Santa Fe Institute Working Group
"Envisioning New Modes of Cultural and Technological Change"
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Workshop organized by:

Doyne Farmer, Eric Beinhocker, John Clippinger, and Steen Rasmussen

Working group participants:

Mark Bedau, Eric Beinhocker, John Clippinger, Molley Crokett, Doyne Farmer, Nick Hanauer, Nick Pinkston, Leif Rasmussen, Steen Rasmussen, Piper Stover, and Joseph Tainter

Workshop summery written by:

Leif Rasmussen, Piper Stover, Mark Bedau, Eric Beinhocker, Molley Crokett, Doyne Farmer, Joseph Tainter, and Steen Rasmussen[1]

Background

A group of scientists, engineers, social scientists, philosophers, business leaders, artists, and entrepreneurs met at the Santa Fe Institute (SFI) in 2017 to seek clarity on an issue that has been discussed in the community for several years: to what degree are our physical technologies outpacing our social technologies? The central hypothesis of the meeting focused on the apparent widening gap between technological advancements and lagging cultural and social structures and institutions, causing a variety of complex societal problems. Some of the issues raised over the three-day workshop included[2] growing economic inequality within nations and the relationship to automation and digital monopolies, the changing nature of work, the rise of populism, degradation of democratic governance systems, loss of privacy and freedom, intensifying societal polarization, cultural dislocation, disinformation and a lack of faith in experts and empirical facts, and the changing nature of what it means to be human in a world of radically evolving technologies. The cumulative cross-disciplinary evidence produced during the session strongly indicated that current institutions, culture, norms, and behaviors are not adequate to face the challenges presented by emerging physical technologies. A critical task for leaders in scientific communities, business, government, the media, and civil society is to accelerate the pace of social technology innovation to limit this widening gap to reduce the risks of major social dislocations and conflict. How such social technology innovation and evolution might be accelerated in the face of these challenges is not well understood and urgently requires further research and deeper understanding.

[1] Point of contact: steen@santafe.edu
[2] Mainly from a Western perspective

Physical and social technologies

Humans create tools to solve problems. Such tools range from stone hand-axes, to the ox drawn plough, the steam engine, and the latest smartphone. In creating such tools humans use their knowledge to order matter, energy and information into something that is useful for their purposes. These methods and designs can be thought of as "physical technologies" (see Beinhocker 2006, p. 244 for a more formal definition). But abstract social organization concepts, such as government, laws, money, firms, and cultural norms are also tools. In these cases people use their knowledge to create methods and designs that order other human beings and their behaviors in ways that are useful for their purposes. These can be thought of as "social technologies" (Beinhocker 2006, p. 262). From a high-level perspective, human society is a complex system of interwoven social and physical technologies, affecting both the macro and micro level - from the individual to the global system. Several times throughout history, situations have emerged when our physical technology has outpaced our social technology. The industrial revolution is one recent example of such change, when new technologies harnessed new energy sources, created mass production capabilities as well as developed new means of communication, shifting the dynamics of labor and capital inputs and creating population upheaval, economic inequality and social unrest. In response, new policies, laws and systems of administration were created to help manage the impact of these new technologies, and living standards and customs changed. The workshop participants agreed that our world is once again entering a significant transition period primarily as a result of advances in our physical technologies.

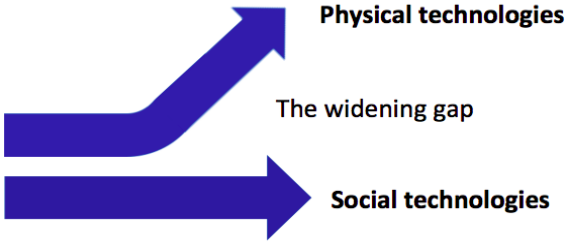

Figure 1: *Our physical technologies are outpacing our social technologies and the widening gap between the two causes increasing conflict and tensions through our society.*

What does it mean to be human?

Even though the symptoms and causes of significant transition periods are difficult to predict, several indicators and a multipronged approach can help guide further inquiry. The workshop proposed to identify and integrate indicators from: the physical technologies, the environment, social institutions, the economy, our culture as well as the more esoteric question: what it means to be human. These areas and their interactions are highlighted in the diagram in Fig. 2 with humans in the center acting as both facilitators and reactors to the dynamics of other framework elements. The historical dimension is defined as the temporal co-evolution of these areas and their mutual interactions.

