy Working Paper Series*, Elliott School of International Affairs, The George Washington University. Retrieved from <http://www.gwu.edu/~iiep/assets/docs/papers/Aaronson_IIEPWP2010-11.pdf>.
- AIKENHEAD, G. S., & OGAWA, M. (2007). Indigenous Knowledge and Science Revisited. *Cultural Studies of Science Education* 2(3), 539–620.
- ALAIMO, S. (2010). *Bodily Natures: Science, Environment, and the Material Self*. Bloomington: Indiana University Press.
- ALLABY, G., KISTLER, L., GUTAKER, R., WARE, R., KITCHEN, J., SMITH, O. & CLARKE, A. (2015). Archaeogenomic Insights into the Adaptation of Plants to the Human Environment: Pushing Plant–hominin Co-Evolution back to the Pliocene. *Journal of Human Evolution* 79, 150–57.
- ALTIERI, M. A. (2004). Agroecology versus Ecoagriculture: balancing food production and biodiversity conservation in the midst of social inequity. *Commission on Environmental, Economic & Social Policy CEESP Occasional Papers* 8-28.
- ANGLIN, S. (2015). Generative Motion: Queer Ecology and Avatar. *The Journal of Popular Culture*, 48(2), 341-354.
- BANKS, M. (2006). Moral Economy and Cultural Work. *Sociology* 40(3), 455–72.
- BARAD, K. (2012). Nature's Queer Performativity. *Women, Gender and Research*. 1-2, 25-53.
- BENKLER, Y. (2013). Practical Anarchism: Peer Mutualism, Market Power, and the Fallible State. *Politics and Society* 4(2) 213-251.
- BENNETT, J., STRANGE, N., & MEDRADO A. (2015). Moral Economy of Independent Work? Creative Freedom and Public Service in UK Digital Agencies. In J. Bennett & N. Strange (Eds.). *Media Independence: Working with Freedom or Working for Free?* (p. 139-158). London: Routledge.
- BENNETT, J. (2010). *Vibrant Matter: A Political Ecology of Things*. Durham, NC and London: Duke University Press.
- BOLER, M. & PHILLIPS, J. (2015). Entanglements with Media and Technologies in the Occupy Movement. *The Fibreculture Journal* 26, 239–71.

-
- BUECHLEY, L. & HILL, B. M. (2010). LilyPad in the Wild: How Hardware's Long Tail is Supporting New Engineering and Design Communities. In *Proceedings of Designing Interactive Systems (DIS)* (pp. 199-207). Aarhus, Denmark.
- CALLAHAN, B. (2016). A Review of Diversity and Inclusivity Initiatives in the BSD Community and Imagining Future Pathways. AsiaBSDCon, March 10-13, 2016, Tokyo University of Science, Tokyo, Japan.
- CALLON, M. (1986). Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Briec Bay. In Law, J. (Ed.), *Power, Action and Belief: A New Sociology of Knowledge* (pp. 196-233). London: Routledge & Kegan Paul.
- CAMERON, J., GIBSON, K. & HILL, A. (2014). Cultivating Hybrid Collectives: Research Methods for Enacting Community Food Economies in Australia and the Philippines. *Local Environment* 19(1), 118-132.
- CAMPBELL, S. K. & BUTLER, V.L. (2010). Archaeological evidence for resilience of Pacific Northwest salmon populations and the socioecological system over the last ~7,500 years. *Ecology and Society* 15(1), 17-29.
- CHOPRA, S. & SCOTT, D. (2006). The Political Economy of Open Source Software. *International Journal of Technology, Knowledge and Society* 1(7).
- CICERO, S. (2013, April 11th). An interview with LadyAda, Limor Fried founder of Adafruit. *OpenElectronics*. Retrieved from <<http://www.open-electronics.org/an-interview-with-ladyada-limor-fried-founder-of-adafruit>>
- COLEMAN, G. (2009). Code is Speech: Legal Tinkering, Expertise, and Protest among Free and Open Source Software Developers. *Cultural Anthropology* 24(3), 420-454.
- DA FONSECA, R.R., SMITH, B.D., WALES, N., CAPPELLINI, E., SKOGLUND, P., FUMAGALLI, M., & SAMANIEGO, J.A. (2015). The Origin and Evolution of Maize in the Southwestern United States. *Nature Plants* 1(1), 1-5
- DEL CASINO, V. (2009). *Social Geography: A Critical Introduction*. NY: John Wiley & Sons.
- DESIGNBOOM. (2013). Arduino factory + production tour. Design Boom. Retrieved from <<http://www.designboom.com/technology/arduino-factory-tour>>.
- DUNBAR-HESTER, C. (2014). Radical Inclusion? Locating Accountability in Technical DIY. In Ratto, M. & Boler, M. (Eds.), *DIY Citizenship: Critical Making and Social Media*. Cambridge, MA: MIT Press.

