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Cybernetics, design and regenerative economics

ABSTRACT

With unbridled exponential economic growth, earth systems and social systems are headed for catastrophic meltdown. Meanwhile, much of humanity is highly dependent on current institutions. Second-order cybernetics can help society come to grips with the enormous demand of adapting existing institutions for a regenerative economy. While the current trajectory of increasing consumption and rapid ecological decay will lead to collapse, the progress achieved by civilization can be vindicated by large-scale investment in regenerating natural capital assets, developing open-source technologies for the public good, and rebuilding local agricultural economies dedicated to health and well-being. It is recommended that regenerative practices are supported by academic institutions centered on place-based service-learning. A regenerative economy, in contrast to a growth economy, is part of the pursuit of the long-term establishment of a steady-state economy. This vision does not limit the possibility that humanity will make outstanding technological progress, explore space or merge with artificial intelligence – but argues that appreciating the nature's technology provided to humanity through eons evolution, and avoiding short-term self-destruction should be priorities.

KEYWORDS

ecological economics
service-learning
degrowth
sustainability
paradox
neoclassical economics

INTRODUCTION

> The more profound the problem that is ignored, the greater are the chances for fame and success.
>
> (Von Foerster 2003: 191)

Even ignorance has limits. Of concern is humanity's obsession with technological advancement against the background of environmental deterioration. Our most sophisticated artificial intelligence is barely comparable to the intelligence of a cockroach, according to physicist Michio Kaku, 'a [expletive], lobotomized, slow cockroach' (C-Span Website 2018: n.pag.). Meanwhile, species are going extinct at a rate faster than any period in the last 64 million years (Wagler 2011: 78).

One need not be an ecologist to understand our predicament. Most of earth's 7.6 billion human inhabitants participate in transforming natural resources into consumer products at a rate that accelerates every year. Humans and their livestock now comprise 96% of mammal biomass; human agriculture covers 40% of the earth's surface (Ramankutty et al. 2008: 1); twelve species now comprise 75% of humanity's food production (Food and Agriculture Organization 1999). In other words, the forces guiding the evolution of life on earth are increasingly governed by the short-term profit motive rather than long-term viability. In humanity's relatively short history with intensive agriculture, approximately half of the earth's top-soil carbon stock has been lost to the atmosphere, leaving once fertile land short of nutrients and life (Sanderman et al. 2017), while billions of kilograms of pesticides enter our soils and waterways every year (Alavanja 2009). The extinction of large animals is most apparent, yet it is death at the base of our food chain that is the most ominous. One 2019 headline from *The Guardian* delivered the message: 'Plummeting insect numbers "threaten collapse of nature"' (Carrington 2019: n.pag.).

Long-term exponential change is a difficult thing to grasp (Bartlett 1969) and yet mounting evidence suggests that the current trajectory is no longer viable. Confrontation with this evidence may produce 'eco-anxiety', defined by the American Psychological Association as 'a chronic fear of environmental doom' (Clayton et al. 2017: 68). This time offers a window in which scholars can imagine ways to mitigate negative impacts, but rampant uncertainty remains.

Alternative political–economic configurations have been proposed; e.g. the steady-state economy (Daly and Farley 2011) and the 'doughnut' economy (Raworth 2012) are both political–economic blueprints characterized by sustainability and social welfare. Even among those advocating for major institutional change, definitions of sustainability remain contentious, or more precisely, there is disagreement about what is to be sustained and how.

Having overshot the earth's carrying capacity, the transition to a desired state of sustainability is another issue – proposed sustainability transitions such as the Green New Deal have begun to capture the social imaginary, but sceptics question their practicality or suggest that projects of this scale might exacerbate current sustainability problems.

Through the lens of established polities and economic entities – those that do not value, measure or otherwise institutionalize sustainability – the transition to sustainability will appear sub optimal, backwards and inefficient. Thus, many activists challenge values and ideologies that underpin current

economic thinking. The degrowth movement (Schneider et al. 2010), advocating degrowth of the current economic system, is a poster child for such confrontation with status-quo economic thinking.

However, completely abandoning current institutions and starting from scratch is also not desirable or possible; in developed economies, physical infrastructure is built consistent with current economic structures. Further, most of the world's 7.8 billion human inhabitants depend heavily on current institutions. Thus, we are left to navigate a paradox, targeting a sustainable world using systems that are not, in their current form, sustainable.

