REFLECTION; the challenge of our time: to achieve the transition to a -global- economy that supports a just society within ecological boundaries.

April 2024, Arie Voorburg

The operating system of our economy is broken. While the take-make-waste model has generated growth and prosperity, it has also caused multiple crises. Systemic redesign, from value creation and business models to innovative technologies, regulations and social outcomes. How can we strive for a regenerative economy?

This reflection is composed with 'a little help from my friends' and it does not make for feel-good reading. It raises awkward questions about the relationship between economic growth, inequity, DeepTech, resources and geopolitical strength. Changing geopolitics and shifting powers concerns economic, fiscal and monetary policies, trade and investment flows, and political developments on a national and international scale, and the effects of these factors on international politics and financial portfolios and company valuations.

THE SHORT VERSION

The economic transition implies redefining economic and financial logic to preserve, regenerate, and enhance our renewable resources, ecosystems, and their biodiversity and related ecosystem dynamics. It is now increasingly understood that continuing along development pathways based on global, linear, fossil-based and GDP-oriented economic progress is literally unrealistic to expect this model to continue forever. There is also clear evidence that the increase in global GDP over the past few decades has not led to significant economic progress for most: socio-economic inequalities are growing as the rich become richer. Policy, business, and society have developed shared values and discourses (*culture*), rules, institutions and networks (*structure*), and routines (*practices*) geared towards progress, growth, and innovation through markets over a period of decades. This growth-based orientation solidified under the influence of globalized markets, financial systems, and related facilitating structures. In this process, the financial system has become increasingly detached from the real economy and has incorporated incentives that reward trading and speculation instead of long-term wealth creation. At the same time, the financial sector moved from being seen as largely 'unproductive' – mainly existing to facilitate the market economy – to a productive and central part of the economy while extracting an

increasingly large share of revenue generated by other sectors. To support growth, finance has excelled in creating financial value and profit.

On a micro scale, these structures and ways of thinking in terms of economic and financial growth and optimization have led to a culture of seeing people as ‘rational economic agents’ and ‘consumers’ rather than human beings with different values, aspirations, emotions, and roles in society.

The system is increasingly targeted for supporting inequality, tax evasion, and for ignoring ecological and social value, while significant attempts are made to stimulate finance for good and green growth.

A transformative shift to an economy that prioritizes nature and well-being over money, inevitably requires new forms of governance, strategy and finance. It requires a double materiality perspective on sustainability: not only financial materiality necessary for understanding the impact of sustainability on a company’s development and performance (internal impact), but also environmental and social materiality for understanding the impact of a company’s activities on nature and society (external im

The number of large but still developing economies and their relative economic weight are likely to increase during the next 20 years. These economies, led by China, could increasingly demand more influence over the direction of economically focused international organizations, altering standards and norms to reflect their economic interests, some of which may be incompatible with the interest of advanced economies. The economic environment of the future, characterized by increasing national debt, a more complex trading environment, diversified global connections, and employment disruptions, will increase strains on governments. Taken together, these trends are likely to shift economic influence to a broader range of players, including private corporations and less open economies).

Several global economic trends, including rising national debt, a more complex and fragmented trading environment, the global spread of trade in services, new employment disruptions, and the continued rise of powerful firms, are shaping conditions within and between states. Calls for more planning and regulation will intensify, particularly of large platform, e-commerce corporations. Our industrial society is following the patterns of consumption shown from the 1972 Limits to Growth base case scenario. In context of this scenario, we have reached or just passed peak industrial production (per captia). This model predicts a peak in services to society (per capita) a few years later, followed by a peak in food production (per capita).

During the next two decades, several global economic trends, including the aforementioned rising national debt, a more complex and fragmented trading environment, the global spread of trade in services, new employment disruptions, and the continued rise of powerful firms, are likely to shape conditions within and between states.

Our monetary systems are not in a fit state to engage in fundamental industrial reform. An unprecedented severe economic downturn in the form of a global bond crisis, followed by a systemic debt default is now mathematically inevitable. Moreover, due to the centralized nature of its operational control, the monetary system fragility and its virtual nature implies a period of paralysis would be inflicted onto the real economy, at a time when the real economy really needs to evolve in a comparative step change. The debt saturation point of the US and EU has almost been reached.

Inflation, debt and interest rate rises are emerging risks. Today, governments and central banks – led by developed markets, notably the United States of America, Eurozone and the United Kingdom of Great Britain – are walking a tightrope between managing inflation without triggering a deep or prolonged recession and protecting citizens from a cost-of-living crisis while servicing historically high debt loads.

Until now, decision-making tends to focus on financial materiality (e.g. by analyzing the impact of so-called ESG factors on financial performance). Creating the conditions – within which economic activity will automatically generate value for nature and people first – requires decision-making based on guiding principles for a sustainable future. It is clear that political and economic leadership have no Plan B beyond these unprecedented levels.

In the face of vulnerabilities highlighted by the pandemic and then war, economic policy, particularly in advanced economies, is increasingly directed towards geopolitical goals. Countries are seeking to build self-sufficiency, underpinned by state aid, and achieve sovereignty from rival powers, through onshoring and friend-shoring global supply chains. Defensive measures to boost local production and minimize foreign interference in critical industries include subsidies, tighter investment screening, data localization policies and exclusion of companies from key markets. At the same time, transformative innovations (alternative concepts, technologies and practices) and sustainability transitions in key markets are emerging in energy, food, mobility and resources. These are supported by new governance strategies, co-operative and civil support as well as through social entrepreneurship and new finance.

These emerging niches are in part interlinked with the destabilization of economic sectors that are based on fossil fuels. This automatically hits the financial sector as well, since it is heavily invested in those sectors. Rapid and nonlinear shifts are possible to economic futures that are circular, decentralized and with internalization of externalities. These shifts thus imply completely transformed economic and financial structures.

In analytical terms, we are in a process -transition- in which a societal system is pushed away from a dynamic equilibrium (regime) into a phase of chaotic and non-linear reconfiguration; the need to imagine alternative futures beyond business as usual! If structural, non-linear changes are inevitable, what potential threats or opportunities do they offer? What are the desired and undesired alternative futures that need to be explored?

THE LONG VERSION

FUNDAMENTAL INTERSECTING CRISES

A number of intersecting crises are currently ongoing at multiple scales, including increasing inequality, ecological degradation and climate destabilization, as well as new surges of populism and mounting public health threats. These emergencies question our economic model of past decades and provoke a rethinking of the general approach to economic policy from a multi-scalar perspective.

The bio-geophysical crisis that has long been announced but not been taken seriously by political decision-makers is showing its devastating effects all over the globe. The extinction of species is progressing, environmental pollution has reached unprecedented proportions. The destructive and exploitative relation of humans with nature is producing an imminent collapse of the ecosystems. Social relations are marked by inequality and worsened in almost all the countries. Financial and economic crises fuel each other and further exacerbated the social crisis.

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MECHANISTIC MATERIALISTIC WORLVIEW

The paradigm that has come to shape our worldview with the Industrial Revolution is essentially a mechanistic materialistic worldview. This mechanistic materialism spent the past 50 years refining a degenerative economy and now it faces trespassing Earth System boundaries, resource scarcity, social inequality, fragile supply chains, political instability and more. Inequalities have deepened across most of the world; amid a rising lack of access to basic services such as clean water, food, energy and safe and moral acceptable working conditions for many. The income of the top 1% has skyrocketed.