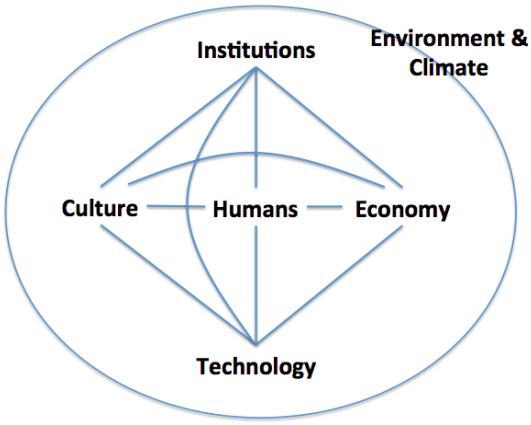

Figure 2: *The main areas and their mutual interactions: the physical technologies, the environment, social institutions, the economy, our culture as well as what it means to be human. History focuses on the time evolution of the above area as well as their interactions.*

Human innovation spurs development of new physical and social technologies, which creates reverberations throughout the system being explored using the approaches given in Fig 2. Our global economy, institutions, culture and the environment are always adapting to new human-influenced parameters.

Transition indicators

At the onset of the workshop a number of possible transition indicators were identified by Doyne Farmer. This list evolved during the meeting as the different perspectives and issues were presented and discussed. The resulting list is shown below. We note that these perspectives are U.S. centric, but find that analogous issues are present globally. This list includes:

Secular stagnation. It has been observed that there has been a multi-decadal relative slowdown in secular economic growth in developed countries versus their growth in the postwar period. Is this indicative of a fundamental slowdown in the rate of technological progress? Or is it just a temporary fluctuation due to other factors (e.g. demographics)? Or is there a problem with our metrics for measuring economic growth in a services and knowledge based economy? While scholars debate these questions it seems clear that there has been some important shift in the Western economic model of growth.

Automation. As the marginal costs of producing almost anything declines, there is widespread concern that automation may eliminate so many jobs that a large fraction of the population becomes unemployable. If this fraction becomes large this could drive major unrest in society.

Inequality. Inequality in America and certain other developed countries has been growing since roughly the 1970s. Closely related, real incomes have stagnated and economic security has decline for those at the bottom and in the middle of the spectrum. Though the gap is shrinking between developed countries and most of the rest of the world, change is still slow and the gulf is still enormous. Half the wealth of the world is held by 63 people.

Digital monopolies. The huge increasing returns to scale and low marginal costs associated with information-based products and services has created a host of new digital monopolies, including Facebook, Amazon, and Alphabet (Google). These companies have generated vast wealth while hiring very few employees, thus contributing to inequality.

Failing taxation system. While more goods and services are based on information and distributed worldwide through the Internet, corporate taxation is still based on the geographic location of corporate legal entities. This enables companies to arbitrage national tax systems by running transactions through entities in regions with no or very low corporate or sales taxes. While the OECD is working to change this practice through a new taxation collaboration framework shared among 100 countries and jurisdictions, base erosion profit sharing (BEPS) continues.

Limits to the market concept. There is an increasing conflict between the ideologies that seek to introduce the concept of a market to help control institutions such as public health, public education, and public taxation and the ideologies that believe such functions are best directed and controlled by a welfare state.

Privacy and freedom. The new digital monopolies mentioned above, as well as government agencies such as the U.S. National Security Agency have vast databases with information about everyone. We have little control over what data is collected and how it is used. Currently, the data is owned by the companies that use it rather than by the people who created it.

Authoritarianism, Nationalism and Populism. The wave of authoritarianism, nationalism and populism that is sweeping the world seems to be reversing the previously promising trend toward greater openness and democracy. What are the causes of this, and what can be done to prevent further retrenchment?

Polarization and cultural flux. There is a growing cultural divide comprised of anti-intellectualism, nativism and identity politics, which has been facilitated in part by new and controversial technology developments.

The breakdown of a perceived common reality. A closely related problem is the breakdown of objective truth in the perceptions of voters. Significant factors in this are the internet and social media, which are products of our emerging new technologies. Populist regimes have become adept at using these technologies to manipulate the truth to create reality bubbles.

Lack of collective awareness. Though our scientific knowledge is growing, awareness and understanding of that knowledge by leaders in politics, business, the media, and by the general public is not keeping pace. This makes informed productive public debates on technology issues difficult.

Loss of faith in experts. The financial crisis of 2008 and some of the trends above have caused many people to lose faith in experts.

Lack of new political narratives. Frameworks of right wing policies and left wing policies still dominate political discourse across the world. This narrative is rooted in the old industrial dichotomy of a power dynamic between the owners of capital and workers producing physical products in factories. Increasingly, this narrative no longer makes sense in a globalized economy dominated by knowledge products and services.

Inadequate institutions. Many industrial era institutions that have served populations well for decades may no longer be fit for the purposes such institutions were intended. Do we need to start considering entirely new institutions that can keep pace with our changing world? New modes of governance?

Environmental sustainability. If the global economy continues to grow, and if environmental impact per dollar of growth does not decline dramatically, then the world will increasingly face global climate changes as well as a potentially catastrophic and irreversible breakdowns in ecosystem services such as clean air, water, and biodiversity.

What does it mean to be human? The interactions of social media and the potential for cyber-augmentation as well as biological reprogramming indicate that human identity is becoming more plastic.