CYBERNETICS AND THE SECOND ORDER OF SUSTAINABILITY

Cybernetics can help to define sustainability and guide the evolution of society towards more sustainable states. The term 'cybernetics' was derived from the Greek word *kybernetes*, meaning steersman, and was used in the mid-twentieth century by Norbert Wiener to mean the science of communication and control (Heylighen and Joslyn 2001: 2). Early cybernetic models had direct application to sustainability, emphasizing the distinction between a system and its material and energetic environment (Røpke 2004: 299). Economic concepts such as stock-flow resources and fund-service resources (Daly and Farley 2011: 70) have their origin in systems and cybernetic thinking.

Second-order cybernetics is characterized by self-referential (also called recursive, circular) descriptions such as the observation of observation, the control of control or the cybernetics of cybernetics. Second-order cybernetic theory suggests that self-reference (and/or the unity of opposites) makes the conception of an autonomous domain possible (Varela 1984: 5). Such recursivity reveals itself as 'sustainability practitioners' address the boundary between systems and their environments. Thus, second-order cybernetics has implications for the evolution of systems towards more 'sustainable states'.

Further, second-order cybernetics takes sustainability beyond the purely technical realm by suggesting that observations co-emerge with viable actions, emotions and even sense of identity (von Foerster 2003: 227; Thompson 2001: 4). The relationship between the observer and the observed implies that an observer must take responsibility for what is observed and the corresponding theory of causality. Physicist Heinz von Foerster said '[t]ell me how the universe came about, and I will tell you who you are' (1990: n.pag.). The same can be said of the cause of the ecological crisis. For example, if one blames the ecological crisis on the economy and desires to control the economy, one lends legitimacy to the boundaries that distinguish the economy. This person is then an 'economist', just as a theist attributes causal agency to God, and a physicist attributes causal agency to physical objects. The relationship between an observer and the observed is circular; fittingly, to observe can be defined either as 'to watch' or 'to conform' (*Merriam-Webster Dictionary* 2021b).

Von Foerster (1990) suggests that across all approaches to cybernetics what is invariant is 'circularity'. Various symbolic representations of second-order cybernetic logic have been developed. These include Spencer-Brown's (1969) *Laws of Form*, elaborated in Varela's (1975) calculus of self-reference, von Foerster's (2003: 225) toroid map of cognition and Kauffman's (2015) logic of elementary discrimination. All express an interplay between elements within a domain and the domain itself – linking the first and second order. This relationship between a distinction and itself, across levels of analysis, can be visualized using the interplay of spatial dimensions and elements as illustrated below.

At the root of any world-view or system (truth, idea, value, law or form) is a distinction.

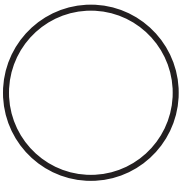

Figure 1: A distinction.

However, concealed (eventually) within this distinction, are two distinctions in a lesser dimension, the distinction and its inverse.

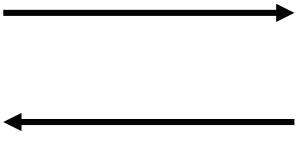

Figure 2: A distinction and its inverse.

These opposite statements appear to create a contradiction. However, rather than leading to cancellation, the polarity can form a union, creating a distinction in a higher dimension. For example, when a designer proposes the axiom 'less is more', the meaning of 'more' is conserved, and not 'cancelled' by its relation to its opposite 'less'.

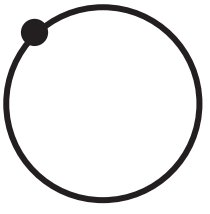

Figure 3: Equal and opposite poles.

If two ends of a rope represent alternative directions, or elements, or perspectives, we may lose the distinction between the two ends by tying the two ends of rope together, but we have created a new distinction between inside and outside the circle. In this illustration, we see that connecting elements in one dimension draws a distinction in another space. This represents the co-emergence of equality and inequality, or relation and distinction.[1]

Such themes of self-reference and/or the relationship of opposites have existed throughout times and across contexts, both undermining and undergirding logical thought. For example, in political terms Laozi wrote '[t]hose that would conquer must yield, And those that conquer do so because they yield' (1972: 19).