Much of economic growth has relied on harvesting readily available, cheap materials to produce products for a growing consumer base. Once those products are no longer needed or wanted, consumers simply dispose of them as waste. Not much has changed: this 'take-make-use-dispose' behavior defines the essence of today's global linear economy. Rising national income as conventionally measured does not price in the loss of irreplaceable environmental resources at the national level nor, in the case of geobiophysical tipping points, irreversible moves toward catastrophic risks for the planet we live on. The most important of is the dramatic effect on the Earth System.

This dominant linear, very simple cause-effect relationships, extraction and exploitation economy fuels both ecological breakdown and wider social inequalities. Even with the introduction of short-term fixes, the approaches to address a problem—such as taxes and subsidies, incentives or feedback loops—are far from optimal.

The linear economy cannot sustain society under the growing pressures of climate change, resource depletion, rapid urbanization, growing population and systemic disenfranchisement, nor can it generate solutions to eliminate those pressures. We must transition to behaviors that eliminate adverse societal pressures, increase the planet's capital and allow us to thrive on the interest.

Furthermore, this mechanistic materialism creates monocultures, an underlying neoliberal theory of doing businesses is all about free markets with a tendency toward bigger and bigger corporations, control and domination. Continuing with this model means inevitable future shocks which will continue to diminish our capacity to recover. Amidst the chaos and uncertainty of a change in era, the economy must move towards—or return to—a more nature-based, resilient and regenerative approach. An opportunity to truly rethink the theoretical framework that guides humanity's relationship with the world.

The most profound opportunities come from thinking about the paradigms that underlie systems. As humans have navigated complexity by breaking things down and categorizing them, the idea of individuals, organizations and systems as deeply interconnected has been forgotten. Holism is the idea that each part of the whole is connected: individual actions cannot be understood without considering their influence on the whole.

RUNNING OUT AND OUTDATED

The planet is a finite dynamically self-regulating system that has been relatively stable for time periods best measured in geological eras. The global economic industrial systems functions as if there are unlimited energy and natural resources. In reality it habitats a finite closed (mostly) biosphere and consumes finite non-renewable natural resources (metal, energy, materials) and renewable resources (sourced from flora and fauna).

The current industrial ecosystem was built with the support of the highest calorifically dense source of energy the world has ever known (oil), in cheap abundant quantities, with easily available credit and unlimited mineral resources. Current economic and industrial system have their foundation in the continuous supply of natural resources. The methods and processes associated with this foundation have significant momentum. This paradigm will not be undone easily. Human nature and human history make it so.

An economy that depends entirely on cheap, affordable energy which, even with today's massive subsidies of fossil fuel production and harvesting readily available cheap materials, is running out. While capitalism thrives on creating artificial scarcity — even for non-competitive goods —it also promotes the idea of endless economic growth. Economic models where the organizing parameters are scarcity, control, hoarding, hierarchies and relationships of power being held over others and defined by the production and consumption of goods and services, and success is measured by output (GDP), are outdated.

NEVER ENDING GROWTH

As aforementioned the worldview of the centralized global linear economy has been based on the idea of limitless material growth: that nature is a free resource and profit is the primary goal of economic activity. This shallow ideology has led us to the brink of ecological and economic collapse via species extinction, global warming, the energy, food, water crisis and growing economic inequality, to name a

few. With many in the middle seeing decades without improvement, if not falling backward and half the world population still struggling to meet basic needs. Fundamental social challenges with no easy solutions in sight. Materials are harder to come by and cost more to extract.

A narrow focus on measured market income misses out on use of resources which are not priced appropriately in the market. The economic system favors profits over employment, with many in the middle seeing decades without improvement, if not falling backward, and half the world population still struggling to meet basic needs. The benefits of development are not shared equitably and the gap between rich and poor is widening. Injustice, poverty, ignorance, exclusion, intolerance, neglect and violent conflict are widespread and present fundamental social challenges. An unprecedented rise in human population has overburdened ecological and social systems even more. The foundations of global security are threatened. These trends are perilous—but not inevitable.

The world economy is running on increasing debt, threatening a return to the financial chaos of decades earlier, but with governments' room for maneuver significantly reduced. Another aspect with this global networked competitive based economy is that it is so tightly globally integrated and so lacking in resilience ('efficiency', being cheaper and more profitable for corporations, has been pursued instead) that a next crash is highly likely to be global.

The forces of disintegration are reflected in growing evidence of the failing institutions of governance, with often discredited leadership, widespread corruption, loss of public confidence and the recent rise of populist, reactionary and autocratic movements rejecting multilateralism and diversity. Contributing to all this is a generalized loss of moral responsibility, higher ethics or values, even spirituality, able to fill the vacuum of any higher human purpose in a materialistic society.

The dominant patterns of production and consumption are causing bio-geophysical and social-cultural devastation, the depletion of resources, and a massive extinction of species.

An ever-worsening ecological collapse cannot be prevented when with philosophy of never-ending industrial growth and increasing human population far beyond what our finite earth systems can support.

The world faces a formidable challenge: in a time of consumerism and demographic growth, how can we balance excess demand with finite planetary resources? It is well established that our current system of linear production and consumption is both unsustainable and environmentally harmful. One possible

way of reconciling the ecological objectives of zero waste and eco-efficiency with economic growth is by decoupling growth from resource use.

The foundations of global security are threatened. These trends are perilous—but not inevitable. With the challenges humanity faces currently, it is widely agreed that any industrial transformation must include regenerative features, an inherently social dimension, and an environmental dimension

CONTESTED, FRACTURED WORLD

In this more contested world, communities are increasingly fractured as people seek security with like-minded groups based on established and newly prominent identities; states of all types and in all regions are struggling to meet the needs and expectations of more connected, more urban, and more empowered populations; and the international system is more competitive and at greater risk of conflict as states and nonstate actors exploit new sources of power, resources and erode longstanding norms and institutions that have provided some stability in past decades.

The geopolitical struggle for control of diminishing natural resources intensifies as growing economies demand ever-more energy, land, minerals, and water. The transformation of the earth itself enacts a most vivid crisis. The iconic issue is of bio-geophysical critical limits, with its 'inconvenient truths': the great danger of disruptive impacts, the need for massive and rapid action and the unprecedented international cooperation required. Another is the impoverishment of biological resources—ecosystems, habitats, species—victims of land conversion, over-exploitation, and, increasingly, climate change. Toxification, the expanding brew of chemical pollutants injected into the environment, poses a third major threat.

With the global population expected to exceed 9 billion by 2050, in order to sustain itself, the linear economy will require exhaustion of the planet's natural capital, not just its annual productivity potential, but consuming the interest and the principal. Add this evolving threat to the adverse impacts of climate change, market volatility and political risks and it becomes starkly apparent there is an immediate and compelling need to change the way the world at large and each one of us conducts business.

Conclusion, the worldview of the centralized global linear economy has been based on the idea of limitless material growth: that nature is a free resource and profit is the primary goal of economic activity. This shallow ideology has led us to the brink of ecological and economic collapse via species extinction, global warming, the energy crisis, and growing economic inequality, to name a few. Materials

are harder to come by and cost more to extract. Despite companies chasing the cheapest human labor around the world, the global labor market is becoming more educated and demanding better compensation and safer working conditions, increasing labor costs for manufacturers. Natural systems are distressed as material extraction becomes more effort-intensive, ecosystem services that sustain life are polluted and reduced, and waste flows regularly threaten vulnerable communities.

The next years and decades will see further dramatic development in technology, society and economy driven by fast-paced technological innovation. Artificial -General- Intelligence, and neural nets are unleashing exponential increase in autonomous computational power -Symbiotic Autonomous Systems- the design of novel materials, synthetic biology, and new scientific and technological modes of controlling and managing the planet's resources, humanity will further deepen its imprint on the Earth and create further uncertainties and vulnerabilities for its safe inhabitation. Deep tech's profound enabling power has the potential to bring about real change.