Below, workshop participants describe in more detail some of the noticeable dynamics of the transition, starting with new physical technologies already introduced and on the horizon.

Our Technology

As physical technologies become more intelligent and life-like, policy makers, businesses and civic society will need to work more closely with the science community to assess implications in the transition, with the goal of creating symbiosis with humans, not competition.

The ecology of technologies, including the converging biological (bio), information (info), nanoscale (nano), and cognitive (cogno) technologies, may all together be labeled as the BINC technologies.[3] These emerging technologies are already impacting and transforming our social structures and what it means to be human. The transformation is occurring at a dramatically faster rate than the previous transition from egalitarian hunter-gatherer societies to hierarchical agrarian societies and it also appears to be occurring faster than the more recent transition from agrarian to industrialized societies. But these emerging technologies may change our notions of what it means to be human both at a pace and in ways that humanity has never experienced before. Whether from gene modification, bio-augmentation, immersive virtual reality, or artificial intelligence, the historic boundaries between the spheres of physical technology, social technology and human biology are breaking down and merging in historically unprecedented ways.

Bio refers to technologies that maintain control over agriculture, food processing, health and reproduction and includes synthetic biology and artificial life. *Info* refers to technologies manipulating, processing and communicating information, including the Internet, virtual reality, mobile devices, social media, data storage, search engines and the Internet. *Nano* refers to technologies that manipulate matter on the atomic, molecular and supra-molecular level, with scientific and industrial applications cutting across many fields, including electronics, photonics, supra-molecular chemistry, functional materials, and brain science. *Cogno* refers to development of engineering methods that underpin thinking and learning - a fusion of cognitive science, artificial intelligence, and machine learning. For example different types of robotics may be developed in all four of the "BINC" areas. The emerging BINC ecology of technologies is not the same as "The Singularity" (Kurzweil, 2005) often discussed by futurists as the point in time when advances in technology, particularly in artificial intelligence (AI), would lead to machines that are "smarter" than human beings through artificial general intelligence (AGI). Also, our current technology driven transformation is sometimes referred to as "The 4th Industrial Revolution" (Schwarp 2016). However, this name suggests that we will remain within an Industrial Age societal framework, which is likely not the case.

The BINC technologies are already interacting with each other, forming an interlinked technological ecology, which as a whole will become greater than the sum of its parts. Future technologies will be built out of nanoscale components that process information and perform cognitive *and* biological functions. The BINC ecology of technologies will change the means of communication, knowledge sharing, products and processes of production, and in turn change how humans interact with technologies and with each other. They give rise to living and intelligent technologies where the interface between biological organisms and human artifacts becomes blurred. They also have the potential to change the current global constraints and scarcities in terms of energy and materials. Worlds envisioned in science fiction, in which humans modify themselves through nano-cyber-enhancement technologies and modify their children through genetic engineering, are becoming a reality. China is already experimenting in this area (Rana et al., 2018).

Several workshop participants discussed the opportunities and challenges of such new physical technologies. Physicist Steen Rasmussen, reviewing the cutting edge of artificial life and synthetic biology, disclosed that we are on the verge of creating simple evolving life-forms, so-called protocells, made from nonliving organic and inorganic materials (Rasmussen et al., 2015, Dogterom et al., 2017). Additionally, "swarms" of microchips (smart dust) in chemical systems can interact and generate life-like behaviors similar to microorganisms (McCaskill et al, 2012, Funke et al., 2016). It is clear that technologies that blur the line between nonliving and living materials will have profound applications - ranging from novel functional

[3] These technologies are sometimes referred to as the NBIC technologies, see Roco & Bainbridge 2002. From years of stakeholder discussions on technology and cultural transformation issues it is our experience that "BINC" is an easier acronym to remember and a more appropriate term to use, see e.g. Andersen & Rasmussen 2015.

materials, unconventional computing, human health support, to earth environment and space applications. More imminent, our technological ability to now genetically modify the human germ line of our children at low cost using CRISPR/Cas9 (Zhang et al., 2014) and other technologies will have profound and unforeseeable consequences as cultures and ethical values about experimentation and science in this area vary greatly around the world (Cyranoski, 2017).

This led to a group discussion about transhumanism (Transhumanism, 2018). Humanity can potentially alter the physical nature of human beings to make ourselves smarter or more cooperative by upgrading our biological hardware, which would give us the capacity to upgrade our cultural software. This could be done through genetic or cyber engineering. We could be the first species to create our own successors. Currently this is far-fetched, but transhumanism provides an alternative approach to basic income, namely modifying human beings so that they remain useful. Of course there are dystopian possibilities with this technology as well, such as engineering humans for military purposes, or creating a new elite of transhumans with capabilities not accessible to the general population.