The same is true for the ecology of concepts and institutions that we bring to bear. At the core of sustainability is the understanding that life cannot exist in isolation. '[U]nless a corn of wheat fall into the ground and die, it abideth alone: but if it die, it bringeth forth much fruit' (John 12: 24).

1. In its ideal form, the two distinctions can be regarded as the same thing. Such recursive logic ties together first-order theories of circular causality, with second-order theories of self-reference and identity. This logic has illustrated the relationship between circular causality, homeostasis and objectivity in human cognition (von Foerster 2003: 244), and Godel's incompleteness theorem (Varela 1984), among other systems.

These rather esoteric themes may become more clear when applied to the economy in the following section.

ECONOMICS

Economics is defined by the analysis of production and consumption (e.g. *Merriam-Webster Dictionary* 2021a). Historically economists put greater attention on theories of the value of production not determined by consumer demand (Daly and Farley 2011: XX) but it is safe to oversimplify the pre-analytic vision of modern neoclassical economists with a basic distinction and co-determination of production and consumption. Production in the economy is largely determined by what people buy, and people buy what is produced. This relationship is represented by the circular flow of money.

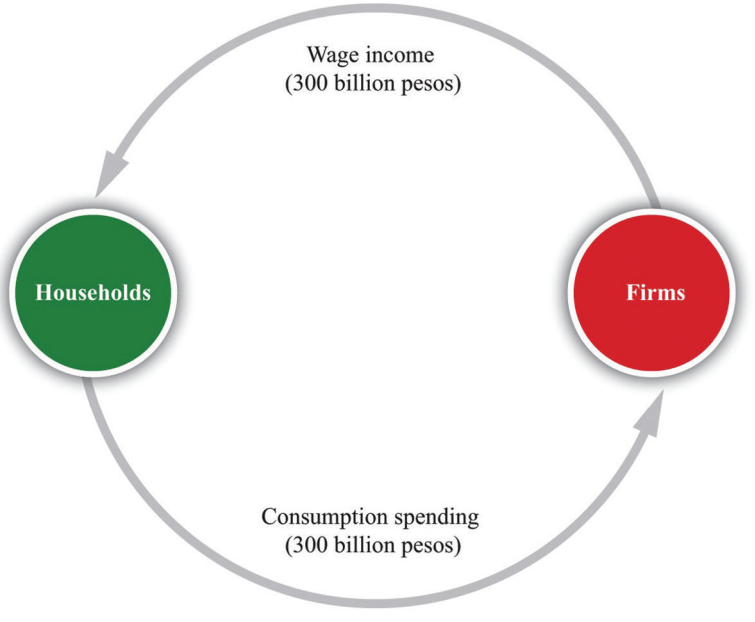

Figure 4: Circular flow of money (Saylor Academy 2012, Creative Commons Licence).

We typically consider economic production as the means to an end, the end being consumption by a consumer. However, in the market, consumption provides the financial means for production. Production and consumption both function as an end and a means to an end. This reciprocity, or reversal of hierarchy, forms the economic domain. As Immanuel Kant wrote, 'An organised product in nature is one in which every part is reciprocally purpose, [ends] and means' (2000: 281).

The circular flow of money is made possible because production can equal consumption.

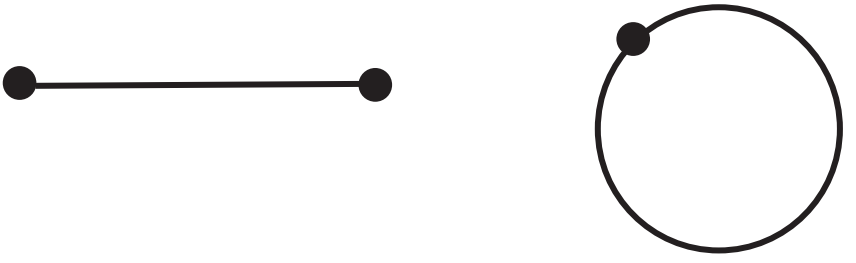

Figure 5: Production equals consumption.