HYPERCONNECTIVITY UNITING AND SEPARATING SOCIETIES

The world will have orders-of-magnitude more devices, data, and interactions, linking together all aspects of modern life and crossing political and societal boundaries. Increasing speed and global access will provide nations, corporations, and even individuals with services and resources once limited to prosperous countries. This hyperconnected world is a future already beginning to emerge; next generation networks, persistent sensors, and myriad technologies will fuse together in a global system with billions of connected devices

EUROPE

It is a fact that strategic rivalry has become a key feature of the world we now live in. Europe must find their way between the US and China: taking into account their values, interests and alliances, they must develop their own strategic objectives while diversifying their friendship networks in a more multipolar world. To maximize its capacity to be heard by its partners and rivals and to be in a position to influence in-depth the rules of the world game, Europe must also regain scientific and technological leadership. The US, China, and Europe's economies are drifting apart. The global decoupling is moving markets.

To maintain and enhance its manufacturing competitiveness, Europe urgently needs to implement an European wide advanced manufacturing plan to allow a faster and scaled-up deployment of existing key enabling technologies, akin to what the USA and China decided to do over a decade ago. However, to

build tomorrow's science and technology leadership, demonstrate the impact of science for citizens, regain strategic autonomy, and boost its growth and competitiveness, Europe needs to leverage its scale effectively. Therefore, it must radically accelerate the implementation of a real and functioning comprehensive single market for science and technology.

Production technology plays a decisive role in the European Union; it is the backbone of the European manufacturing industry, creating value and securing European competitiveness. Continuous innovation of production is therefore a key success factor for Europe. The European manufacturing industry is both a provider and a user of new technologies, a core enabler of progress and prosperity. It helps to ensure that the diversity of products that surround us in our everyday life make it to market while being affordable for all members of the society. Staying competitive globally requires constant development of new processes and technologies and adaptive organizations.

A new economy could account for hybrid models of use, zero waste, regeneration, the sharing of finite critical resources and the deployment of regenerative, bio-based and non-invasive materials. Rather than being based on ownership and control, such an economy could be founded on care, stewardship, radical creativity and innovation capacities. As Europe has to face up to material constraints, it will need to discover new immaterial abundances. The degrowth of material, energy and extraction could be accompanied by a growth in care, maintenance, participation, collective intelligence, new forms of logistics and virtual, augmented and other immaterial assets. To accomplish this will require investment in intangible, immaterial infrastructures. This future will require Europe to focus on the formation of new regenerative relationships affecting how to relate with nature, soil, water, space and time. There is a need to recognize human co-habitation of this planet and the power of intense biodiversity in building our regenerative systems in practices of business, finance, manufacturing, materials or nutrients.

In general Europe requires structural investment in building new capacities for material innovation, resource management. surgical mining, bio-design, technology, systemic learning and craft, shifting from a material extraction economy to one that combines durability, regeneration and biogenity. This is a future which will also require us to transition our labor economy, both in terms of skills and automation, addressing the implications of structural demographic shifts and the structural re-skilling necessary for this new future. Develop new capabilities for storing, disassembling, processing materials and building components, shift in transport and logistics towards local and circular, design for infinite life spans and full regeneration and reuse, detoxification technologies for circular use of materials.

THE PROMISE OF THE TECHNOSPHERE

The last century a large segment of humanity has unknowingly entered a technological sphere of existence. It is not nature or even society that now dominates our lives; rather, it is technology. Even as it exploits, wastes, and exhausts our natural and social resources, the Technosphere provides the means of production and survival. It depends on this technological system for sustenance and it provides the basis of collective and individual dreams and desires—from visions of an endless array of products to hopes for new techniques that will cure all disease, feed the world and conquer the solar system. This Technosphere, refers not only to the massive and interconnected systems of machines and techniques used, but also to the technocratic organizations, including corporations and government bureaucracies, that are required to utilize and operate this massive and increasingly global technological infrastructure. Without much awareness or comment, the technological-technocratic system has usurped the natural and social milieus to become the primary environment in which we live. Our homes, workplaces, transportation, food, energy, entertainment, leisure, education, and government have all been almost completely absorbed into the technological grid.

The relationship between technology on the one hand and economy and society on the other is not uni-directional. Not only does technological progress result in the continuous change of economic and social structures, including the evolution of attitudes and values, but has at the same time a major impact on the direction and the speed of technology development. In economy, business, there may be a strong tendency towards bi-polarization of company structures -- a trend towards very big global players on the one side, and very small, highly specialized companies on the other. In business and government, it might be the end of the traditional hierarchical command and control structures. These are increasingly replaced by horizontal networks and co-operative teams, providing members with greater freedom and responsibility in decision-making. All this will increase efficiency further, but at the same time, will provide scope for growing diversity, for greater individual choice and for many new opportunities for people's self-determination and self-fulfillment.

Novel technologies enable humanity to manipulate and shape phenomena that have long been taken to be given and natural. At the same time, humanity’s control of nature is limited. Moreover, technologies themselves are also increasingly exerting influence – artificial intelligence, robotics, health surveillance. The boundaries between technological artefacts and living entities are becoming less and less clear, and this is raising ethical and political debate at all societal levels, from local to global.

CHANGE IS GONNA COME

Since we have inherited a highly dysfunctional global economic system, a full economic-systems change is the only solution. Address the failures of capitalism and its ineffective forms head-on by creating decentralized and cooperative local economies, emphasizing local production with local resources to meet local needs, and to build quality of life.

In general, the definition of economics has and will be further shifted, away from transactions to interactions. Economics can be seen as a facilitation mechanism rather than a transaction mechanism and becomes a discovery and exchange process, one of interaction, acknowledgement, collaboration, and creation. Characteristics are the free flow of information, engaging and interacting with that information, and more generally active participation.

The first shifting out of the mechanistic way of considering evolution as a kind of competition into understanding evolution as a co-creative endeavor and seeing ourselves as participating within the world. Our actions, our interactions, and our relationships have consequences. Progression and adoption of the circular economy, biomimicry, systems-thinking and regeneration shows that by shifting how economic thinking positions human relationships with the world, and by addressing critical questions around how economic actors consider value, agency and responsibility, a new path for prosperity can be forged.

In a full, liberation economics, the measurement metrics are self-chosen by individuals and groups. Another feature is that there is a mindset shift to access rather than ownership, or at least an attunement to different ownership models, and the notions of rights, responsibilities and stewardship attached to each. There are peer-produced commons goods, sharing economic properties and a multi-currency society where other currencies and values such as attention and intention are monetized. Societal shared trust stems from individual identity being known by others.

The application of nature's laws and patterns of systemic health, self-organization, self-renewal and regenerative vitality to socioeconomic systems. This concept emphasizes the importance of considering socioeconomic systems as one entity, not one where social outcomes are seen as removed from the economic system. Inspired by nature and copy patterns, principles, and processes and apply them to the economy. Designing our products circular, biophilic design, biomimicry. But regeneration does not stop there. Leading by nature and regenerative leadership is a mindset, reconnecting relationships.

Characteristics of this economy are free flow of information, engaging and interacting with that information, and more generally active participation. An economy based on abundance, access, availability, collaborative willingness, and power shared with others. This economy of abundance is measured in fulfillment; though actualization, connection, purpose, and meaning.

A shift in paradigm in how society sees that natural environment is required. That natural environment allows the long term habitation of our society and should be maintained accordingly. At the same time, all resources that support our society come from that environment. Change the paradigm, humanity as part of the planetary environment, not consumers of it (the current Linear Economy paradigm).

