

## ECONOMY 4.0 AND DIGITAL SOCIETY (Version 0.2) –

### The participatory market society is born

by Dirk Helbing

*The invention of the steam engine turned the agricultural society (with its "Economy 1.0") into an industrial society (with the "Economy 2.0"). Later, the spreading of education enabled the service society (with the "Economy 3.0"). And now, the pervasiveness of digital technologies – such as the World Wide Web, Social Media, digital devices, artificial intelligence, robots and the Internet of Things – is driving another technological revolution, creating digital societies (with the "Economy 4.0"). For example, the sharing economy, co-producing consumers ("prosumers"), and the makers community indicate the beginning of an entirely new era, which I call the Participatory Market Society. This society is ultimately characterized by the ubiquity of information, bottom-up participation, co-creation, self-organization, and collective intelligence as organizational principles, furthermore, by user-centricity and -control, personalized products, and hyper-variety markets. Furthermore, many people will engage in "projects," empowered by social collaboration platforms.*

Our economy is in the middle of a major transformation process, as it occurs only every 100 years. The invention of the computer, the World Wide Web, Social Media, and the Internet of Things are now about to redefine the ways we are doing things, and the institutions our economy and societies are based on.

When the steam engine was invented, it turned the agricultural society (with its "Economy 1.0") into an industrial society (with its "Economy 2.0"). This society was driven bottom up by entrepreneurs, and there was little consideration of the social and environmental externalities, corresponding to the way of thinking of the self-regarding "homo economicus."

In the beginning of the first industrial revolution, many jobs were lost, but new ones were eventually created by the service society (with its "Economy 3.0"). This was enabled by offering a good education to many people. The service

society is characterized by administrations that are trying to plan and optimize their domains of influence. Therefore, many countries have created health insurances, social security systems, and laws to protect our environment. In a way, new jobs have been created by increasingly complicated regulations.

By now, however, the world has grown so complex that it can't be optimized in real-time. Neither today's markets nor today's political regulations have solved problems such as overfishing, environmental exploitation, climate change, or international conflicts, and the financial system can still not be considered to be under control. We must further realize that top-down solutions are lacking flexibility, and can't satisfy the diverse local needs well. Nevertheless, reducing diversity by laws, norms and standards is not a solution, since diversity is key for innovation, cultural evolution, economic prosperity, societal resilience, and happiness.

In response to the above challenges, entirely new and more efficient approaches have started to emerge around evolutionary organizational principles, which enable collective intelligence – intelligence that surpasses even the smartest person and even the most powerful computer. This collective intelligence is not feasible, if decisions are taken in a top-down way. Even though majority decisions are often better than top-down ones, as they usually take more perspectives and knowledge on board, in our increasingly complex world, majority votes are reaching their limits, too. Therefore, complex systems that are run in these classical ways are often not working well enough, and this is also the reason why we will see new forms of organization of our economy and societies.

The creation of new institutions is inevitable. We need suitable information platforms allowing diverse knowledge and skills to come together, such that better decisions and more effective actions can be taken. Before I describe how I think the new organizational principles of the emerging Economy 4.0 may look like, I will give a quick overview of some of the transformations that

are already on their way, to illustrate that we have to expect fundamental transformations of our socio-economic systems, as we haven't seen them in a century.

### *Personalized education*

In the past, the academic system has done a remarkable job in compressing ever more knowledge into a few lectures. Often, the knowledge gathered over hundreds of years is squeezed into a single course. However, our world is now changing more quickly than ever. We can't anymore understand it in the way we used to do. We are facing a situation where most of our personal knowledge might be already outdated. It's impossible to follow all the relevant news in the world. Even scientists and doctors are facing difficulties to catch up with the exponentially increasing amount of literature and knowledge. Politicians and business leaders are confronted with similar problems, too.

In response to this challenge, the educational system has already started to change. Rather than just a few classical fields of study, such as math, physics, chemistry, biology, history etc., we are now seeing an explosion of different bachelor and master degrees. Greater diversity is a trend, and people can now find study directions that match their interests and talents better. Moreover, massively open online courses (MOOCS) are quickly spreading through platforms such as *Coursera*, where people can learn about almost any subject from some of the best professors in the world. Such virtual courses might be visited a hundred thousand times or more, and even for free. In perspective, this allows us to share up-to-date high-quality knowledge with millions or even billions of people, who can learn a subject whenever they need it.

The next step in the evolution of personalized education might be the development of multi-player serious online games or Interactive Virtual Worlds. These would allow everyone to explore the laws of nature, to discover

different historical ages or cultures, and to interact with fellow students. Professors may act as "chatroom masters," providing guidance, correcting misunderstandings, and answering questions that cannot be readily addressed with knowledge from the Internet. Furthermore, virtual, three-dimensional video meetings may become a standard, once the technology and bandwidth are there.

Of course, schools must change dramatically as well. Teachers complain about burnouts and about aggressive pupils who don't concentrate on the subject anymore and fail to answer tests that previous classes easily passed. Are schools really preparing kids well enough for a successful future?

Pupils complain that the knowledge they learn is outdated and not very useful for them. By using information sources from the Internet, they can easily know more than their teachers. It's probably true that pupils lose the ability to memorize facts and focus, and they expect several things to happen at a time. But they still like to learn things that fit their personal interests. Unfortunately, the standardization of today's education destroys the interests and creativity of many of them.

In the future, we will need less standardized education, but education that embraces diversity, innovation and creativity. Rather than teaching kids a standard collection of knowledge, they need to learn how to find information, how to critically assess it, and how to use it for their purposes in a responsible way. Rather than forcing them to put their smartphones and iPads aside, we must reach them where they like to spend their time: on the Internet. They need to be supported in using the opportunities of the information age to develop their ideas and successfully perform projects with others.