Rasmussen also demonstrated how bio-inspired alternatives and distributed data storage architectures are under development and could form the basis of a "citizen-centric" and distributed Internet of Things (IoT), offering a new level of cyber-privacy and security (Monti et al. 2017, Monti & Rasmussen 2017). Such architecture would provide novel implementation possibilities such as distributed community social networks, crypto currencies, state administration, and democratic access to the means of production through advanced, distributed, and digital manufacturing, such as "personal fabrication," devices that will "3D print" just about anything. All of this would provide a very different path from the centralized data management offered and controlled by cloud computing. Indeed, how policy-makers choose to implement and regulate new technologies will dictate the shape and form of our future society.

Inventor and Silicon Valley entrepreneur Nick Pinkston, CEO Plethora, also disclosed several updates on digital manufacturing process technology disruption. Pinkston expressed reservations about the potential for mass adoption of distributed, personal fabrication devices. Although distributed digital fabrication technologies exist and are becoming more robust, Pinkston argued that human culture today tends to acquire the "best products" resources allow. Practical, perhaps more mundane but still functional and locally manufactured products may remain less attractive than resources from other locations, he added. Local do-it-yourself (DIY) manufacturing also may have issues competing on price and resources in today's economy. Finally, easy-to-use DIY interfaces still lag behind cutting edge technology capabilities.

Fotini Markopoulou, physicist and CEO *doppel*, provided perspectives on how these new technologies, through empathic engineering and due to the plasticity of the self, rapidly can blur the physical boundaries of the human body. Our body is key to how we think, feel and behave, and our body itself can be hacked. In a presented example, a wristband with a sensor and an actuator can detect a test person's arousal level through heartbeat frequency and skin temperature. Subsequently, it can lower the arousal level of the test person by gently tapping the wrists at a decreasing frequency below the heart rate. The heartbeat will follow the tapping rhythm and the arousal level will decrease in the test person. Another example of body hacking is illustrated in an experiment where flash cards are laid out on a table in front of a test subject. By using a remote infrared camera the heartbeat of the test person can be identified. Using this information to control the frequencies of blinking lights underlying the flashcards can affect a subject's card choice. In 90% of the tests, the test subject choses a card overlaying blinking lights that mimics the frequency of their own heart rate. These kinds of discoveries could already today be used to manipulate a subject's decision-making behavior, creating an array of ethical and policy implications, which will be discussed further below.

Professor Mark Bedau reported how the evolution of technologies can be understood and quantified using patent data as a proxy (Valverde et al. 2007, Chalmers et al. 2010, Buchanan et al. 2011). The genealogies of

specific technologies can be constructed by tracing how individual patents are referenced and continue to be referenced. This means that a particular technology can have many "parents" (referencing multiple previous patents) and at the same time have multiple "off-spring" (referenced by later patents), which differs from biological evolution with at most two parents. Tracking the patents with the highest number of citations can identify new important technology traits and mutually supporting technologies can be identified by similar methods. Contemporary natural language processing and machine learning algorithms, including topic modeling and semantic vector spaces (Le and Mikalov 2014), can also be used to identify how technologies influence each other. One of the unique properties observed by studying the evolution of technology is the socio-technical systems' apparent ability to continue to create novelty: The technological evolution seems to be open-ended.

Professor and historian Joseph Tainter emphasized that even though technology seems to be outpacing our social technologies, it may be possible to foresee an eventual decline in the rate of this process. Institutionalized innovation as we know it today is a phenomenon of industrialized societies. Past societies innovated infrequently. The challenge is that as an area of research develops, the research problems become harder and more complex. Innovation fields then evolve from lone-wolf scholars to large interdisciplinary teams and expensive institutions. As this happens the research process becomes more costly. Researchers have shown that the sizes of academic teams grow continually larger (Wuchty et al., 2007; Jones et al., 2008), indicating that greater intellectual diversity is needed to address research problems. Strumsky et al. (2010) and Tainter et al. (2018) have shown that technical innovation leading to patents requires more innovators and greater complexity over time, and produces diminishing returns in patents per inventor. It takes more and more resources to achieve an innovation meriting a patent. From 1974 to 2012, productivity measured as U.S. patents per inventor declined by 22 percent. This decline in productivity can be seen even in the dynamic field of information technology. If this trend continues, high-frequency innovation must someday reach an economic limit. Since innovation is needed to solve societal and environmental problems, this could become a critical challenge for the future. In contrast, however, and not withstanding the reduced rate at which new technologies are introduced, the generation of novel technological combinations enables a practically infinite space of technological possibilities, This upward trend based on technology combinations is also reflected in data (Youn et al., 2015).