What is proposed here is a fundamental restructuring of our entire industrial ecosystem, starting with an evolution of the social contract. not just a new economic theory, but a new philosophy of economics.

HARD CRITICS

We have to critically discuss alternatives. This is important because the dominant system also tends (wants) to put forward its own solutions which are intended to give the impression that they are serious about resolving the different crisis, but actually only strengthen the status quo. Prominent examples of such false or superficial solutions are recycling (while not tackling the creation of waste in the first place), carbon trading and net-zero climate approaches (which in fact do little to tackle greenhouse gas emissions at source), the green economy (which greenwashes neo-liberal or capitalist profit-making) and others. Given the large number of concepts that are unsuitable for solving the crises, criteria are needed in order to distinguish between false / superficial / symptomatic solutions, and real alternatives that help transform at a systemic level. These approaches typically focus on reducing anthropogenic harm to acceptable levels, such as through improving efficiency (e.g., net zero carbon targets), which is deemed too incremental and superficial given that we have already transgressed planetary thresholds. Moreover, sustainability often fails to challenge the underlying drivers of current crises, such as capitalism, commodification, and worldviews where humans are viewed as separate from nature.

NEW ECONOMIC NARRATIVES

Deregulated extractivist models of development that currently underpin a majority of modern societies globally are continuing to fuel the rampant externalisation of social and environmental costs and faced with hypercapitalism and ever-growing costs, there are new initiatives striving for the collectivization and/or socialization of basic goods and services in many European countries (and North America).

A foundational economy approach, emphasizes the importance of material infrastructures such as the water, food, energy and sewer systems, and welfare services such as health, education, and elderly care. These goods and services are generally a matter of social provision where access to networks and branches – pipes and cables, healthcare centres, schools, and supermarkets – determines possibilities for individual consumption. The foundational economy is important, both because it addresses the mundane needs of the population and employs a large part of the population.

During the last 30 years, economic development policy has been fixated on the contribution of high-tech, knowledge-based industries, and property-led regeneration to increase GDP. However, in comparison to foundational provision, growth in GDP does not translate into improvements in living standards for many households and, unless accompanied by high progressive taxation, has rather led to greater economic inequality . Focussing on basic fundaments attempts to formulate a new ethos for place-based economic development which takes regional preconditions as a starting point for satisfying foundational needs rather than growing GDP.

New economic narratives have come on stage, with ecosocialism as a modern, ecological, democratic version of socialism being on the rise. While ecosocialism borrows from many practical concepts, it is foremost a theoretical framework, a narrative and political project that aims at envisioning a different society as a whole.

Degrowth is a major branch of critical debate in many parts of the Global North. While ecosocialism stems from the critique of a privatization of means of production, degrowth has its roots in a general critique of the capitalist system's need for an ever-increasing production and consumption of goods and services. The concept connects to and integrates a variety of other approaches in the Global North as well as in the Global South, for example Post-Development and Post-Extractivism. It is a dynamic concept which involves academia, practice and activism, e.g. through conferences, camps and summer schools in different countries.

The economy of the common good is based on the approach that companies are evaluated by their contribution to the common good. Companies are then to compete with each other on the basis of this score instead of company profit. Thus, in contrast to many other approaches, the economy for the common good does not want to abolish competition outright but change the goal of it. The concept includes the values human dignity, solidarity and social justice, environmental sustainability and transparency and co-determination.

The current, predominant contrast to a linear economy is a circular one. The circular economy, as part of the economic transformation, is a stock-maintenance concept. Within a circular economy, which was initially defined for manufacturing processes, the lack of waste and absence of pollution are primary characteristics. Products and materials are used and re-used as long as possible, and natural systems are regenerated. Maintaining and increasing the stocks of available capital, whether manufactured capital, social capital, infrastructure or natural capital – the capacity of the land, sea forests to produce a flow of goods and services over time. The model of a circular economy was developed as a solution to pressing modern challenges associated with finite resources: economic ones, such as price volatility and supply security; and environmental ones, such as pollution, greenhouse gas emissions and biodiversity loss.

These challenges stem from the predominantly linear nature of our production and consumption systems: we take materials, make products out of them, use those products and eventually dispose of them. The circular economy reimagines our global and local economic systems to minimize pollution and waste and increase efficiencies. One of the main principles of the circular economy is that all materials become an input for new products. A circular economy is one of the current sustainable economic models, in which products and materials are designed in such a way that they can be reused, remanufactured, recycled or recovered and thus maintained in the economy for as long as possible, along with the resources of which they are made, and the generation of waste, especially hazardous waste, is avoided or minimized, and greenhouse gas emissions are prevented or reduced. The gist of the transition to circularity implies setting up feedback loops in the economy, so that products, components and materials no longer end up as waste but re-enter the supply chains as valuable inputs.

Doughnut Economics argues that key models of neoclassical economics have permitted economic policy to put growth at the top of the agenda by separating the market from social and environmental systems. To provide a model that better explains the actual costs and dependencies of the economic system, the model differs from neoclassical economic theory; Doughnut Economics highlights that the economy is

dependent on commons, that is, free and open resources such as environmental goods and services and knowledge. It highlights that the economy is embedded in the environment and depends on the Earth as a source – extracting finite and renewable resources, but also as a sink for its wastes. Equally, knowledge is the foundation for all industrial and economic activity.

Conceptually, Doughnut Economy is different from the foundational economy. While the foundational economics almost exclusively focuses on the social sphere, the doughnut formulation emphasizes that providing for the social foundations also needs to happen without damaging Earth's life-support systems. In line with many ecological economists Doughnut Economy highlights that the economy is not a self-reproducing system, but an open system with constant in- and outflows of energy and material. Consequently, economic policy needs to integrate social and environmental concerns rather than considering them as separate issues. Hence, the doughnut model can be seen as an extension of the circular approach, integrating many of its social concerns but encouraging deeper thinking of how to incorporate environmental issues into policies for the foundational economy.

An alternative approach gaining traction worldwide, encouraging rapid and deep change, is to strive for regenerative practice, dynamics and systems. Regenerative social-ecological systems—regions, economies, cities, businesses, communities, and so forth—can be defined as those that maintain positive reinforcing cycles of wellbeing within and beyond themselves, especially between humans and wider nature. Regenerative approaches encourage more positive, creative visions and narratives to guide action. This is in contrast to the common societal focus on difficulties of transformation or the threat of dystopian futures, which risks creating a self-fulfilling prophecy and encouraging denial, paralysis, and defeatism. Although they resonate with many new economic concepts and models - approaches aiming to replace the hegemony of neoliberalism- regenerative approaches for social-ecological systems are still relatively unfamiliar.

It must be stressed that a meaningful transformation must go far beyond the economy. Radical transformation is intersectional and this transition towards a regenerative resource balanced economy has to happen at a time when there is comparatively very expensive energy, a fragile finance system saturated in debt, critical resources and an unprecedented number of human populations, embedded in a deteriorating bio-geophysical Earth system.

The circular economy is based on several concepts, two of which — biomimicry and permaculture — indicate that we live in complex yet orderly systems in which all resources and flows must be taken into account.

This economic model also emphasizes the need to park within a liveable balance between resilience and efficiency of the systems on which we depend for our survival. Here, the sustainability of these systems is today a top priority.

The circular economy is a model based on the notions of regenerating our natural capital and restoring our reusable and re-manufacturable capital. Contrary to a model based on exploited resource utilization volumes, it is a matter of optimizing these resources and flows, in order to keep them as long as possible in our eco-systemic sphere (economy of system). This model is therefore an approach to better manage the quantity and preserve the quality of these stocks as well as to capture all the flows of all the renewed energies available.