In conclusion, the schools of today are schools of the past. They are an outdated concept that doesn't fit its purpose anymore. Drumming standardized knowledge into pupils' heads just doesn't work anymore. We

must rather guide pupils in their individual discovery of the world, and in critically using the knowledge we have accumulated before.

### *Science and health, fueled by Big Data*

Our health system and science are about to change dramatically as well. Even though I don't subscribe to the credo of Big Data enthusiast Chris Anderson that we will soon see the "end of theory," I believe that Big Data has the potential to change many scientific disciplines. Traditionally, we have had three pillars of knowledge creation: theoretical analyses, experiments, and computer simulations. Now, there is a fourth pillar: Big Data analytics.

Big Data analytics is not a universal tool to answer all questions in the world, but the availability of large data sets allows us now to get insights that were not possible before. Big Data analytics empowers one to explore large knowledge bases easily and to find initial evidence. In many cases, the correlations and patterns detected in this way will not be sufficient to draw reliable conclusions. But if data-centered approaches are complemented by targeted experiments, computer simulations, or analytical models, this can combine the advantages of different methods and lead to better knowledge more quickly and potentially at a lower price. For sure, it can increase the innovation rate and quality of results.

The health system certainly belongs to the most promising application areas of Big Data. For example, IBM's Watson computer will soon support doctors in diagnosing and treating diseases, by evaluating a much larger body of medical literature and integrating more pieces of evidence than doctors can do by themselves. In addition, it will become possible to correlate our health status or diseases with what we eat, our genetic predisposition, and the socio-economic conditions we are living in. Rather than exposing us to unspecific broadband medical treatments with considerable side effects, as we often had them with antibiotic and other medication, we will be able to get personalized

medicine and individualized treatments. This will be more effective while reducing undesired side effects. What is good for one person might be bad for another. Furthermore, we might be able to diagnose emerging diseases early on, before they break out, thereby helping us to prevent them. So, disease prevention might become more important than treating diseases. Obviously, this will cause a major paradigm shift in the health system.

Let me give a further example relating to the work of Olivia Woolley Meza with Dirk Brockmann and myself. To fight pandemics, it is important to immunize people, to dampen the cascade spreading of infections from one person to another. But how to ensure that the right number of people will be immunized? Immunizing everyone is often not possible, because there are typically not enough immunization doses. Moreover, informing everyone about the infection level through mass media is also not effective. Many people will either not respond or panic. Surprisingly, however, if people knew about the number of infected people in their social circles, this would trigger effective immunization of those who are most likely to be infected. In other words, local information can be more effective than global information, i.e. locality is an advantage. With information platforms such as *Flu Near You* (<https://flunearyou.org/>), such information services are now becoming available.

To unlock the health-related opportunities mentioned above, we must enter a partnership with the patient. Before we can open up the potential of sensitive personal and health data, we need to establish a careful relationship and trustable information technologies, where the patients have a sufficient level of control over their data and what happens with them. Improving the health system requires a stronger bottom-up involvement.

### *Banking and finance*

The financial business is in turmoil since at least 2008. This is best illustrated

by the latest financial crisis and by new phenomena such as flash crashes, which may destroy market values of nearly 1000 billion dollars in less than half an hour, as it happened on May 6, 2010. Such flash crashes are considered to be side effects of algorithmic trading. In fact, about 70 percent of all financial transactions are now autonomously performed by computers, which permanently evaluate and test the markets for potential opportunities. An entirely new financial business based on high-frequency trading has emerged, and it has undermined the fundamentals of classical financial investments.

Furthermore, we have seen an explosive expansion of shadow banking and the derivatives market. In many cases, derivatives have taken the role of insurance contracts. They have entirely transformed the insurance business and the financing of real estate, too (which ultimately was the trigger of the financial crisis). On top of this, payment processes and money themselves are undergoing a transformation. While most payment processes were based on cash or cable transfers in the past, they are increasingly replaced by credit card payments and now by *Paypal*, *Google Wallet*, *Apple Pay*, etc.

Furthermore, we see a trend towards micro credits, peer-to-peer lending and peer-to-peer money transactions, be it through *BitCoin* or *P-Mesa* or other means. Hence, the trend goes towards decentralized approaches, where banks are not needed as intermediaries anymore. Money transactions are directly executed between people. This may be seen as a response to the failure of banks to provide a good service for everyone, such as affordable loans for a broad range of companies and people. Some people even think the last financial crisis, by far the biggest ever, was already a result of the digital revolution, because it replaced trust-based interactions by credit default swaps and other financial derivatives serving to insure traders against high losses. Without any doubt, to be successful in the future, companies will have to pay much more attention to their clients.

*The pillars of democracies*

Democracies are often said to rest on four pillars: legislative, executive, jurisdiction, and the public media. I personally think, science should be a further, fifth pillar, as evidence-based decisions create competitive advantages. But all these pillars will undergo fundamental transformations, and have already started to change.

We have seen the perhaps most dramatic changes so far in the media business. Online media have challenged the classical print business, in particular as they are often provided for free in an attempt to attract more readers. Digital media have, therefore, undermined the traditional business models behind newspapers, as we have also seen it in the music and movie business. However, the businesses have caused the trouble themselves: they did the step towards digital media without previously adapting their sales and customer service models.

On top of this, it can be observed that people increasingly turn away from mass media in favor of *TV on demand* and own information sources they appreciate and trust. In other words, there is again a trend towards personalization and decentralization, where media consumers play a greater and more active role. In fact, in its new strategy, the New York Times identified their readers as their most underutilized resource. With comments and blogs, but also by spreading news through social media, they are increasingly contributing to the content and success of the media. A further interesting development points towards grassroots journalism, building on local experts.