Cyberneticists often recapitulate George Spencer-Brown's first directive in his work *Laws of Form*, which is '[d]raw a distinction' (1969: 3). One could also say, 'draw an equation', as the two functions mutually implicate. In either case, cyberneticists emphasize this moment of apparent agency. There are no external objective criteria by which production is equal to consumption. A cup of coffee is not the same thing as a handful of coins or a half-loaf of bread. The economic domain emerges out of the possibility of equating production and consumption using money. National accounts are formed out of the aggregate of these exchanges. As the US Bureau of Economic Analysis explains of their accounting 'as the circular flow diagram suggests, income is equal to product (GDI is equal to GDP)' (Pritzker et al. 2015: n.pag.). From the cybernetic perspective, it is apparent that the economic domain emerges out of this (in) equality between production and consumption.

Of course, equality of production and consumption rests on the assumption that money provides a consistent frame of reference across contexts. While one can never make a positivistic claim that money, or economic value provides a consistent store of meaning, the market does show degrees of self-consistency. If it were not for the relative consistency of currency, people would lose faith in the integrity of the market as happens in cases of rapid inflation and deflation. Here, we see the link between first-order and second-order cybernetics. First-order concepts of e.g. circular causality, dynamic stability and homeostasis affect the capacity of an observer to draw a distinction or relation in a 'sustainable' manner.

However, neoclassical economists have not embraced the cybernetic revelation – that such 'equality' and equilibrium is also a distinction, i.e. anything that exists, exists in an environment. As order increases inside the economy, order decreases externally. For several centuries, the economy has been growing exponentially and the ecosystem has been in decline. Economic equilibrium is not a mechanical fact, but at best a statistical probability maintained by energy throughput (Garrett 2015).

ECOLOGICAL ECONOMICS

Ecological economists have embraced a new pre-analytic vision of the economy, marked by the distinction between the economy and the ecosystem.

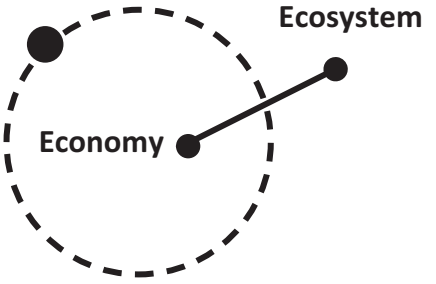

Figure 6: The pre-analytic vision of ecological economics.

To suggest that there is an environment, outside of which production does not equal consumption, is deeply threatening to the economic domain. Outside of the economic domain, essential characteristics of the economic equilibrium fall apart, and assumptions that follow also crumble, such as the assumptions that utility is continuous across time, that market allocation is optimal and that allocation is efficient. From this challenge can stem the rejection of using market instruments, prices or systems of valuation.

For some, the question of integrating economic and ecological domains is a non-starter. The framing of 'environmental externalities' captures this tension. Whereas some economists hope to 'internalize externalities' many ecological economists argue that this is not possible. Kapp argues that 'externalities' are better conceived as 'broad failures of the market system as a whole' (1970: 844).

However, while markets are often perverse or non-existent in the face of ecological and social complexity, second-order cybernetics suggests that one who draws a distinction (such as between the ecosystem and the economy) becomes responsible for integrating domains. First, ecologists need not distinguish the economy as a causal force. There are plenty of explanations nascent to ecological science that explain society's unsustainable behaviour, e.g. herd behaviours, addiction, dominance hierarchy, without relying on the economy. Ecologists particularly require the economy as an explanatory principle if they believe that the ecosystem does not naturally degenerate. If the ecosystem is intrinsically sustainable, it must be an external force, such as the economy, which causes it not to be itself. But this assumption is unnecessary. For example, contrary to the Gaia hypothesis, the Medea hypothesis (Ward 2009) suggests that mother earth is committing global matricide to return to its naturally microbially dominated state. In other words, it is in mother earth's nature to kill all higher life forms. If an ecologist adopts the perspective that ecological collapse is natural, there is no need to distinguish the economy.

If one is to draw a distinction between the economy and the ecosystem (and avoid infinite regress), a second loop must reconcile the distinction between the economy and the ecosystem.