The biological nutrients from the biosphere and technical nutrients from the technosphere (or technical sphere) are the two stocks favoured in the circular economy model.

The biosphere is disappearing at a fast pace. Our common priority is to deploy strategies to regenerate it. The aim here is to preserve its foundations and to replicate, in perfect mimicry, the natural cycles in order to protect it while overcoming the economic and agricultural needs of a world of ten billion inhabitants. The biosphere is by far the most important sphere because vital.

The technosphere must be developed and therefore re-evaluated by questioning the way we access it. Estimate its potential to ensure that it meets the economic needs of the world's population in a mode of intensive collaboration.

The insertion of the human dimension allows humans to be an integral part of the 'equation of life on Earth, as a vital component of adaptation of a complete symbiosis to evolve towards new perceptions and innovations in our ability to adapt to the ecosystem. Including humans in the dynamic balance and points of interaction with the biological and technological sphere identifies the future human role a symbiotic model that is not only regenerative and restorative but also inclusive and just. Integrating all ecological, social and economic dimensions into a comprehensive symbiotic approach to regenerate, restore and protect.

REGENERATIVE

Regenerative economics is a significant extension, focused not only business models but on systems and frameworks and the necessity for new, non-neoliberal narratives. The regenerative economy is one which, while circular in nature, creates ever greater capacity for life without diminishing capital. A regenerative economy does not just retain resources that exist, it creates new resources while maintaining a dynamic balance between the ecological, economic, social, and cultural dimensions, context / place -basedness (including awareness of the material flows, mainly through thresholds and allocations), post-ownership and multiple capitals letting go the dominance of financial capital alone. A regenerative economy would have critical value adding exchanges occurring within networks of reciprocal relationships in contrast with commoditized transactions.

Redesigning our economic system of production and consumption around the regenerative patterns of nature, resource and energy that we observe in mature ecosystems is only one part of redesigning our economy using the insights of ecology. To create a truly regenerative economy challenges us to ask deeper questions and initiate more far-reaching transformative change. The material flows of a regenerative economy will mimic the metabolic process found in resilient living systems with wastes being fully recycled or upcycled in an ongoing, productive, circulatory and value enhancing flow. The flow of information and money would follow similar patterns. Self-regulating processes and feedback loops maintain the dynamic balance in ecosystems; by analogy, a regenerative economic and financial system seeks a balance between efficiency and resilience, global and local, diversity and uniformity, innovation and conservation, flexibility and constraint. An regenerative economy based on abundance, access, availability, collaborative willingness, and power shared with others. Regenerative economies need to focus on the (bio-)regional scale, given a spatial size that includes sufficient diversity and scale to build a regenerative economy. The priority of regenerative development is to apply holistic processes to create feedback loops between physical, natural, economic and social capital that are mutually supportive and contain the capacity to restore equitable, healthy and prosperous relationships among these forms of capital. Regenerative processes have three primary goals (which correspond nicely to the UN Sustainable Development Goals (SDGs):

- Fostering positive feedback loops where excess human and natural resources are reabsorbed by the system to create mutually beneficial relationships that self-replicate to build inclusive resilience
- Respect and deep consideration to local contexts, whether economic, cultural or ecological, so that development is properly adapted to local ecosystem, cultural and economic circumstances

One of the most interesting models of intersectionality is regenerative bioregionalism. In many parts of the world, political boundaries intersect and interrupt the flows of nature (e.g. a national boundary cutting a river basin), or cultural connections (e.g. fences and armies blocking traditional routes of nomadic pastoralists). This kind of interruption or blockage has many negative ecological, economic and socio-cultural consequences. Bioregionalism attempts to interrogate such political boundaries, and imagine, as also plan and implement policies and practices that can re-establish flows and connectivity across these boundaries. Bioregions are geographic areas having common characteristics of soil, watersheds, climate, and native plants and animals that exist within the whole planetary biosphere as unique and intrinsic contributive parts. Bioregional development is refitting human patterns to the bio-geo-physical patterns through which life creates conditions conducive to life. Stimulate self-regulation to local ecosystems and reconciliatory design takes the additional step of making explicit humanity's participatory involvement in life's processes and the unity of nature and culture capable of continuous learning and transformation in response to, and anticipation of, inevitable change.

The regenerative bioregional economy is one which, while circular in nature, creates ever greater capacity for life without diminishing capital. The transition to a regenerative economy is about seeing the world in a different way — a shift to an ecological world view in which nature is the model. A regenerative economy does not just retain resources that exist, it creates new resources while maintaining a dynamic balance between the ecological, economic, social, and cultural dimensions, context / place -basedness (including awareness of the material flows, mainly through thresholds and allocations), post-ownership and multiple capitals letting go the dominance of financial capital alone. A regenerative economy would have critical value adding exchanges occurring within networks of reciprocal relationships in contrast with commoditized transactions.

A regenerative bioregion maximizes the ability of Earth's biosphere to build, maintain, repair, and reproduce itself, as well as adapt and evolve, such that it retains its integrity over time. It embeds a holistic view of human wellbeing in which everyone's full suite of needs is met and ongoing human

cultural and intellectual evolution is enabled. Emphasis on higher-order needs alongside basic needs sets regenerative approaches apart from others with narrower accounts of human dignity and personhood.

The desired outcome is not only ecological and human regeneration but also a mutually reinforcing dynamic between these. This is an important example of a more general dynamic needed in regenerative systems: the mutual reinforcement between regeneration of a system in question (internal regeneration) and regeneration of the wider system it sits within (external regeneration).A fully regenerative system would be both internally and externally regenerative.

This form of regenerative -localized- economy, enriched with the synergies of technology is a powerful and potentially highly productive combination. New, emerging technologies whose development and application are only now beginning to take shape and could be available anywhere within a five-to-ten-year horizon. They are expected to generate new opportunities and offer a wealth of socio-economic benefits.

The regenerative localized economy is challenging established monopolies and oligopolies because it is participatory, responsive, decentralized and diverse. Without giving up on globalization, it is restoring the local connectivity that has been breaking down over the last decades. It also offers enormous possibility to change our economic models even further. If we want to.

LET'S EXPLORE…..

The redesign of societies and cities -as drivers of change- so that they are bioregionally self-sufficient is fundamentally based on both the mounting external pressures as well as novel socio-material capacities to create thriving communities. A renewed emphasis on living in reciprocity with our local places, their ecosystems and bio-geo-physical realities. The emergence of networks of distributed human systems that are situated within their bioregional ecological systems would be a fundamental shift to the way our societies are presently organized.

Rather than championing the ideals of isolationism and protectionism, relocalized economies would be better served by an underpinning approach of cosmopolitan localism; the formation of nested networks of mutually supportive communities, with local production and governance complemented by global open-source knowledge and skill sharing as vital catalysts in facilitating bioregionalism. This type of economic relocalization does not argue that our societies need to be completely bioregionally self-sufficient and that global trade needs to be completely abolished; rather the call for action is to mobilize

the emergence of resilient communities that can provide for their basic needs through localized, circular supply chains. There needs to be an ongoing discussion to help define what types of global trade are viable and valuable — whilst centering on economies that are largely defined by local production coupled with global knowledge networks. Shortening supply and resource chains and relocalizing the production of essential food, water, energy and goods can help to shift us away from our throwaway culture and move towards conscious living within the limits of our earth System.

The capacity for distributed production coupled with a globally connected network of knowledge sharing turns economic relocalization into a paradigm-shifting proposition. With the internet (Web2 & Web 3) affording the existence of countless online communities for skill sharing and open-source design, the development of local circular economies for food, water, energy and materials is not stifled for innovation as it might have been previously.