Bedau concluded by discussing how to develop and adapt ethical principles to the new reality created by rapidly evolving BINC technologies (Bedau and Triant 2009). Traditional risk analysis weighs the pros and cons of a technology and assesses uncertainties, and it works well for relatively well understood technologies. However, traditional analysis is virtually unusable for emerging technologies based on novel principles applied to novel domains, which is the case for most of the BINC technologies; our inevitable and ineliminable uncertainty forces us to "decide in the dark" (Bedau and Triant 2009). Extra caution is one understandable reaction to deciding in the dark, and the so-called precautionary principle seeks to restrict the use of technologies that might be deemed harmful, even when the risks are uncertain. The main challenge applying the precautionary principle to the BINC technologies is the principle's tendency to promote stasis and forgo potential new benefits to humanity, resulting in a myopic perspective on our future. Thus we are left with a significant challenge of developing new ethical frameworks for our uncertain future, in part generated by our new technologies (Bedau 2014).

Our Economy

Several attendees discussed how social and physical technologies are affecting the global economy. Since the industrial revolution, various ideological struggles emerged focusing on how best to organize society with a

well-functioning market. The market is a human behavioral-cultural-institutional construct for producing goods and services, exchanging goods and services, providing employment, and managing risk. It has been one of the most consistent structures in recent human societies, evolving in complexity together with society and technology.

In the discussions about the inner workings of the market and capitalism, one can distinguish between three main categories:

- *Traditional capitalism*: A firm that is owned by its shareholders and that performs most of its operations by itself or through contractors.
- *Distributed platform capitalism*: Firms like AirBnB or Facebook enable individuals and organizations to interact by proving a common transaction platform.
- *Cooperative un-capitalism*: Organizations like Wikipedia or open source software projects enable individuals to cooperate to achieve their eudemonic goals, without necessarily making a significant profit while doing so.

As discussed earlier, the huge increasing returns to scale and low marginal costs associated with information-based products has created a host of new digital monopolies, including Facebook, Amazon, and Alphabet (Google), not to mention media and cable conglomerates such as Fox, CBS, Spectrum and Comcast. These companies have generated vast wealth while hiring relatively few employees for their scale thus making a growing contribution to inequality. Whereas monopolies in the past tended to control material resources, such as consumer products or energy, today's monopolies accumulate and control access to information. As noted by lawyer Leif Rasmussen, this boom in monopolies based on distributed platform capitalism is a result of technological changes, which has allowed a specific type of market failure, "Mandatory Participation Third Party Payer markets" (Clemons and Madhani, 2010), to propagate. Regulating previously obscure and abstract market failures increasingly will become a challenge.

Further, these new monopolies have extensive knowledge about almost everyone. Since our activities in cyberspace and social media plays an increasing role in defining our identity and shaping human interactions, the "commodity" that these companies have monopolized is closely related to our identity as human beings and our fundamental modes of communication with each other.

Prominent market advocates, primarily from neoliberal schools of thought, suggest that too much state intervention in the market place creates an environment for actual (or the potential for) gross infringement on personal liberty (e.g. Hayek and von Mises) as well as loss of economic efficiency (e.g. Friedman). On the contrary, advocates of democratic socialism have historically emphasized the necessity of the state to regulate or organize certain aspects of the economy in a mixed market/state model in an attempt to create greater equality, stability, and a higher net benefit for all (e.g. Keynes). In modern history, much of the political discussion around regulating markets/economy is about the manner and degree in which people and entities, such as governments, should participate in economic affairs.

It is important to recognize that well-functioning markets are by nature a set of regulated interactions. For instance, if one wishes to acquire a good or service, one is not allowed simply to take it from another person. Complex laws and social conventions regulate most market transactions. In general terms, our human experience has found that total command economies are undesirable, as are completely unregulated economies. As such, there is an increasing conflict between the ideologies that seek to introduce market concepts to organize and manage institutions such as public health, public education, electoral politics, and public taxation, and the ideologies that believe such functions are best directed and controlled by a welfare

state. These debates on market versus state have framed political discourse in the West throughout the postwar period.

Entrepreneur and business leader Nick Hanauer and economists Eric Beinhocker and Doyne Farmer (also a physicist), discussed how social and physical technologies currently affect the global economy and have the potential to change this historical political framing. It was emphasized that while market capitalism as a general system has empirically delivered more human material prosperity and freedom than alternative systems, our current version of capitalism as a "social technology" is under strain from various forces, including physical technology and globalization, and for several decades has not been delivering benefits equitably in many countries.

The neoliberal version of capitalism has dominated economic ideology in the Western world from the 1970s, at the same time economic inequality within Western countries has grown. Closely related, incomes have not risen for those at the bottom and in the middle of the spectrum (Piketty 2014). Though the economic gap has shrunk significantly between developed countries and most of the rest of the world, and several formerly very poor countries now have large middle class populations, gulfs in wealth remain enormous. Today the wealthiest eight people own as much wealth as the poorest half of the total population on earth (Oxfam, 2017).