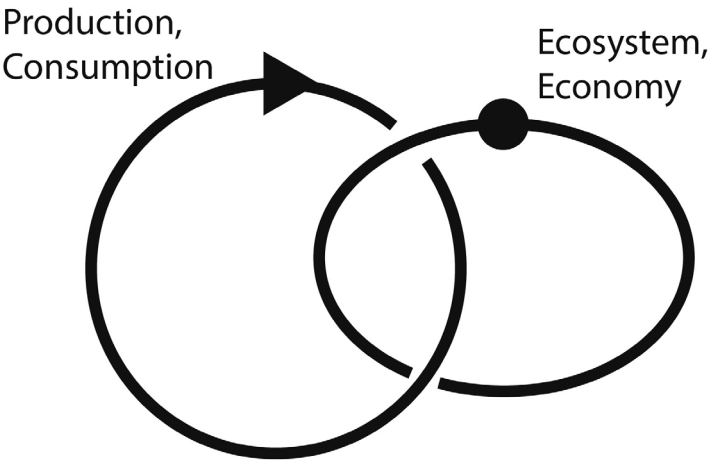

Figure 7: Two distinctions form the first and the second order.

The relationship between the economy and the ecosystem can be modelled as a cybernetic system with a 'first-order' and a 'second-order'. First-order cybernetics deals with circular causality and the observation of elements in a system (Heylighen and Joslyn 2001), while second-order cybernetics deals with a meta-circularity, e.g. the observation of observation (von Foerster 2003). In other words, only one loop can be perceived as 'real', or 'actual', at a time, while the other loop deals with self-reference, or the imaginary. These two loops already exist in economics. In the first order is measurement of consumer goods and labour in an economy. In the second order is the value of currency in an economy. If the value of currency changes (too much) in an economy, the economy is inconsistent with itself. A distinction between the economy and the ecosystem can be considered a distinction between the economy and itself, because in recognizing the value of ecological productivity, or nature's economy, we also devalue economic productivity,[2] meaning that the economy is inconsistent with itself, and production does not equal consumption.

A paradox results from the oscillation of the two circles. For example, an attempt to measure the value of natural capital may change the economic structures, which led to that valuation in the first place. These circularities can lead to a perceived relativism. For example, Malghan postulates '[i]n general, it is not possible to compare measured values of [sustainability] across spatial and temporal dimensions' (2010: 2264). However, theoretically, determining self-consistent results is possible over time when circularities are understood as the natural consequence of integrating domains or maintaining a distinction (without resigning to the advent of a new distinction).

EQUAL AND OPPOSITE

Paradoxically, a distinction between the economy and the ecosystem can only be established when a relation between the economy and ecosystem is established. If the relation between the ecosystem and economy is arbitrary, i.e. if measures of wealth, productivity and price are unrelated to ecological phenomena, then economic activity could theoretically become 'decoupled'

2. In recognizing the value of ecological productivity, or nature's economy, we also devalue economic productivity, or human-built assets, meaning that there is too much money relative to productivity. This suggests that humans have overestimated the value of economic value, or technological progress. Consider the case of GMO technologies that allow for increased use of pesticides. These same technologies lead to decline of pollinator populations, decrease soil fertility and pollute fresh waters while replacing ecological process (ecological technologies) that perform beneficial functions. When considering the ecological–economic impact of these technologies, it is apparent that they are 'really' worth much less than their market value or prior investment would suggest. Research already demonstrates that GMO development and pesticide increase in the United States and Canada have failed to increase yields beyond those in Western Europe where GMOs were not used and pesticide use decreased. This is a real-time allegory for the replacement of natural capital with human-built capital, i.e. for the replacement of economic technologies with ecological technologies, resulting in un-economic economic development. In aggregate, and in the long run, this trend represents an inflated value on technologies and economic assets.

from ecological impact. Then, the economy could presumably grow forever, and technological advancement could be the key to saving the earth.

An integrated ecological–economic perspective shows that this is utter fantasy – thus justifying the distinction, or boundary between ecological and economic activity. One profound discovery was made by Garrett (2015) in a comparison of global accumulated GDP (the aggregate of all previous GDPs) and global energy throughput. Garrett (2015) found a fixed scaling relationship whereby, e.g. a doubling of accumulated GDP led to a doubling of energy consumption. This relationship is fixed within 1 or 2 per cent from 1970 through the date of the article and continues today. Garrett writes: 'The observation is much like the basic expression of quantum mechanics […] the quantities they relate are not correlated but instead can be viewed as being interchangeable representations of the same thing' (2015: 4).