Creating decentralized and cooperative local economies, emphasizing local production with local resources to meet local needs, and to build quality of life. Unfolding the ubiquitous on-demand resource network grids, which is fundamental in the mindshift to abundance and will be enabled by disruptive technologies such as high-performance clouds, artificial intelligence & machine learning, data analytics, swarm intelligence, bio-processing, functional additive manufacturing, autonomous systems and many more. More and more resources are becoming fully dynamically available, to be called forth on-demand for use at any moment contribute to the ongoing mentality shift from scarcity to abundance.

Customers will have a central role in value creation, with increasingly important participation in design and manufacturing. The fast-growing development and adoption of AI and Virtual Reality based applications for product and process development, combined with increasingly lower cost equipment and services for additive manufacturing, empower costumers to develop and, eventually, produce conventional and new products. Naturally, this places a significant challenge to the industry in many domains, like new business models, the location of production and service centers, quality and safety.

A regenerative bioregional economy, enriched with the synergies of technology is a powerful and potentially highly productive combination. New, emerging technologies whose development and application are only now beginning to take shape and could be available anywhere within a five-to-ten-year horizon. They are expected to generate new opportunities and offer a wealth of socio-economic benefits.

The focal point of this economic transformation is needs, and more effectively responding to unmet needs, where the needs of all entities readily surface and can be met. A needs-based regenerative economy focuses on the most important aspects and deeper level of what occurs in economic transactions. Some of the most important needs for humans tend to include acknowledgement, connection, contribution, meaning, and action in the world. Economics is a strategy for getting these and other needs met.

BIOREGIONAL REGENERATION ECONOMY

The critical linkage between ecology and economy are human beings, who are biophysical beings, dependent upon natural processes to survive, AND socially constructed beings, whose lives are socialized and lived as members of societies, economies, communities, and cultures. Thus, the perspectives of human ecology and coupled human and natural systems is focused on the interdependence of humans and nature within bioregional systems. Understanding that the critical aspects that the socially-constructed spaces that humans occupy, namely cities and towns, are embedded in ecological bioregions and the health of those bioregions is directly related to the regenerative capacity of our economy, the physical infrastructure that distributes resources (e.g. bridges, electrical grids, waterways), the individual human social capital brought into the system, incorporated social quality, durability and the cultural practices that binds them.

Regenerative economies need to focus on the (bio-) regional scale, given a spatial size that includes sufficient diversity and scale to build a regenerative economy. Bio regenerative social economies recognizes the inherent interconnectedness between local ecosystems, economies and communities within a specific geographic region. It emphasizes the importance of nurturing local economies, fostering community connections, and incentivizing regenerative practices to address the shortcomings of national attempts to achieve the Sustainable Development Goals (SDGs). Bioregional Economics places a strong emphasis on local economic self-sufficiency, resilience and focuses on harnessing the resources and talents within a specific bioregion to support vibrant local economies. By encouraging the production and consumption of goods and services locally, it ensures that wealth and resources circulate within the community, creating employment opportunities, reducing dependency on external markets, and enhancing economic stability.

The bioregional regenerative economy embeds negative social externalities within the circular economy. A model that is not only regenerative and restorative (circular economy) but also inclusive and just.

EXPLORING FURTHER; A SYMBIOTIC ECONOMY

The symbiosis of economy and environment, society and science, is the way future wealth could be created. The different key sustainable economic innovations of the last years share a core structure, based on collaborative practices, forming renewable ecosystems, and producing positive impact. If assembled, innovations from three spheres of economic activity – those using natural ecosystems, social and collaborative innovation and efficient technology – enter into symbiotic relationship. A symbiotic economy is premised on an understanding that economies are sub-systems of life rather than super-systems that are separate from and above life. Consequently, it takes a higher value on living assets (people and Nature) than on non-living capital assets – an ideal based on the reality that living assets are the source of capital assets and, indeed, all economic value. This reversal of traditional industrial doctrine is revolutionizing capitalism by attuning it to the living world that all economic systems ultimately depend upon. The symbiotic economy is founded on the interdependence of technological advancement, natural ecosystem power, and human knowledge.

The symbiotic economy is comparable to the circular economy, but takes it one step further. Whereas the concepts of circular economies seek to satisfy its needs within a circular system and so generate little to no waste, the symbiotic model is actually regenerative and is inspired by the natural world and attempts to provide all those implicated within the process to a shared benefit. This means that the individual contributors to this economy (be it society or the environment) can achieve complementarity and gain from the synergies produced by their exchange.

A symbiotic economy is characterized by the properties of self-organization, co-evolution, and adaptability, initiating and integrating the processes of the cooperation, collaboration, and competition of all actors in order to provide a comfortable and safe environment for the interaction of all actors of the region, city or megapolis, their sustainable development, and a high level of quality of life for each resident.

BROADER IMPLICATIONS OF TECHNOLOGY EVOLUTION

Innovation can be classified into two categories: radical innovation that leads to technological breakthroughs, and incremental innovation that gradually ameliorates existing technologies. In reality, radical and incremental innovations are often intertwined. From a macro perspective, a wave of innovation with major impacts on the economy (e.g., digital technologies) typically consists of three stages: the advent of revolutionary technologies, the diffusion of their applications and eventually changes in lifestyles and economic patterns when new technology applications sufficiently adapted.

We are at the forefront of a transformative shift in the global economy, as we transition from programming machines to instilling them with the ability to autonomously learn and evolve. This pivotal change is poised to inject trillions into the global economy, redefining the very fabric of enterprises and fundamentally reshaping how they build, market and use products. Highly specialized machine intelligence will outperform any human doing specialized work, unlocking tremendous potential for productivity gains and competitive advantages across a wide range of domains.

Emerging technologies are rapidly improving a broad range of human experiences and capabilities, but at least in the short term, these same technologies may disrupt longstanding systems and societal dynamics, forcing individuals, communities, and governments to adjust and find new ways of living, working and managing. As with any disruption, some will thrive whereas others will struggle, potentially facing increasing inequalities and imbalances. Emerging technologies are not solely responsible for the following developments, but they are likely to aggravate and amplify them.

To remain competitive, it is essential to constantly develop new processes, technologies and organizations. To ensure a higher rate of agility, flexibility, anti-fragility and innovation, ways of working need to converge, too: Silos between industries, disciplines and businesses need to be dissolved.

Industry and manufacturing convergence stands for new connections emerging between previously unrelated technology areas, work processes, businesses, supply chains, and even entire industry sectors. Convergence happens as technologies, processes, businesses, and industries blend into each other (in the annex an overview of emerging technologies).

DISCUSSION

Converging technologies include the existence, distribution, adoption, design, governance and impacts of autonomous, augmented and assistive technologies. This broader perspective helps us understand how these technologies supplement human capabilities and establish new societal, economic, and developmental frameworks. The shift towards integrating autonomous machines and perhaps self sovereign machines signals a move from a purely human-centric development model to a hybrid one, where human and machine capabilities are intertwined. Now, consider adding the analysis of biosystems and their systemic contributions, recognizing a further shift beyond human centric futures. This framework aims to sense, visualize, analyze and transform the real-time interplay between human societies, technological systems, and bio-systems.

This approach must acknowledges that human activities and technological progress are deeply reliant upon the natural world. Including biosystems in our world view allows for an examination of how they contribute to, constrain and are impacted by human social, economic and technologies, such as the effects of urbanization on biosystems and the effect of biosystems on viable urbanization or how agricultural practices interact with ecosystems.