Executive and jurisdiction are also silently changing. Police, secret services and other authorities are now using surveillance and Big Data to determine crime hotspots, possible terrorists, speeding drivers or people that hide untaxed money, or bribe others. To accelerate trials, judges are making more



deals with the delinquents, and court procedures are shortened, with fewer opportunities to challenge a court sentence. The international trade agreements, which are currently being negotiated, are even planning to settle conflicts of interest outside the current court system. This again is driven by the desire to increase efficiency by removing regulatory obstacles. But in the future, many conflicts of interest could also be settled with moderation procedures in a community-based way.

Many administrative routine jobs, too, will be taken over by computers. It is just a matter of time, until legislation itself will undergo a fundamental transformation. On the one hand, the concept of centralized decision-making is increasingly questioned by countries and citizens, since the value of diversity is not appreciated enough. On the other hand, we have to overcome the problems of over-regulation by new approaches that allow more innovation and locally adapted solutions to happen. Therefore, I bet that the current principles of long-term planning and administration will increasingly be complemented or replaced by (semi-)automated and more flexible approaches. For example, future information systems, including the Internet of Things, will be able to support self-organization, (co-)evolution, and collective intelligence, which might become the new organizational principles.

Instead of trying to control innovation by means of regulation, it might be better to create jobs by innovation, which takes responsibility for the externalities created (i.e. the costs and damages). The simple rule that everyone has to come up for the externalities caused, could replace thousands of regulations and unleash a lot of creativity that is currently prevented by red tape. About 25 million unemployed people in the EU-28 states (and close to 20 million in the Euro countries) are speaking their own language. And this does by far not count everyone, who doesn't have a job and prefers to have one. Unfortunately, things will get even worse: eventually, the digital revolution will eliminate further jobs that were traditionally performed by people. Many experts predict that the number of jobs in the

industry and service sectors will drop by 50 percent, while the large information technology companies will create comparatively few new jobs in the fourth sector of information and knowledge creation. This would mean an unemployment rate of perhaps 30 to 50 percent or more – a number that probably no country can manage in the way it is organized today. Faced with such numbers, it is clear that we need to re-invent everything: our economy, the way we innovate, the way we do business, and the way we run our societies (see also Information Box 1).

### *Industry 4.0*

Recently, there is also much reporting about the “Industry 4.0”. To explain what this is about, let us start with the “Industry 1.0,” which represents the first stage of industrial automation, as we know it from the steam engine or the mechanical weaving loom. In contrast, the “Industry 2.0” stands for the age of the conveyor belt, which enabled mass production. Then came the “Industry 3.0”, which means production with robots. Finally, the “Industry 4.0” stands for machines (or robots) directly communicating with each other or with the remaining production staff. It represents the next step of automation, leading to a largely self-organizing production system. For example, in modern car factories, one will find very few workers. Most of the work is already done by robots, which are remotely controlled by a few skilled engineers.

The key technology driving this development is the Internet of Things, which uses networked sensors to generate the data needed for real-time feedback and control. At home, the Internet of Things drives similar developments, allowing us, for example, to control our Bluetooth radios or TV sets with our smartphones. But it would be naive to believe that digital technologies would just make our production more efficient and allow for smarter gadgets. The digital revolution will transform our entire economy, and our societies as well. We will see a trend towards self-organizing systems everywhere, enabled by the combination of the Internet of Things with knowledge from cybernetics and

complexity science. They provide us with the key to a better future.

*New avenues in production, transportation, and marketing*

Let us now look into the disruptive innovations in the areas of business and transportation. For 100 years, vehicles have looked more or less the same. They had four wheels, a motor running on gas, a steering wheel, and a driver. Production was locally concentrated in the hands of a few companies, due to the "economies of scale," and advertisements served to make mass products attractive to a large number of people. Suddenly, it becomes fashionable to drive electric *Tesla* cars, while *Google* and other companies are developing driver-less cars.

*Uber* is challenging the classical taxi business by connecting passengers directly with cars in the neighborhood willing to provide the requested ride. And *Amazon* is experimenting with delivery by drones. Based on personal data, advertisements are trying to reach exactly those people who might buy a particular product rather than everyone. The customer does not anymore have to search for products matching the own interests – products and services now directly find the customers that might be interested in them. Rather than visiting a shop and hunting for the product we would like to have, we shop online more and more frequently, and the right products are delivered home. The shopping platforms know our desires and suggest, which book to read, product to buy, and hotel to book.

But this is not all. Companies like *ebay* allow everyone to be a seller. This creates a peer-to-peer market. Rather than throwing a used product into the garbage, we might now sell or donate it to somebody else who appreciates it, or share it with others. In fact, we can currently witness the emergence of a sharing economy. Now, with new services such as *couchsurfing* or *airbnb* (and thanks to reputation systems), many people even offer strangers to stay as guests at their homes – something that they had probably not imagined to

do just a few years ago.

Perhaps being the result of the last economic crisis, the sharing economy opens new doors to a high quality of life for everyone, while promoting a more sustainable use of resources. The sudden move towards shared use is enabled by novel information and coordination platforms that directly match local supply and demand. The companies running such socio-economic coordination platforms enjoy remarkable growth rates of around 20 percent. This apparently correlates with a trend that increasingly replaces the desire to possess by a custom to share.

We can now also buy tailor-made jeans and personalize our products. In fact, entire shops are run on the individualization of mass products. The next logical step is personalized production, or even production at home as 3D printers allow it now. After a century of democratization of consumption, we are finally entering an age of democratization of production. The separation between producers and consumers increasingly disappears. We are becoming prosumers, i.e. co-producing consumers. In the Internet and even more so in social media, this has been true already for some time.