Hanauer and Beinhocker suggest that an important reason for the failures of modern capitalism is that neoliberal/neoclassical ideology fails to understand how capitalism actually works. They introduced a new framework for understanding capitalism that starts with re-thinking the notion of economic value. They proposed that at a fundamental level, when a product or a service is priced and sold, it is used to solve a human problem, need or desire (Beinhocker and Hanauer, 2018). Thus the wealth of a society *could* be measured by the availability of solutions to address human problems, needs or desires. Measuring access to solutions could become a fundamental metric for wealth. For example, while value is measured by the price for the purchase of a basket of goods and services, Hanauer and Beinhocker suggest similarly that a basket of "solutions" could be aggregated and made available to an economic entity. For example, healthcare provides a valued solution for sickness; the availability of healthcare for consumption can be measured with a high degree of accuracy. Such a solutions metric has the capacity to change the way a culture thinks about a future economy amidst our changing technologies and environment.

The most widely used measure of prosperity is GDP per capita, which as an average does not convey distributional information, and as a monetary measure does not necessarily reflect impacts on human material well-being. In the U.S. market, with a high GDP per capita, access to solutions like healthcare, cheaper clean energy and quality food are still limited for vast segments of the population. Also GDP does not distinguish between goods with positive impacts on material well-being (e.g. drugs that cure cancer) versus goods with negative impacts (e.g. cigarettes which cause cancer). Adjusting use of economic metrics could help policy makers design policies and measure actions, which more directly focus on the material well-being of the broad population, instead of relying on the narrow focus of the GDP metric.

Beinhocker and Hanauer further argued that such a theory of value as "solutions to human problems" could provide a basis for a new theory of growth and a broader understanding of what makes effective capitalism (this is described in detail in their forthcoming book *True Capitalism*). They noted that solving human problems requires the creation of order in both our physical and social technologies. This in turn requires complex, large scale, and sustained cooperation among non-kin. They argued that such large-scale cooperation requires the evolution of institutional structures and cultural norms that facilitate economic, social, and political inclusion and are founded on fair, reciprocal social contracts. They contend that the breakdown of modern capitalism is due to a breakdown in these institutions and norms (facilitated by

neoliberal ideology and politics), which in turn has led to a loss of inclusion and fairness. Thus a critical question is how we build a new, inclusive and fair model of capitalism given the accelerating changes in technology and society discussed in the workshop.

Society will need to create and articulate the moral and ideological parameters for how our future economy should work. Technological changes underway are already highlighting potential conflicts between moral and ideological objectives. Take genetic engineering in humans and other life forms as a prime example. Genetically modifying the human body to become resilient against disease or aging, or to increase intellectual capacity, may be valuable to humans, offering a solution to problems or shortcomings of the human body. Indeed, new modification technology would affect standard GDP indicators. However, current GDP indicators cannot capture the broad consequences of such a "solution". In addition to potential ecological impact, the social implications of genetic modification technology could be radical. How should communities operate a fair and just economy when only some people might have access to a valuable and powerful human body enhancement technology? If such a technology is made available on the "free market", should some but not all people be able to purchase such technology? All participants debated these and related questions about economic structures that might be envisioned in a post-industrial, BINC technology era.

Compounded with the arrival of the many disruptive physical technologies affecting our economy and social systems, attendees agreed that capitalism will need to evolve and adapt to the new reality. If not, a new disruptive economic system and ideology of resource administration might take its place. Doyne Farmer emphasized, for example, that there is an untapped potential to make significantly better human decision-making models and thus improve our understanding of the important ongoing societal and economic processes by combining insights from multiple scientific disciplines, including psychology, sociology and anthropology traditionally removed from economic theory, and by integrating all disciplines with the explosion of available real-time data. Such insights would also be valuable to explore computer simulations of possible solutions to problems, as well as potential scenarios that might be more desirable than others.

Our Institutions

Institutions are also affected by technology adoption. Radical changes in economic and cultural dynamics routinely necessitate change in governance systems and institutions. Administrative states emerge when the complexity of a society reaches a level requiring regulation to maintain stability and order. Institutions are by and large reactionary by design. For example, the birth of the modern Western administrative state was created to stabilize labor markets and social upheaval as the industrial economy developed. Otto von Bismarck is typically credited with establishing the first modern welfare state in 1886 giving the state significant control of the economy and providing a social safety net for workers to mitigate uncertainty due to the new conditions created by the industrial transformation. Since then, nation states have continued to use a growing amount of national resources to maintain increasingly complex societies. Workshop participants proposed that government administration and institutions would be forced to evolve as the full impact of the BINC technologies arrives.

The industrialization era spurred large state administration systems to regulate industry, labor policy and the environment, to manage resource use, and to act as a trusted third party, ensuring food was safe, financial institutions were stable, and citizens had access to healthcare. The administrative regulation of labor, as outlined above, is only a small part of this institutional revolution in which trusted third parties took on

increasing roles in the economy and governance of society.