The transition towards a hybrid human-machine-ecological economic societal model presents opportunities and challenges; it offers new ways of perceiving relationships among human, technological and natural systems, but it also raises important questions about work, income distribution, ethical considerations of machine and biosystem sovereignty, and the governance of independent technologies.

Fundamentally, this perspective of delving into a broader theory of machine-human ecological systems and their agency encourages to examine the nature of interactions between these agents. It highlights the emergence of complex sense making and governance dynamics, prompting a shift in how to conceptualize these relationships—from transactional and narrowly focused optimizations to embracing a new theory of systemic care.

ETHICAL QUESTIONS AND RESPONSIBILITIES

Clearly, living in this era raises very different ethical questions and responsibilities than did the past milieus of human existence. Humanity finds itself not only in a novel physical environment, the technological system, but also in a new ethical landscape. For technology is never neutral.

On one hand, a hybrid human-machine-ecological economic societal model harbors the potential to fully unlock the latent capacities of humanity, enhancing our ability to innovate, collaborate, and thrive within these constraints. On the other hand, it poses the risk of giving rise to a new pathway of tyranny and systemic inequality, one where access to resources, technology, and information might be structurally unevenly distributed, exacerbating run away inequalities and delivering asymmetric freedoms.

These technologies raise complex ethical issues that can have considerable socio-economic impact and generate lively debates on research ethics and Human Rights. The areas of genomics and man-machine interactions are of particular importance due to their innovative nature and potential impact on jobs and growth. Body and mental enhancements as well as the changing nature of the relationship between humans and machines (i.e. robots) raise complex ethical issues that need to be addressed in order to promote an inclusive and sustainable socio-economic model. There is a pressing need to provide ethical responses and practical options which support innovation, the research community, facilitates the work of ethics committees and addresses the expectations of society.

Due to their transformative potential, these technologies are also likely to pose a number of ethical challenges and societal consequences. With the conceptual, ethical, and political issues associated with the way in which humanity can manipulate living systems and nature and how technologies are changing us as well, we have a chance, now in the early stages of their development (and not only in the economic domain), to ensure that ethics is prioritized.

Technology changes society. Technologies change human behavior. Technologies bring forth new norms and responsibilities. This raises questions about the power of technology. Technology matters, because it is inseparable from being human, and how technologies have been incorporated into culture of difference. Technology might be instrumental, but is it just a neutral tool? And who is in control of technology? How does technology change the perception and experience of the world? And how does technology affect the forms of engagement and involvement with the world?

ANNEX

After digitalization and Industry 5.0, today it is the rapid development in life sciences that is giving the industry new impetus across the entire process and value chain. The imitation and integration of biological systems in human made technical and information systems, but even more the interaction between them, is opening new innovation spaces and enables new opportunities to achieve the world's sustainability goals.

An intriguing concept is biologicalisation, defined as the use and integration of biological and bio-inspired principles, materials, functions, structures, and resources for intelligent and sustainable manufacturing technologies and systems with the aim of achieving their full potential. A transformation of industrial value creation, a systematic application of the knowledge of nature and/or natural processes aiming at optimizing a manufacturing system regarding its societal and business challenges by seeking a convergence of bio- and technosphere. Consequently, there is need for new concepts and technologies that can actively contribute to biological transformation in the field of advanced manufacturing. Nature, as a as a source of inspiration for a manufacturing system and knowledge; bioinspiration (primarily bionics/biomimetics), biointegration (primarily biotechnology and process engineering) and biointelligence (promoting bioinspiration and biointegration approaches with the help of molecular and digital technologies.

The synergies can be intensified due to relevant developments in the field of Life Sciences and particularly in biotechnology. Diversified application areas such sensors and actuators, bio-refineries or energy storage illustrate and fuel a continued and stronger collaboration.

Nature inspired manufacturing can also lead us to design and operate more sustainable eco-systems, from the organizational to the technology levels, for example, how to combine different actors and activities with efficient processes to recycle and reuse materials. Technological disruptions are turning the prevailing extraction and exploitation, scarcity, economy and business and central control model of production on its head, driving a new model of localized creation from limitless, ubiquitous building blocks—a world built not on coal, oil, steel, livestock, and concrete, but on photons, electrons, DNA, molecules and (q)bits.

The waves of advanced technologies—AI, robotics, 3D printing, the Internet of Things (IoT), digital biology, XR, blockchain, global gigabit connectivity, and so on—are converging at a pace that's accelerating exponentially and will affect every aspect of personal and societal life even sooner than many imagine.

Cloud computing, automation, big data analytics, AI, and other information technologies are enabling new distribution modes that expand access to international markets for all sellers but especially for small and medium-sized enterprises that have historically faced high foreign market entry costs.

The rise of e-commerce platform firms could help spur the growth of small and medium-sized enterprises, which have historically made a significant contribution to economic growth and job creation. These small and medium-sized firms often face funding constraints, but e-commerce platform firms offer lower customer acquisition costs and potentially greater market reach that could reduce costs, increase financing, and enable faster growth. In developing and emerging markets, these platform firms could lower the barriers to entry, help unlock financing.

As the possibilities from convergence multiply, so will the possibilities for economic and industry disruption.

CYBER-PHYSICAL PRODUCTION SYSTEMS

An intelligent manufacturing system is a composite intelligent system comprising humans, cyber systems and physical systems with the aim of achieving specific manufacturing goals at an optimized level. The building blocks of the new production system will be the bit (and later qbit), photon, electron, molecule and DNA (or gene). These building blocks are available and plentiful everywhere and can be recombined in infinite ways to create new products and services at essentially zero cost. Information technology will dominate the system of production, but information needs to be embodied in matter and energy. Building blocks that are more powerful, lighter, and faster are superior to those that are less (or similarly) powerful, slower, and heavier. Bits and photons will disrupt electrons, which will disrupt atoms and molecules. Photons are more powerful but orders-of-magnitude lighter and faster than electrons, which are as powerful but orders-of-magnitude lighter and faster than atoms. Similarly, when creating molecules (food, materials, and medicines), manipulating DNA at the microorganism level allows for the faster production of molecules, with a far lighter production infrastructure and higher degree of precision and accuracy than manipulating a macro organism.

The digitalization of industry, by means of cyber-physical production systems, modelling and simulation, cloud and edge-based manufacturing, manufacturing as a service and smart manufacturing will change manufacturing paradigms. It will provide the means to address challenges such as mass customization and the need for continuous improvements in flexibility, productivity, accuracy, security and sustainability, in cybersecure environments. One of the main changes will probably emerge in value chain organization, including the geographical location of manufacturing activities. The combination of customization and circular economy, with technologies like 3, 4 & 5D printing, new ways of 3D-Printing are using light in liquids, as liquids give the most flexibility in material design, will boost the complete redesign of future manufacturing towards consumer centric grids aiming at providing the required products and services while optimizing the usage of resources, including materials and energy (also in transports), creating balanced and sustainable eco-systems. Developments in robotics and flexible automation will enable the simultaneous improvement of efficiency and flexibility. Collaboration and integration between humans and technology will augment human capabilities, instead of replacing them, allowing humans to concentrate on more added value, creative and socially relevant activities.

ON-DEMAND CUSTOMIZATION

Customers expect more choices and customization options. Providing these options, however, is generally costly because businesses need to make those customizations at scale. But with artificial intelligence (AI) converging into more industries, processes can become more flexible and adaptable. Manufacturers are implementing the mass assembly of more tailored products and precision-crafting unique components. Rapid manufacturing reconfiguration capabilities are required because of the increasing market need for mass customization and increased variability in supply and demand. This calls for a potentially sudden change of system configuration whilst maintaining full system effectiveness in the event of unpredictable customer demands, line failures, supply disruption, or a need for maintenance. Logistics will be able to function largely autonomously.