Eventually, it will not make much sense anymore to manipulate our opinions by means of advertisements. Companies will instead end up delivering us what we really want, if we are willing to let them know. In the future, a two-way interaction between producers and consumers will be the key to economic success. Companies that don't care about the wishes and opinions of their customers will have little chances to offer the best products and services, while those engaging in a fair partnership with their customers will thrive. Therefore, we will see a shift from a company-centric market to a user-centric market. And we will also see increasingly intelligent cooperation networks that integrate the wisdom of companies and customers to create better services and products.

The trend towards more personalized and individually customized products will furthermore create a "hyper-variety market." In fact, the digital economy will open up infinite opportunities for new products, as the information age enables uncountable dimensions of creativity. The unlimited possibilities to produce creative artifacts such as music, news, blogs, and videos, but also smartphone apps as well as products and services for virtual worlds illustrate this well. For example, every minute, more than 500,000 posts are published on *Facebook*, and more than half a million smart phone apps exist today. In 2013, *App Store* users spent more than 10 billion dollars, and they downloaded more than three billion apps in December 2013 alone. This has very interesting implications for the future structure of markets. While today, we have a few core businesses and some peripheral business activities, one can expect that peripheral products will dominate market activities in the future.<sup>1</sup>

#### *Where are we heading? New forms of work*

We are also confronted with new forms of work. In the past, long-term employments in one and the same company were common (at least in large German companies such as Daimler Benz, BMW, or Bosch). Eventually, however, multiple successive short-term employments became common in most companies. Now, we have a growing fraction of temporary employees, and we are quickly heading towards short-term engagements. *Amazon Mechanical Turk*, for example, matches tasks and workforce in such a way that working relationships often last for minutes only! But it also becomes possible to translate a 200-page document within minutes, by splitting the task into 400 subtasks, done by 400 people.

Such short-term commitments may certainly come with extremely increased stress levels. Therefore, and in view of the increased existential risks related with new forms of employment, some people think it would make sense to

---

<sup>1</sup> One may visualize this by representing today's core businesses by the core of a sphere and peripheral businesses at its surface. Interestingly, the relationship between the surface area  $A$  of an  $n$ -dimensional sphere of radius  $r$  and its

introduce a small basic salary allowing everyone to survive, but not very comfortably.<sup>2</sup> This is hotly debated based on ideological grounds. Why should people be entitled to get an unconditional payment? Would the state be able at all to pay for this? And would people still work hard, or would they get lazy? I certainly think that we will still need a merit-based organization of our economy and society in the future, but to reach a good quality of life, most people would probably try to upgrade their salaries by paid work.

Independently of the reader's position on the above, it's likely that people will run more and more "projects" to make a better living by offering own products and services. Such projects will be task-driven, short-lived, and very flexible. Future entrepreneurs will set up and coordinate such projects, and organize the necessary support, as discussed in detail below. Once completed, a project would terminate, and the previously involved people would look for other projects to coordinate or to participate in.

Everyone will probably be a coordinator and a participant of several short-lived projects at the same time. This has a number of advantages. Participating in projects will provide new opportunities to influence issues one cares about. Another advantage is that projects make more self-determined and exciting work possible. A further positive side effect is that short-lived projects can overcome the "Peter principle," according to which people currently tend to get promoted until they end up in a position that overstrains their abilities.

It is likely that, over time, companies, political parties, and other established institutions will increasingly be complemented by projects as more flexible form of organization. Today, however, we are still living in a world of many slowly adapting institutions, which (in the best case) are trying to take optimal decisions for many people, based on representative data.

---

<sup>2</sup> Some institutions have already calculated whether this would be affordable. If everyone got such an unconditional mini-salary, one might not need a complicated and expensive social benefit administration and, therefore, the overall public budget needed would not significantly change.

*Prosumers and the future role of entrepreneurs*

Although institutions typically have bottom-up elements, a great deal of decision-making is still done in a top-down manner. However, as systems become more complex, they will require more bottom-up elements and local knowledge to meet the diverse local needs. Otherwise, complex socio-economic systems will perform poorly or may even destabilize over time. We can see this even for the case of the European Union, which is currently not doing so well, probably because it has become too centralized and standardized, while not offering sufficiently diverse opportunities for countries, regions, and local communities with different interests, needs, weaknesses, and strengths.

Fortunately, digital technologies are now enabling entirely new and more flexible ways of organization. People start to use social media platforms to organize their own interests and realize their own "projects" in a bottom-up way. In principle, everyone could do this, given the required technical and social skills. The on-going developments are gradually turning consumers into "prosumers," i.e. consumers who are co-creating products they buy (and sell).

The co-production in the World Wide Web, in social media channels, and of 3D-printed home-made products are just three examples. In fact, 3D printer technology is now enabling local production by small teams or individuals who may sell their products to friends, colleagues or even the rest of the world. Rather than just specifying the color and individual features of a product when ordering it, we can increasingly design its components or composition and commission its production. One may even set up a team of designers, engineers, marketing people, and other specialists to design an own smartphone with components produced by other companies or with new components commissioned from home. That is, old-style factories and the newly emerging digital economy, based on collaborative projects, are increasingly working hand in hand.

To a certain extent, projects of the above-described kind are already in existence today, for example, open source software projects. Many such projects are driven by volunteers or employees of companies, who rely on open source components and want to get their required features implemented. There, the development is bottom-up and open. The related "open source ecosystem" is based on a number of ingredients such as "viral" open source licenses, which encourage that those using open source code in their own software will also contribute something back. In other words, software licenses (such as the *GNU* General Public License) reward a culture of fair sharing (which fits the other-regarding preferences behind the networked thinking discussed in the previous chapter.) In the context of open source development, the *GitHub* platform has become particularly popular among software developers, recently. The platform also indicates who has contributed what, thereby creating incentives for contributing. Thus, everyone can benefit from a growing ecosystem of open source software. The result is a way of competition that also engages in collaboration, sometimes called "co-epetition."