- EGLASH, R. (2002). Computation, Complexity and Coding in Native American Knowledge Systems. In Hankes, J. & Fast, G. (Eds.), *Changing the Faces of Mathematics: Perspectives on Indigenous People of North America*. Reston, VA: NCTM.
- EGLASH, R. (2013). An Ethnocomputing Comparison of African and Native American Divination Systems. In Beek, W.E.A. & Peek, P.M. *Reviewing Reality: Dynamics of African Divination*. 295-312. LIT Verlag
- EGLASH, R. & BANKS, D.A. (2014). Recursive Depth in Generative Spaces: Democratization in Three Dimensions of Technosocial Self-Organization. *The Information Society* 30(2).
- EGLASH, R. & GARVEY, C. (2014). Basins of Attraction for Generative Justice. In Banerjee, S., Şule Erçetin, S. & Tekin, A. (Eds.), *Chaos Theory in Politics*. (pp. 75–88). Germany: Springer Science.
- EGLASH, R. (2016). Of Marx and Makers: an Historical Perspective on Generative Justice. *Teknokultura*, 13(1).
- EKBIA, H., & NARDI, B. (2014). Heteromation and Its (dis)contents: The Invisible Division of Labor between Humans and Machines. *First Monday* 19(6). Retrieved from <<http://firstmonday.org/ojs/index.php/fm/article/view/5331>>.
- ENGELS, F. (1902). *The Origin of the Family, Private Property and the State*. Chicago: C. H. Kerr.
- EPSTEIN, S. (1996). *Impure Science: AIDS, Activism, and the Politics of Knowledge*. Berkeley: University of California Press.
- FLANDERS, L. (2012 April 30th). Talking With Chomsky. *CounterPunch.org*. Retrieved from <<http://www.counterpunch.org/2012/04/30/talking-with-chomsky/>>.
- FOSTER, J. B. & MAGDOFF, F. (1998). *Monthly Review*. Jul/Aug 1998, Vol. 50(3), 32.
- FOX, S., ULGADO, R. & ROSNER, D. (2015). Hacking Culture, Not Devices: Access and Recognition in Feminist Hackerspaces, *CSCW '15*, Vancouver, BC; 56–68. ACM Press.
- GERTZ, E. & DI JUSTO, P. (2012). *Environmental Monitoring with Arduino Building Simple Devices to Collect Data About the World Around Us*. Maker Media, Inc.
- GIBSON-GRAHAM, J.K. (2006). *A Postcapitalist Politics*. Minneapolis: University of Minnesota Press.
- GRADY-BENSON, J. & BRINDA S. (2015). Fossil Fuel Divestment in US Higher Education: Student-Led Organising for Climate Justice. *Local Environment* 0(0): 1–21.
- GRAEBER, D. (2011). *Toward an Anthropological Theory of Value: The False Coin of Our Own Dreams*. Basingstoke, UK: Palgrave Macmillan.

-
- GREENE, T. (2014). Gay Neighborhoods and the Rights of the Vicarious Citizen. *City & Community* 13(2), 99–118.
- GRINDE, D.A. & JOHANSEN, B.E. (1991). *Exemplar of Liberty: Native American and the Evolution of Democracy*. Los Angeles: American Indian Studies Center, University of California.
- GRONOW, J. (2003). *Caviar with Champagne: Common Luxury and the Ideals of the Good Life in Stalin's Russia*. Oxford: Berg.
- GRUNDY, T. (2015, July 13). How the Communist Party's controlling urges hinder China's start-up revolution. *Hong Kong Free Press*. Retrieved from <<https://www.hongkongfp.com/2015/07/13/feature-how-the-communist-partys-controlling-urges-hinder-chinas-start-up-revolution/>>.
- HALL, V. (1980). The Role of Force or Power in Liebig's Physiological Chemistry. *Medical History* 24(1), 20–59.
- HAMARI, J., SJÖKLINT, M. & UKKONEN, A. (2015). The Sharing Economy: Why People Participate in Collaborative Consumption. *SSRN Scholarly Paper*. Rochester, NY: Social Science Research Network. <<http://papers.ssrn.com/abstract=2271971>>.
- HARAWAY, D. (1984). Teddy Bear Patriarchy: Taxidermy in the Garden of Eden, New York City, 1908-1936. *Social Text* 11, 20–64.
- HARAWAY, D. (1992). The Promises of Monsters: A Regenerative Politics for Inappropriate/d Others." In Grossberg, L., Nelson, C. & Treichler, P.A. (Eds.), *Cultural Studies*. New York; Routledge, 295-337.
- HARAWAY, D.J. (1997). The Virtual Speculum in the New World Order1. *Feminist Review* 55(1), 22–72.
- HARAWAY, D.J. (2008). *When Species Meet*. Minneapolis: University of Minnesota Press.
- HESMONDHALGH, D. & BAKER, S. (2011). *Creative Labour: Media Work in Three Cultural Industries*. London: Routledge.
- HILL, A. (2015). Moving from 'matters of Fact' to 'matters of Concern' in Order to Grow Economic Food Futures in the Anthropocene. *Agriculture and Human Values* 32(3). Retrieved from <<http://www.communityeconomies.org/site/assets/media/AnnHill/Hill-AHUM-for-distribution-2014.pdf>>.