To meet fluctuating customer and market demands, production systems must be as responsive as possible, and intelligent system architectures such as multi-agent systems allow for on the fly reconfiguration of manufacturing system control, exploiting asset flexibility and control to change the behavior of the manufacturing system.

The advancement of on-demand manufacturing over the coming decades has the power to transform society in fundamental ways by enabling physical artefacts to be designed and distributed in the same way digital ones are today. Ubiquitous access to personal computers and internet has meant that almost anyone, anywhere can access digital products, from songs to software, with a click. The past two decades, digital manufacturing has set manufacturing on a radically new path, physical products may soon be designed analogously, on demand, customized by and for users. Characterized by digital design, automation and customization, wrapped in a hardware package that's inexpensive compared to traditional manufacturing infrastructure, technologies like 3D printing, have disrupted manufacturing industries by affording users the ability to rapidly and inexpensively produce customized parts of almost arbitrary geometries from a single design file.

Generative design helps designers and fabricators find solutions that meet unique design criteria—it can also be an ally to customization. Thanks to atomically precise manufacturing, we will soon have the power to produce radically more of what people want, and at a lower cost, making new matter through nano technology and molecular engineering -precisely arranged atoms -. The advent of this kind of atomic precision promises to change the way we make things -- cleanly, inexpensively, and on a local scale. As mentioned, the building blocks of the new production system will be the bit (and later qbit), photon, electron, molecule, and DNA (or gene). These building blocks are available and plentiful everywhere and can be recombined in infinite ways to create new materials, products, and services at essentially zero cost. The result will shake the very foundations of our economy and environment.

VIRTUAL CREATION

Digital twins and the virtual environments possible through extended reality (XR)—the combined term for virtual reality (VR), augmented reality (AR), and mixed reality (MR)—let innovators embody their creativity in immersive experiences. Virtual creation links digital and physical worlds in new, beneficial ways. Digital twins visualize real-time operations of a building or product. Simulations of a product's performance in changing environments show the product's viability. And hyperrealistic worlds onscreen or in XR enthrall users through visually rich, multisensory experiences. Virtual creation is permanently transforming experiences and expectations.

RESHAPING ATOMS

At the frontier of bio-nano-manufacturing that broadens our imaginative horizon. Advancements facilitated by bio-nano manufacturing could radically modify the traditional materials used in industry / manufacturing.

Syn-bio and nanotechnologies that can restructure natural forms of matter, pushing the boundaries and command materials in ways that seemed implausibly ambitious a mere decade ago. Nanotechnologies that can restructure natural forms of matter; molecular manufacturing that offers unlimited repurposing. Design and order customized materials with these transformative tech tools per our needs; required strength, flexibility or swift biodegradability, function, behaviour / shape shifting, morph wastes, often deemed 'worthless,' into products that carry substantial value.

INTELLIGENT PRODUCTION / MANUFACTURING

An intelligent production / manufacturing system is a composite intelligent system comprising humans, cyber systems, and physical systems with the aim of achieving specific manufacturing goals at an optimized level. This bionic manufacturing, where technology enhances and augments relevant human capabilities, is the winning combination for highly automated and robotized processes, yet capable of providing flexibility and adaptability to new customer requirements. Factories will adapt and become resilient to foreseen and unforeseen changes in the market and in technology.

The concept of the Metaverse is a massively -scaled computer -simulated environment or virtual world which replicates spatial and physical characteristics of humans. Technological Advancement generates a significant understanding of science or technology with the utilization of AI and digital twins in the Metaverse.

EDGE COMPUTING MEETS AI AND 5G / 6G

Edge Computing refers to devices that analyze data close to the source where it's captured instead of sending it to a centralized server such as a cloud service for storage and analysis. As data volumes grow, so does the need to extract insights as quickly as possible so action can be taken more quickly and the cost of transmitting *noisy* raw data to the cloud can be reduced. The ongoing rollout of 5G / 6G networks will make Edge computing viable for many new applications, while AI integration will make edge devices smarter and more autonomous. This is likely to lead to a spike in adoption and innovative new use cases.

DECENTRALIZED

Decentralized Autonomous Organizations (DAOs) are poised to fundamentally reshape the economy by introducing a new paradigm of collective ownership, decision-making and profit-sharing. By leveraging blockchain technology for transparency and trust, DAOs democratize business operations, allowing for broader participation in economic activities. Web 3.0 is characterized by peer-to-peer transactions and decentralized control over digital services. It is in this context that DAOs flourish. By leveraging blockchain technology, DAOs operate public infrastructures that anyone can participate in. This transformation provides participants with the autonomy to contribute to the governance and maintenance of the network they are part of, significantly altering the centralized dynamic that Web 2.0 was built upon.

The automation of tasks within a DAO, driven by consensus mechanisms and smart contracts, significantly changes how organizations operate. In time, with advancements in artificial intelligence (AI), there is the integration of more sophisticated AI-driven governance models within DAOs, further automating decision-making processes and potentially redefining the nature of digital coordination and operation.

This shift not only challenges the conventional norms of corporate governance and investment but also empowers communities, giving rise to an economy that is more resilient, adaptive, anti-fragile and aligned with the collective interests of its participants. The integration of AI into DAOs has the potential to increase efficiency and scalability while also presenting novel challenges and considerations in terms of ethics, security, and the balance of power between automated systems and human oversight.

DECENTRALIZED FINANCE (DEFI)

A set of alternative financial markets, products and systems that operate using crypto-assets and ‘smart contracts’ (software) built using distributed ledger or similar technology DeFi protocols, a specialized autonomous system of rules that creates a program designed to perform financial functions.

Smart contract. Code deployed in a distributed ledger technology environment that is self-executing and can be used to automate the performance of agreements between entities. The execution of a smart contract is triggered when that smart contract is called by a transaction on the blockchain. If triggered, the smart contract will be executed through the blockchain’s network of computers and will produce a

change in the blockchain's state (for example, ownership of a cryptoasset will transfer between market participants).

The emerging crypto-economy uses blockchain technology and cryptocurrency tokens like Bitcoin to automate and facilitate human (and human-technology) interaction patterns. Decentralization as a new organizational paradigm extends our capabilities beyond hierarchical organizational models (both practically and values-wise (e.g.; more autonomy for all agents)) into trustless very-large scale models for coordinating world-scale activity.

Cryptographic ledgers could coordinate spot transactions (cryptocurrency) and the interactions with smart contracts and autonomous Decentralized Applications, Decentralized Autonomous Organization entities and all physical and intangible assets registered as smart property.

IN GENERAL

DeepTech and especially artificial Intelligence (AI) has become a game-changer in various industries, and finance is no exception. There is a growing interdependence between the industries: on one hand, finance is a key driver of deep tech growth through capital investment and talent; on the other, deep tech presents unique opportunities and tools to help professionals navigate the challenges of the modern finance world.

From algorithmic trading to risk management, AI is reshaping traditional financial practices, offering new insights, efficiency, and opportunities for both businesses and consumers. AI will continue to revolutionize the finance industry in the coming years. We'll likely see AI used in many complex ways to analyze data, identify patterns and insights, automate processes and make many recommendations. In investments and trading, AI may become advanced enough to make very accurate market predictions and also execute sophisticated trading strategies. This could allow the firms to optimize investments and also returns. However, appropriate governance will be very necessary as AI takes on more financial decision-making. For banks, AI will help better understand their customers through data analysis, allowing more personalized services.

From algorithmic trading and risk management to personalized financial services and regulatory compliance, AI-powered solutions are reshaping traditional practices and paving the way for a more dynamic and inclusive financial ecosystem.