Another trend besides short-term commitments and projects, co-creation, home production, sharing, personalization and hyper-variety markets is the importance of a modular organization of projects such that they form a network of projects. For such "super-projects" to grow, the interaction must be of mutual interest and will often involve a multi-dimensional value exchange (see the Information Box 2). The interaction of all these projects creates an innovation, product, services, and information ecosystem. We will discuss this and the multi-dimensional micro-payment system needed for it, towards the end of this chapter. Before, however, we must pay attention to another fundamental change, which relates to the way we organize socio-economic systems: we will see a trend towards bottom-up participation, as the Internet is increasingly reaching out to the citizens, customers, and users. To understand this better, it is useful to discuss the advantages and



disadvantages of top-down and bottom-up organization.

### *Top-down vs. bottom-up organization*

Let us start with top-down approaches, as they are common in military organizations, administrations, and many companies. Top-down approaches support power and allow one to exert control. They also make it easy to define accountability. Top-down approaches enable quick decision-making and a faster coordination over large distances, but the collection and evaluation of information required for this is often considerably delayed.

With top-down approaches, it is easier to reach a system optimum, given that the goal is well defined, the variability of the system is low, changes are reasonably well predictable, and the optimization problem is well tractable. Under such conditions, top-down control can increase the performance of the system, but often, at least one of these conditions is violated.

Top-down approaches provide more opportunities for individual intelligence and expertise, but mistakes have also a greater impact. In other words, they can solve problems, but also create them. Top-down control enables faster change, but it may also block or delay it. Moreover, it facilitates benefits from standardization.

Altogether, top-down approaches work well for sufficiently simple and deterministic systems. They are common in situations where it is more important to take a decision than waiting until disagreements can be sorted out. A medical surgery is a typical example. But top-down controlled systems are vulnerable, and they can be easily corrupted.

Bottom-up approaches, in contrast, may perform better under complex and largely variable conditions, if suitable coordination mechanisms are in place. Good examples are our immune system, markets, and ecosystems. Bottom-

up approaches support flexibility, local adaptation, diversity, happiness, creativity, exploration and innovation. They also tend to be more resilient to disruptive events.

Bottom-up approaches support democratic processes, but may also cause herding behavior. To work well, good education and willingness to take responsibility on the bottom is required. Decentralized approaches have higher information processing capacity and enable collective intelligence, but information integration tends to be difficult.

Altogether, top-down approaches are based on power and control, while bottom-up approaches build on an empowerment of people to help themselves and also each other, for example, to create their own jobs. Top-down approaches tend to relate to constructivism, bottom-up approaches to (co-)evolutionary principles. But given that both, top-down and bottom-up approaches have their strengths and weaknesses, there is not one correct approach that works best in all situations. They play complementary roles. Both approaches are needed, but must be applied in the right circumstances or suitably combined.

Currently, top-down approaches and control architectures for socio-economic systems are promoted by Big Data. However, bottom-up approaches are also spreading, depending on the following success factors: good education; access to reliable high-quality information, decision support systems and services; emergence of coordination platforms (such as social media); spreading of reputation systems that promote accountable and responsible behavior, and the consideration of externalities (which tend to make good solutions for individuals better compatible with good solutions for the overall system). These factors are currently on the rise with the spreading of Open Data, citizen science, recommender systems, moderated Internet communities, the makers movement, the Internet of Things, etc. Further game changers are the increase in variability, complexity and diversity.

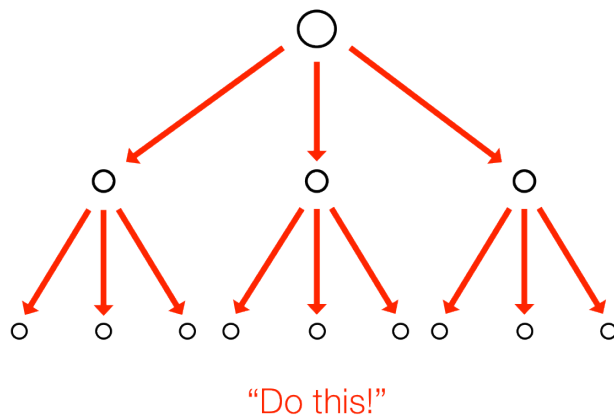
For such reasons, decentralized and bottom-up solutions are currently spreading. The rise of *Bitcoin* is a good example for this. Peer to peer lending is another one, and swarm intelligence, too. We also see the (co-)production of electricity by citizens, enabled by Smart Grids. Furthermore, citizen science has established a number of credible information platforms and community services, where governments or businesses haven't provided them. Examples of such crowd-based approaches are the creation of a distributed earthquake sensor network in California, or the monitoring of nuclear radiation in Japan.

*Allowing diverse resources to come together quickly*

Let us now explore, how today's information systems allow top-down and bottom-up approaches to come together in new ways, to create superior systems. For this, it is useful to study the case of disaster response management, which is an area that has traditionally been managed in a top-down way. However, my perspective dramatically changed, when I recently organized a hackathon on earthquake resilience in San Francisco, together with SwissNex, Thomas Maillart and Alexei Pozdnoukhov. Even though this happened to be on the national day of civic hacking, the subject hit the nerve of the Silicon Valley and attracted about 80 people. They formed nine teams around a number of different project ideas, and the results established a new paradigm of disaster response management, powered by modern information systems.