- IRANI, L. (2015). Hackathons and the making of entrepreneurial citizenship. *Science Technology and Human Values*, 40(5), 799-824.
- JENKINS, H., FORD, S. & GREEN, J. (2013). *Spreadable Media: Creating Value and Meaning in a Networked Culture*. NY: New York University Press.
- KAWANO, E., MASTERSON, T. & TELLER-ELLSBERG, J. (eds). (2010). *Solidarity Economy I: Building Alternatives for People and Planet*. Amherst, MA: Center for Popular Economics. Retrieved from <https://www.academia.edu/2472194/Building_a_Solidarity_Economy_from_Real_World_Practices>
- KOURI-TOWE, N. (2015). Textured Activism: Affect Theory and Transformational Politics in Transnational Queer Palestine-Solidarity Activism. *Atlantis: Critical Studies in Gender, Culture & Social Justice* 37(1), 23–34.
- LATOUR, B. (1993). *We Have Never Been Modern*. Translated by Catherine Porter. Cambridge, MA: Harvard University Press.
- LIBBY, C. (2012, June 7th). OpenRelief Launches Open Source Disaster Relief Drone. *Linux News*. Retrieved from <<https://www.linux.com/news/featured-blogs/200-libby-clark/586942-openrelief-launches-open-source-disaster-relief-drone>>.
- LINDTNER, S. (2015). Hacking with Chinese Characteristics The Promises of the Maker Movement against China's Manufacturing Culture. *Science, Technology & Human Values*, 40(5), 854-879.
- LOL OAKLAND (n.d.). Donate. Retrieved from <<https://oaklandmakerspace.wordpress.com/donate/>>.
- LYLES, D., LACHNEY, M., FOSTER, E.K. (2016). Generative Contexts: Generating Value between Community and Educational Settings. *Teknokultura*, 13(2).
- MAY, K. (2013). Architecture infused with fractals. *TED blog*. Retrieved from <<http://blog.ted.com/architecture-infused-with-fractals-ron-eglash-and-xavier-vilalta/>>.
- MARX, K. (1976) *Capital*, vol. I, New York, NY: Vintage.
- MCALLISTER M., YUEN E. & BUSH S. (2012). Cultivating Design Citizenship: A Participatory Design Exploration Engaging People with Disabilities. Retrieved from <<http://www.idsa.org/cultivating-design-citizenship-participatory-design-exploration-engaging-people-disabilities>>.

-
- MCCABE, C. (2013). Transforming Capitalism through Real Utopias: A Critical Engagement. *Irish Journal of Sociology* 21(2), 51–61.
- MCRROBBIE, A. (2002). Clubs to Companies: Notes on the Decline of Political Culture in Speeded up Creative Worlds. *Cultural Studies* 16(4), 516–531.
- MEDEA. (2013). Arduino FAQ – With David Cuartielles. *Medea*. Retrieved from <<http://medea.mah.se/2013/04/arduino-faq>>.
- MENKING, A. & ERICKSON, I. (2015). The Heart Work of Wikipedia: Gendered, Emotional Labor in the World’s Largest Online Encyclopedia. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, 207–10. CHI ’15. New York, NY: ACM.
- MONICKA S., SUGANYA C., NITHYA BHARATHI S. & SINDHU A.P. (2014). A Ubiquitous Based System for Health Care Monitoring. *International Journal of Scientific Research Engineering & Technology*, 3(4).
- MOROZOV, E. (2013). *To Save Everything, Click Here: The Folly of Technological Solutionism*. New York, NY: PublicAffairs.
- MURILLO, L. R. (2013). New Expert Eyes Over Fukushima: Open Source Responses to the Nuclear Crisis in Japan. *Fukushima Forum*. Retrieved from <<https://fukushimaforum.wordpress.com/workshops/sts-forum-on-the-2011-fukushima-east-japan-disaster/manuscripts/session-3-radiation-information-and-control/new-expert-eyes-over-fukushima-open-source-responses-to-the-nuclear-crisis-in-japan>>.
- NELSON, R. & COE, R. (2014). Transforming Research and Development Practice to Support Agroecological Intensification of Smallholder Farming. *Journal of International Affairs* 67(2).
- O’NEIL, P. (2009, Jan 22nd). Pro-life, eco-feminists work for consist ethic of life. *National Catholic Reporter*. Retrieved from <<http://ncronline.org/news/pro-life-eco-feminists-work-consist-ethic-life>>.
- ORSINI, L. (2014, May 12th). Arduino’s Massimo Banzi: How We Helped Make The Maker Movement. *ReadWrite*. Retrieved from <<http://readwrite.com/2014/05/12/arduino-massimo-banzi-diy-electronics-hardware-hacking-builders>>.
- OSTROM, E. (2010). Beyond markets and states: polycentric governance of complex economic systems. *American Economic Review* 100(3), 641–672.
- PARKER, A. C. (1910). *Iroquois Uses of Maize and Other Food Plants*. Albany, University of the state of New York.
<<http://archive.org/details/iroquoisusesofma00parkrich>>.