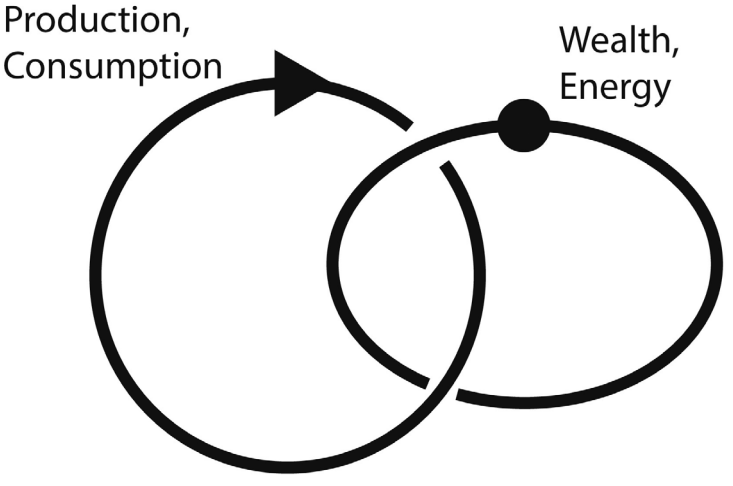

Figure 8: Equal scaling of wealth and energy throughput.

In Figure 8, the economy and the ecosystem (using wealth and energy as proxies), which could be represented as polar opposites along a single line, or distinguished in two dimension space with a circle, are set as equals, forming a second circle, integrating the inside and outside of the economic domain. The key insight is that economic growth corresponds to the relative complexity of an economy, a complexity that scales with energy inputs. The consequence is simple: given the finite nature of natural resources, and the fixed input of solar energy, a sustainable economy will not be a growing economy, but a steady-state economy – an economy that is not growing as measured by wealth or GDP. In economic terms, this implies that the ecosystem and the economy are equal. At any given scale, the resources used are equal in value to the wealth created through their use; the question only regards the sustainable rate of resource use and the structural complexity that is possible at that scale of economic activity. Further, Daly and Farley (2011) define 'optimal scale' as the scale of economic activity in which the marginal value of economic activity is equal to the marginal value of ecological productivity. This can include additional values such as concern for non-human life.

3. Of eigenforms.

A more philosophical interpretation forces us to reconsider the economy as an imposition upon nature, rather than as an expression of 'natural law'. For example, Czech's (2019: 74) trophic theory of money suggests that historically money emerged from agricultural surplus, and money still exists in relation to agricultural extraction today. Thus, monetary policy is ecological policy.

A REGENERATIVE ECONOMY

While most nations have, yet, been unwilling to intentionally degrow their economy to regenerate ecological and economic capitals, destabilizing forces such as COVID-19 will continue to offer opportunities. The challenge we face is that the economy is both 'too big to fail' and 'too big to be sustained'. This article uses the term 'regenerative economy' to connote an economy that makes use of society's current large-scale, centralized power towards the development of small-scale, decentralized economies. In other words, the goal of a regenerative economy is not to start over with entirely new institutions, but rather to invert the purpose of the economy in order to regenerate the assets upon which the economy is built.

Whereas some in the degrowth movement are hesitant to rely on conventional economic concepts and instruments, a regenerative framework sees existing concepts and instruments as tools for inverting economic processes for sustainability and justice. For example, when the concept of marginal value is applied to the macroeconomy, economic logic becomes self-limiting. 'What is the value of more economic activity as a whole?' As Kauffman writes[3] '[s]uch circularities suggest a possibility of transcending the boundaries of a system from within' (2011: 1). A regenerative economy turns the economy inside out, by placing value on what is 'external' to the economy.

The last few centuries have been a unique period of increased activity and economic growth, making the notion of natural capital regeneration exceedingly foreign. Cybernetic theory would suggest that in the long run, phases of regenerative economics, in which GDP is decreasing, supply chains are localizing, the labour market is de-specializing and inequality is decreasing will need to be equal to phases of economic growth.

A regenerative economy can be likened to building a staircase while walking down it. The floor below represents a new steady-state, but building stairs requires resource surplus. As economies reach limits to growth and debt increases, access to surplus will emerge in three ways. (1) Borrowing against future inflation, particularly for states that print their own money. (2) Targeting lower levels of GDP (and redistributing wealth). (3) Destabilization that temporarily frees resources to be combined in new ways; resources include money, technology, labour or built capital.