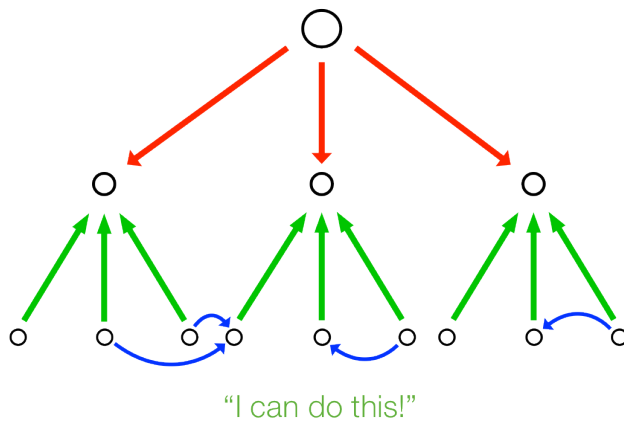
Let us first discuss the classical system. Here, a commander tells others, what to do, and these again tell their subordinates to execute the orders from the top (see figure below). However, during a disaster, the information flows and command chains are often not working well, for example, due to lack of information, disturbances, delays, or simply capacity constraints. In fact, it often takes 72 hours until disaster response units can work at full capacity. Sadly enough, that's also the time period after which many people will have

died from injuries or lack of water.



Allowing for some autonomy on lower levels can achieve better results – given suitable equipment and good education. In fact, rather than micro-managing and telling everyone what to do exactly, the hackathon results suggested a different approach. Accordingly, it was better to determine and publicize: "We must do this, that and that." In response, people, companies, non-government organizations would reply: "I can do this," "We could to that," and so on (see figure below).

For this approach to be efficient and effective, it is important to have suitable information platforms that match and coordinate supply and demand. Such a coordination platform was often not publicly accessible in the past or missing completely, as the technology needed to reach good coordination was not sufficiently widespread. But now we see the emergence of information platforms and communities such as *CrisisMappers*, which make valuable contributions to a better disaster response.



### *Towards a more resilient society*

Interestingly, one of our three hackathon winning teams, *amigocloud* (<https://www.amigocloud.com/homepage/index.html>), came up with a smartphone app that allowed everyone to take pictures of broken infrastructures or other problems, and add further information, which would be uploaded to a public webpage as soon as connectivity was back. In the future, such connectivity could also be provided, when central infrastructures are dysfunctional, based on ad-hoc networks or meshnets (as smartphone protocols like *Firechat* will support).

Another winning team proposed ChargeBeacon (see <https://www.youtube.com/watch?v=LVGwHAtLwVQ>), a local and autonomous infrastructure using solar panels, which would allow citizens to recharge their smartphones during an electrical blackout. The third winning team, Helping Hands, developed a smartphone app that allowed everyone to ask for help and offer it.

For example, someone could write that he or she needed baby food, or could offer water or warm clothes, how much of it, and where. This enables a powerful help-yourself-community approach. As a positive side effect, the

public disaster response teams will be able to focus more on providing aid, where people can't help themselves. So, the Helping Hands approach frees up public disaster response capacities for other urgent matters. Consequently, everyone can benefit: the citizen and the state. Remarkably, all of the above concepts came together in a single hackathon, in a single day!

It is also noteworthy what Yossi Sheffi writes in his book *The Resilient Enterprise*. He describes what it takes to keep a business going when struck by disaster: the boss of the enterprise must provide a framework that allows the company's experts to find solutions. However, the boss shouldn't interfere with the details of the fixing process, as attempts to micro-manage are often not helpful without a sufficient knowledge of details. Instead, the boss should empower the staff to find new solutions.

Why should we care about this example of disaster response management? Because it is paradigmatic and highly relevant. Many challenges in politics and business today are very similar in nature. It sometimes seems that, by the time a problem appears to be solved, there are already one or two other problems awaiting urgent attention. In a quickly changing, largely variable, and hardly predictable world, we need flexible solutions that can quickly adapt to local needs and circumstances. This determines the resilience, survivability and success of a complex system, be it a company challenged by its competitors, a disaster-struck city, or even a state faced with the turmoils of globalization.

These complexity challenges also call for a more intelligence – collective intelligence. As we have seen in the previous chapter, collective intelligence is directly related with a distributed approach, which is also a precondition for diversity to exist and thrive. But for collective intelligence to be possible, the coordination of diverse inputs is needed. We must, therefore, build participatory coordination platforms. Such platforms could in particular support co-learning, co-innovation, and co-creation. In perspective, this would create

something like a participatory "information, innovation and production ecosystem," in which there are niches for diverse, but competitive solutions to a problem, each created according to its own rules of operation, fitting the respective project goals. Then, we will typically have enough partial solutions to assemble things on a higher level in a modular way. In fact, when thinking of a modern plane or fancy car, we immediately understand that some of the systems created today are so complex and require so many different skills that nobody understands all their details.

Importantly, by growing such a diverse ecosystem, in which many different approaches co-exist and co-evolve, we will also make our society more resilient. Then, whatever happens, we will have a rich arsenal of options to respond. The currently negotiated international trade agreements, in contrast, might easily create too much homogenization and standardization in the world, and eliminate the niches in which new ideas emerge and spread. Niches are needed to create opportunities to experiment – it's one of the major success principles of evolution (remember also the importance of local interactions for the emergence of cooperation). A serious side effect of too much homogeneity in our socio-economic systems would be a higher vulnerability to disruptions – that would be a very high price to pay.