Most trusted third parties, including state administration, will need to evolve significantly and perhaps be replaced altogether as new algorithmic innovations, such as blockchain-style automatic ledger technology, become more ubiquitous. Blockchain-style technologies can guarantee that every transaction is valid and true, just as a trusted third party can do (e.g. a bank or a state administration). However, it is done by an algorithm that makes sure transaction details are distributed in multiple copies to a network, which makes it virtually impossible to cheat without the whole network becoming aware of the cheating. Thus, most transactions currently conducted through banking, taxation, healthcare benefits, etc., could potentially be done much faster, much more reliably, and much cheaper through automated blockchain-style algorithms.

Indeed, both for commerce and government administration, blockchain-style technology will have a significant impact on transparency and security. For example, the international shipping company MAERSK already uses blockchain technology to keep track of shipping containers. For both MAERSK logistics and government regulators, remote access to the whereabouts and contents of containers improves operation efficiency and safety, as the self-authenticating ledger is very difficult to corrupt. Other examples include diverse activities such as banking, livestock movement, and even identification of diamonds (Fortune, 2017).

John Clippinger, research scientist, discussed a number of ways blockchain-style technology likely would disrupt traditional operations of industries and government. He stressed that traditional banking institutions will be particularly challenged in the near-term. Already, the role of cash is diminishing, particularly in China and other parts of Asia with non-traditional financial agents such as Tencent and Alibaba providing virtual currency exchange. Workshop participants discussed several financial scenarios where blockchain-based crypto currencies could become mainstream, possibly displacing the role of traditional banking institutions. Further, crypto currencies could act as tokens for certain goods and services, in parallel with our current generally accepted fiat currencies. New social technologies in the form of government regulation of financial markets and crypto currencies will also be necessary to ensure stability and keep criminal activity in check. Such regulations would need to include guidelines for intelligent algorithms, which most governments at this point do not have the competence to manage.

Additionally, institutions – both public and private - are grappling with the future role of privacy as technology increasingly is able to access the human body's "coding" through genetic, biometric, search engines, credit card data, and social media systems, which are owned by few multinational companies maintaining personal and business data. As such, this power of corporations could easily affect the functioning of democratic institutions and/or market-based economies. Examples of this include alleged election manipulations both in the 2016 US presidential election and the 2016 Brexit vote (Cambridge Analytica) – both examples of big data, individually-tailored manipulation campaigns targeting entire segments of a population. Scientific documentation shows how proprietary search engine algorithms can skew democratic elections just by sorting "good" information for one candidate to the top of a search, while sorting "bad" information to the top of a search for other candidates (Epstein and Robertson, 2015). Breakdown of a fair market is widespread today due to the growing technology-induced so-called mandatory participation third party payer business model used e.g. by Google, Amazon, AirBnB, UBER, etc. (Clemons and Madhani, 2010) .

The Internet of Everything (IoE) that includes the connection of people, businesses, government as well as the Internet of Things rapidly engulfs most aspects of our lives. This includes communication, data storage, banking, commerce, digital manufacturing, health, transportation, etc., why it becomes increasingly urgent to ensure that the governance of the IoE develops in a transparent and democratic manner to guarantee

freedom, privacy and security of citizens who seek such civil rights. There are significantly different perspectives on data ethics (see e.g. DataEthics.eu/en) across the globe, where the EU with the new GDPR (GDPR 2018) laws are leading the way toward personal data protection, while China, in the other end of the spectrum, is moving in the opposite direction with massive state sponsored private data surveillance systems (Mitchel and Diamond, 2018).

New legal and technological systems under development that could work in tandem with algorithmic technologies to protect our civil rights and return an individual's autonomy over his/her data and 'self code' as the IoEs evolve. Steen Rasmussen disclosed that such IoE governance architectures are already being designed; one example is called RAIN (Monti et al. 2017, Monti & Rasmussen 2017), which is an encrypted, redundant, distributed ledger communication and data storage system based on transaction schemes similar to blockchains.

Our Culture

Human culture is another crucial element of the transition framework. Human thoughts and behavior patterns as well as arts, beliefs and products are affected greatly by technology, varying region-by-region. The human brain evolved over millions of years in the context of face-to-face, small group interactions that exerted selective pressures on the development of social emotions like shame, empathy, envy, guilt and outrage. These emotions promote cooperation at a scale unmatched by other species, which has played a critical role in human survival and flourishing.

Psychologist Molly Crockett demonstrated how emotions and technology are beginning to clash with our evolved biology through her study of how modern social media tools influence social emotions like moral outrage, which motivates punitive behavior when another human violates a social norm (*e.g.* fairness). Expressions of moral outrage serve two broad functions: first, they send a signal that violators of moral norms will be punished, thus bringing benefits to the social group by incentivizing cooperative behavior (Fehr & Gachter, 2004). Second, expressing moral outrage signals one's own moral quality to others – someone willing to incur costs to punish a norm violator is less likely to violate that norm themselves (Barclay et al. 2006; Jordan et al. 2016).