-
- PARRY, J. (2012). From Beastly Perversions to the Zoological Closet: Animals, Nature, and Homosex. *Journal for Critical Animal Studies*, 10(3), 7–25.
- PICKERING, A. (1995). *The Mangle of Practice Time, Agency, and Science*. Chicago: University of Chicago Press.
- PIORE, M.J. & SABEL, C.F. (1984). *The Second Industrial Divide*. New York, NY: Basic books.
- RATTO, M., MEGAN BOLER, M. & DEIBERT, R. (2014). *DIY Citizenship: Critical Making and Social Media*. Cambridge, MA: MIT Press.
- RATTO, M. (2011). Critical Making: Conceptual and Material Studies in Technology and Social Life. *The Information Society* 27(4), 252–260.
- ROSS, A. (2007). Nice Work If You Can Get It: The Mercurial Career of Creative Industries Policy. *Work Organisation, Labour & Globalisation* 1(1), 13–30.
- SBICCA, J. (2012). Eco-Queer Movement(s): Challenging Heteronormative Space through (re)imagining Nature and Food. *European Journal of Ecopsychology* 3(1), 33–52.
- SCHRÖDINGER, E. (1944). *What is Life?* Cambridge, MA: Cambridge University Press.
- SEAVER, J. (1992). *A Narrative of the Life of Mrs. Mary Jemison*. New York, NY: American Scenic and Historic Preservation Society.
- SMITH, B. (2011). General Patterns of Niche Construction and the Management of 'Wild Plant' and Animals Resources by Small-scale Pre-industrial Societies. *Philosophical Transactions of the Royal Society of Biological Sciences* 366, 836–848
- SPARKFUN (2009, January 28th). *QCPete, Costumer Profile*. Retrieved from <<https://www.sparkfun.com/users/59173>>
- STITES, S.H. (1905). *Economics of the Iroquois*. Lancaster, Pennsylvania: The New Era Printing Company.
- TAUSSIG, M. (1977). The Genesis of Capitalism amongst a South American Peasantry: Devil's Labor and the Baptism of Money. *Comparative Studies in Society and History* 19(2), 130–155.
- TERRELL, J., KOFINK, A., MIDDLETON, J., RAINEAR, C., MURPHY-HILL, E. & PARNON, C. (2016). Gender Bias in Open Source: Pull Request Acceptance of Women Versus Men. *PeerJ PrePrints*. Retrieved from <https://peerj.com/preprints/1733.pdf>.
- TOUPIN, S. (2013). Feminist Hackerspaces Safer Spaces? *DPI magazine*. Retrieved from <<http://dpi.studioxx.org/fr/feminist-hackerspaces-safer-spaces>>.

- WAGNER, S. (1993). The Iroquois Influence on Women's Rights. In Sakolsky, R. & Koehnline, J. *Gone To Croatan: Origins of North American Dropout Culture*. Brooklyn, New York: Autonomedia. 240–247.
- WALTERSCHEID, E. C. (1998). Use and Abuse of History: The Supreme Court's Interpretation of Thomas Jefferson's Influence on the Patent Law. *IDEA: The Journal of Law and Technology* 39, p. 195.
- WASHICK, B., WINGROVE, E., FERGUSON, K., & BENNETT, J. (2015). Politics that matter: Thinking about power and justice with the new materialists. *Contemporary Political Theory* 14, 63-89.
- WERNER, K. (2008). Understanding and Reclaiming Money Creation: Our Experiences Creating the North Quabbin Timebank. In *Solidarity Economy: Building Alternatives for People and Planet*, edited by the Solidarity Economy Work Group, conference proceedings from the U.S. Social Forum, 139-154.
- WILLIAMS, L.D.A. (2013). Three Models of Development: Community Ophthalmology NGOs and the Appropriate Technology Movement. *Perspectives on Global Development and Technology*. 12(4), 449-475.
- WRIGHT, E. (2013). Transforming Capitalism through Real Utopias. *American Sociological Review*. 78(1), 1-25.
- ZITTRAIN, J. (2008). *The Future of the Internet and How to Stop It*. New Haven: Yale University Press.