### *A new kind of economy is born*

Why not use the above approach, which combines top-down and bottom-up approaches (or centralized and decentralized elements), every day? In fact, the creation of goods, services and knowledge in the emerging Economy 4.0 works exactly like this. You may, of course, ask whether we haven't managed companies in this way already for a long time?

Of course, companies make calls for bids (tender offers), to select the best subcontractor(s), and this works more or less in the way the previous figure suggests. However, internally, many companies still seem to be pretty much

run in a top-down way. That may avoid certain undesirable things from happening (e.g. duplicate developments), but it also prevents favorable things.

Just suppose a company experiences an economic downturn, i.e. it sells less products than expected. Traditionally, it would discharge many people to improve its balance sheet. However, one obvious reason why the company does not sell enough products is that it doesn't offer enough interesting products that people would buy. Therefore, suppose the company would decide to make an internal call for new product ideas, which make use of the knowledge, skills, and machinery available in that company. Most likely, the company would generate several interesting ideas for new products, which might help to overcome the innovation crisis that a large company often experiences. In other words, the company could create some autonomous development units for a limited period of time and then decide, whether these should be closed down or turned into spin-off companies.

Note that the principle combining top-down and bottom-up elements, illustrated in the above figure, could be applied on all organizational levels: within companies and their units, within cities, or even the federal states of a country. In fact, this exactly corresponds to how Alexandros Washburn describes the nature of urban design, as it is practiced in New York City.

In the past, most of us couldn't participate in the improvement of the man-made systems around us, as we did not have the right coordination tools to bring the knowledge and skills of many people together. This is now changing. With the existence of suitable information systems and organizational principles, individuals will actively engage as citizens in their cities, as employees in their companies, as consumers, and as users. By building suitable coordination platforms, we can create more opportunities for everyone, enable people, companies and institutions to take better decisions, and encourage people to act responsibly.

*Emergence of a Participatory Market Society*



The Silicon Valley can give us some further insights. In the Silicon Valley, there is a surprisingly fluent exchange of workforce between companies. If a company goes bankrupt, which is pretty normal in the Silicon Valley, people usually find a new job quickly. In some sense, one might interpret this to be effectively a long-term employment in the Silicon Valley rather than a short-term employment in many companies. In other words, the Silicon Valley is like a super-company, in which there is an invisible knowledge flow and network of people that connects basically all companies. But companies may be considered as niches, in which a lot of experimenting takes place and a lot of diversity can exist. In other words, a success principle of the Silicon Valley is that it supports the co-evolution of companies and ideas.

We may also interpret this interaction network of companies to form something like an "economic ecosystem." As I explained in the previous chapter, evolutionary principles are eventually expected to lead from a self-regarding to an other-regarding, networked thinking, because this produces superior outcomes and higher average payoffs. For companies, this means that they need to reach out and team up with their suppliers and customers to a larger degree. Next-generation social media will provide suitable tools for this. Those companies that manage to offer individually tailored, customized products and services will have competitive advantages. Clearly, this requires more information exchange and, to be sustainable over a longer time period, a trustable and fair two-way communication and collaboration. As a consequence, one must learn to engage in systems thinking, which integrates and balances different interests and perspectives. Companies like Porsche, for example, are well aware that one can produce and sell top-quality cars only by engaging in a partnership with the workers on the one hand and with the customers on the other hand.

Therefore, we might imagine the economy to work like an "ecosystem," where the different biological species represent the different economic stakeholders.

For the economy to work well, it is obviously important that all consuming and delivering sectors work well. If one of them disappears, it's as if a species dies out, which disrupts the entire economic ecosystem. In fact, an interesting study by Hidalgo, Klinger, Barabasi and Hausmann showed that economic development and prosperity largely depend on the variety in this "ecosystem." In particular, the greater is the diversity, as reflected by the variety of economic products, the better.

### *Preparing for the future*

What can we do to prepare for this new kind of economy? In the past, we built public roads for the industry society to thrive and public schools for the service society. Now, we will need to build public institutions that allow people to help themselves: information platforms, which support everyone in taking better decisions, and more effective actions; participatory platforms, which support creative projects and participatory production. To master the challenges ahead of us successfully, it will be important to team up with citizens, consumers, and users, and to treat them as mission-critical, first-class partners. If we really want to create a new job market, we must boost the opportunities for small and medium-size companies, and self-employments, too. For this, an Open Data strategy is key.

Well-designed, participatory information platforms could help everyone to identify suitable project partners, to communicate easily, to coordinate each other and collaborate, to co-create, to perform financial and project planning, to manage supply chains, to schedule processes, to do accounting, and to execute all other activities needed to manage a project or company, such as handling health insurances, tax payments and declarations, etc. Then, everyone could easily set up collaborative projects without the frictional losses of today, where suitable supportive tools are expensive or lacking. In fact, a future job platform would have all these features.

## INFORMATION BOX 1: Re-inventing innovation

Compared to material goods, information is a special resource: it can be reproduced cheaply and as often as we like. While material resources are limited and imply conflicts, for information-based goods it does not have to be like this. Nevertheless, current intellectual property rights treat digital artifacts pretty much like material goods. A different kind of intellectual property right (IPR) might dramatically accelerate innovation and create many more jobs. While we have to catch up with the pace at which our world is changing, the current IPR protection approach creates major obstacles. What we need is a novel co-creation paradigm.

In fact, one could fundamentally innovate the way we do innovation. Currently, many people don't like to share their best ideas, because they want to be rewarded for them rather than allowing other people to become successful or rich on them. It often takes years until an idea is shared with the world through a publication or patent. But what if we innovated cooperatively from the very first moment? Let us assume, an idea is born in Europe, and it is shared with others through a public portal such as *github*. Then, experts from America could work on these ideas just hours later, and experts from Asia would build on their results. In such a way, one can create a research and development paradigm that never sleeps; one that overcomes the limits of a single team; one that embraces "collective intelligence."