Crockett presented data suggesting social media might be amplifying moral outrage in our culture in several ways. Moral-emotional content is more likely to go "viral" on social media (Brady et al. 2017); thus engagement-driven newsfeed algorithms select for such content and prioritize it for display. Consistent with this, data from a study of moral emotions in daily life show that people experience more outrage from content they encounter online than in person or through traditional media (Crockett 2017). Furthermore, social media lowers the costs of expressing outrage. Offline, expressing outrage is risky: someone who violates a norm might physically retaliate if confronted. Social media, however, removes the risk of confrontation, which may amplify outrage by lowering the threshold for its expression. As it is easier than ever before to express outrage on social media (*see:* Brexit, the 2016 U.S. elections, responses to policies of the Trump administration), there is a concern that the original function of moral outrage – punishing social norm violations – may lose its "bite", as signal becomes lost in noise.

With a significant portion of the world's population now communicating through social media, an "over expression" of strong feelings as moral outrage runs the risk of alienating humans from one another – reducing social cohesion and a sense of shared reality. Companies like Facebook have designed their online communities to segregate like-minded users, hindering diversity of thought. Research shows that moral expressions are more likely to be shared amongst ideologically similar individuals (Brady et al.

2017), which may contribute to growing political polarization. A side effect of this business model is exploiting human behavior in ways that reduce social cohesion.

Another group discussion regarding human nature and culture focused on *hedonic vs. eudemonic purposes*. What is the true nature of our culture and goals? Under the hedonic hypothesis, we act to maximize pleasure (utility). Under the eudemonic hypothesis, we act to have meaningful lives. Are we approaching a critical point in human evolution and culture where the fundamental nature of what it means to be human is about to change? From hedonic to eudemonic goals?

Our Environment

Humans are the prime example of approximately seven species on the planet classified as "eco-engineers", which means we are able to create significant changes in a natural environment to meet an objective. Threats to our Earth's environment, according to traditional risk criteria, are assessed by how devastating an action could be to the environment in *relation to oneself*. A well-documented risk to our environment is a continued and increased emission of greenhouse gasses that is causing significant climate changes. The world's increasing demand for cheap energy, which since the industrial revolution has been generated by coal and later also by oil, is attributed as one of the main causes for CO_2 emissions. The emerging BINC technologies, together with new social technologies (economic and legal frameworks as well as belief systems), may accelerate the move away from primary energy production based on coal and oil. While manipulating the natural environment for the benefit of humans has been an endeavor since before the earliest agrarian culture, as we continue to manipulate our natural ecosystem, the risk "to oneself" will change. Autonomous, AI based defense robots and drones pose a risk, as do genetically-modified organisms or novel life-forms interacting with existing living organisms. The new BINC technologies introduce new risks, as all new technologies do, but many of the environmental risks of the BINC technologies are still unknown.

Possible solutions and concluding remarks

A few of the many proposed solutions discussed at the workshop to consider and debate are highlighted below:

Take control of our private data. Acquire and use the vast quantities of data that are already collected to help improve society as a whole rather than to make profits for the few. Preserve privacy and allocate economic value of data to the individuals who generate it. A technological solution may include implementation of citizen-owned, redundant, encrypted data storage architectures as discussed above. Such architectures could also form the basis for a citizen-centric, blockchain style, governance architecture for the Internet of Everything.

Develop a new school of economic thought. Create alternatives to neoliberalism and other older style economic structures and narratives. A new movement could develop and supply intellectual leadership. As discussed above, such a new social technology could be based on a more appropriate definition of wealth, for example, by measuring "the production of and access to solutions to human problems" and a deeper understanding of how such solutions are created, notably through human cooperation and the evolution and co-evolution of physical and social technologies.

Develop new narratives. New narratives are necessary to make sense out of our changing world and provide a more realistic view of technological and cultural change that can be absorbed by the average lay person. As discussed above, the old industrial narratives, which seek to divide politics into "left" and "right", can and should be updated to fit the new reality, where the political fault lines increasingly are defined by how we implement new technologies, restrictions on our personal freedom and power due to loss of privacy, economic (in)equality, cultural diversity or conservation, and environmental sustainability.

The discussion framework created by the workshop participants depict a human-centered push-pull relationship between new and arriving physical technologies and our existing and lagging social dynamics - including economic systems, institutions, culture and the environment. Such a framework could be used to further communication among scientists, government, business, artists, etc. to better understand what it will mean to be human as more post-industrial, BINC technologies are introduced. Creating a roadmap of various scenarios and options the human species should consider in the months and years ahead could help clarify both the many new great opportunities and minimize negative or unpredicted outcomes to the detriment of the human race and the planet. Humans can and should think about ways to expand and implement physical technologies in responsible ways while also updating accompanying social technologies to new physical realities.

The Santa Fe Institute has pioneered the use of complex adaptive system tools to help articulate the interconnectedness and emergent properties within systems. A change in one element can have significant consequences on another and on the system as a whole. The complicated and at times uncomfortable conversations about how humans can or should engineer new technologies to help provide solutions to human problems and needs on planet Earth should continue.

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