This transition may seem particularly severe given the high levels of financial leverage that exist in the economy. Accordingly, large-scale initiatives such as the Green New Deal are being proposed; it should be noted that debt resulting from the 1930's New Deal was ameliorated by the following war-time economy and GDP growth made possible by a large increase in natural resource extraction and energy use. A large-scale programme such as the New Deal would need to be followed by a contraction of the monetary sector and decreased resource use, if it were to be 'green'. It would also need to develop economic structures compatible with a less complex and less globalized economy, providing conditions for well-being with less consumption and production.

A regenerative economy would channel resources towards rebuilding local economies and generating technologies that serve the public good. Ecosystem structures and ecosystem services are often non-rival and non-excludable (Daly and Farley 2011: 159), meaning that it is difficult to develop legal structures for ownership by individuals. Thus, investments that target ecosystem services cannot be expected to yield the same returns that typical private-sector investments do. The benefits of green technology would be maximized if said technology were made widely available, rather than made prohibitive through conventional patent or pricing systems (Farley and Perkins 2013). This is particularly true for the development of technologies that target the poor, as these technologies are unlikely to generate significant revenue (Kubiszewski et al. 2010).

A new distinction/relation that is a progenitor for systemic evolution, implies not only new hierarchies, and change within existing hierarchies, but also new 'equalities'. These equalities are embodied in institutions and individuals that must develop alternative forms of trust, motivation and collaboration for the production of value not yet measurable or recognizable within the current system (e.g. Ostrom 2010; Ratner 2020).

Thus, a strong institutional precedent for a regenerative economy is the US land-grant university system. Passed in 1862, the Morrill Act established centres of agricultural and economic extension service that were used to conduct research for the public benefit and to disseminate knowledge. In the United States, several service-learning efforts have been launched that build upon such University-community engagement. Open science movements and other commons-based strategies are consistent as well.

While the development of regenerative agricultural economies must take precedent, myriad possibilities exist for a twenty-first-century Morrill Act; such efforts could include, for example, the development of digital platforms for communications, collaborative planning and civic engagement. One living example is in Front Porch Forum, a Vermont, US-based social network developed to bring neighbours together to discuss community happenings. This platform is noticeably distinct from mainstream competitors in not only its simplicity but also its procurement of content aimed to support social capital rather than drive revenue. Founder Michael Wood-Lewis is a good Samaritan, but it is possible that university anchoring and/or alternative ownership structures may help to ground such initiatives. Iterations of this model could, for example, expand to local economic coordination, e.g. targeting sustainable food systems, providing coordination and assisting in the recycling/reuse of resources.

Engaging communities and rebuilding sustainable local economies requires developing alternative institutions that are adaptive, experimental and creative as systemic boundaries are crossed. For example, research in Vermont found that large portions of the population were willing to donate land for urban agriculture (Erickson et al. 2011). Implementing transition through University-led community engagement and collaborative design creates the space for possibility and problem solving.

Active entrepreneurship and collaborative design facilitation would be well complemented by a more passive form of community participation, in the form of service-learning. Existing service-corps models could be adapted to service-learning as universities serve as a natural hub for coordinating service opportunities. This model could also translate to job-guarantee programmes in periods of significant economic depression.

Where economies and governments have grown with returns to scale, the challenge for a regenerative economy, i.e. the transition to a sustainable economy, is to identify solutions for local social and ecological contexts.

CONCLUSION

Cybernetic lessons will be key as we attempt to design a sustainable world. Dissatisfied with existing 'isms' – capitalism, socialism, communism, anarchism, etc. – many who appreciate the depth of our societal challenges are searching for new models of governance. However, no matter how radically different tomorrow's institutions are, they will not be developed from scratch. Rather, they will be composed from elements of past institutions. Building tomorrow from yesterday can result in confusion, resistance and paradox. Second-order cybernetics can help to guide this evolution.

Achieving sustainability peacefully will require design for a regenerative economy. A regenerative economy depends on proactive investment, but must target a sustainable scale of economic activity, and not merely add new capacity to the current unsustainable scale of economic activity. In the short term, this means designing for less. In the long run, this means designing with less, and designing less altogether ('less' in the paradoxical, cybernetic sense).

'A flower is made of many non-flower elements. The entire universe can be seen in a flower. If we look deeply into the flower, we can see the sun, the soil, the rain, and the gardener' (Thich Nhat Hanh, Love Letter to the Earth, 2013: 9–10).

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