Such an approach would produce considerable synergy effects. As my colleagues Didier Sornette and Thomas Maillart have recently shown, the collaboration of two people on producing open source software creates outcomes that would otherwise take 2.5 people (" $1+1=2.5$ "). Geoffrey West, Luis Bettencourt, others and I discovered a similar scaling law for cities: productivity that depends on social interactions grows super-linearly with city size (namely according to a power law with an exponent around 1.2). This is

probably the main reason for the dramatic on-going urbanization of the world.

Now, with Internet forums of all kinds, something like virtual cities have grown. Many citizen science projects (and also the famous *polymath* project on collaborative mathematics) underline that a crowd-based approach can outperform classical approaches in research and development.

Given the great advantages of collaboration, what are the main obstacles to the immediate sharing of ideas? I would say, mainly the lack of proper incentive systems. Researchers live on two kinds of rewards: their limited salary and the applause they get in terms of citations, i.e. the mentions they receive by fellow scientists. Therefore, many scientists share their ideas with others only after publication. Patents are a further obstacle to sharing and the wide use of good ideas. While they are actually intended to protect the commercial value of ideas and thereby to stimulate innovation, in the area of digital products, patents seem to be more an obstacle to innovation rather than a catalyst for it.

Patents on ideas are a bit as if everyone would own a certain number of words and would charge others for using them – this would certainly obstruct the exchange of ideas considerably. Interestingly, it has recently been difficult to legally enforce hardware and software patents, and we see ever more patent deals between competing companies. The electro-car company Tesla has even decided to allow others to use their patents. All this might indicate that a paradigm shift in terms of Intellectual Property Rights is just around the corner.

Moreover, it has become increasingly difficult to earn large amounts of money on copies of music, movies, or news. This is not just a problem of illegal downloads. In contrast to material resources, information is an increasingly abundant resource. Given that every year, we are producing as much data as in the entire history of humankind, information will become cheaper and

cheaper. As a consequence, we may head towards an increasingly immaterial age. This applies even more, as we are spending ever more time with information systems.

*Micropayments would be better*

So, why not pursue an entirely different IPR approach – perhaps in parallel to the intellectual property approach of today? It's the nature of information that it wants to be free and to be shared. Information is a virtually unlimited resource, which can be reproduced almost for free. In contrast to material resources, it allows us to overcome scarcity, poverty, and conflict. Nevertheless, we are currently often trying to prevent people from duplicating digital products. Therefore, what if we allowed copying, but introduced a micropayment system that ensures that every copy generates some profit for the originator? Under such circumstances, we would probably love duplication!

Rather than complaining about digital copies, we could make it easy to be paid for the results of creative and innovative activity. Remember that, some time back, *Apple's iTunes* made it simple to buy songs and download them, for 99 cents each, thereby overcoming the need for individual negotiations. It would be great to have a similarly simple, automatic compensation scheme for digital products, ideas and innovations. Today's powerful text mining algorithms could be the basis. Then, whenever another person's or company's idea would be used, there would be an automatic payment, which could be made dependent on the amount of investment made, the invention's novelty, and the advance it has created (the "innovativeness"). This would overcome obstacles like patents, and it would encourage cooperative innovation activities without having to worry that someone could steal an idea.

A micropayment system would also allow companies and citizens to earn on data generated and exchanged by them. Everyone could earn money with it, by contributing to the global information ecosystem. This would create an

incentive system that rewards the sharing of data. But to get paid for every copy, one would need a particular file format. Copies ("offspring") of data would have to be linked with their respective source ("parent") via a kind of "data cord" principle, such that micro-payments between data owners and data users can be processed. In fact, a "Personal Data Store" would be needed to execute these payments. Another function of this Personal Data Store would be to give each user control over his or her own personal data. Whenever personal data would be (intentionally or accidentally) produced about someone, it would have to be sent to that person's data store (which may be imagined like a mailbox for data). The person could then determine what kind of data to share with whom, for what period of time, and for what purposes.

#### INFORMATION BOX 2: Multi-Dimensional Money

Current money has a serious short-coming: it is just one-dimensional.<sup>3</sup> This makes it unfit to manage complex dynamical systems – a problem well-known from control theory. For example, complex chemical production processes cannot be steered by a single control variable such as the concentration of a particular chemical ingredient. In a complicated production process, one must be able to control many different variables, such as the temperature, pressure and the concentrations of many different ingredients.

It is also instructive to compare this with ecosystems. The plant and animal life in a place is not just determined by a single control variable such as the amount of water, but also by the temperature, humidity, and various kinds of

---

<sup>3</sup> Even though there are many different currencies in the world, we can convert them in an almost frictionless way, which makes money effectively one-dimensional.

nutrients such as oxygen, nitrogen, phosphor, etc. Our bodies, too, require many kinds of vitamins and nutrients to be healthy. So, why should our economic system be different? Why shouldn't a healthy financial system need several kinds of "money"? Besides today's money, this could, for example, include environmental factors and other externalities, as well as immaterial values such as social capital (for example, trust or reputation).

*We could all be doing well*

The fact that people respond to many different kinds of rewards, as we have seen in the previous chapter, allows us to define a multi-dimensional incentive and exchange systems. This opens up entirely new possibilities for adaptive feedbacks and self-organization, which is highly important to successfully manage complex socio-economic systems. However, compared to the currency system we have today, these different kinds of "money" would not be easily convertible, encouraging everyone to earn different kinds of money or value. Depending on how many dimensions we consider, everyone could be doing well, each on the dimensions fitting his or her personal strengths, skills, or expertise. That itself would be an interesting perspective.