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# **TUM Forum Sustainability**

Science, Reason  
& Responsibility



**Forward Thinking  
for the Post-Corona Era**

TUM Senior Excellence Faculty  
TUM Institute for Advanced Study

# TUM Forum Sustainability

## Science, Reason & Responsibility

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**Forward Thinking  
for the Post-Corona Era**

**Published by**

**Michael Molls**  
**Jörg Eberspächer**  
Hermann Auernhammer  
Georg Färber  
Birgit Herbst-Gaebel  
Udo Lindemann  
Klaus Mainzer  
Winfried Petry  
Ralf Reichwald  
Jürgen Scheurle  
J. Leo van Hemmen  
Peter Wilderer

TUM Senior Excellence Faculty  
TUM Institute for Advanced Study



**Professor Dr. Thomas F. Hofmann**  
President of the Technical University of Munich

## Never Waste a Crisis

The idea behind these variously rendered words of the Barack Obama presidency is something we should be taking to heart right now. As the COVID-19 pandemic confronts the global community with challenges of historic proportion across borders real and imagined, the null point is being recalibrated and the future composed anew. While this universal caesura has exposed the weaknesses of our world, it has also revealed potential for the transformative development of society and unprecedented opportunities to fortify Germany as a leading site of science and industry. To recognize and act on these opportunities will require our utmost—the unyielding courage of politics to pursue change, the transformative capacity and creative power of higher education, the real-world practice and agility of industry, and a society whose shared sense of responsibility provides the foundation for a concept of innovation in community that is not limited by professional, institutional or intellectual boundaries.

Germany can no longer afford to lag behind paradigm-shifting innovations in the global race for technologies of the future. Indeed, we are called upon now to exert our greatest efforts to finally address the shortfalls in “digitalization” laid bare by COVID-19. We must invest in the potential of secure digital connectivity with encrypted network traffic and in the promise of artificial intelligence as key factors in the development of our economy and health care system in the post-COVID era. Precisely there, where digital progress and the principles of living nature converge, we will see epochal transformation in the economic and health sectors. Technological “biologization”

promises groundbreaking innovations, such as those in industrial biotechnology, where efficient and sustainable processes valorize atmospheric carbon dioxide and bio-residuals, converting them into specialized chemicals, active ingredients, polymers and food ingredients to make these resources the drive belt of a circular bioeconomy. The healing potential of personalized biomedicine, too, just as the biological and bio-compatible structural scaffolds for artificial blood vessels and organs, or the functional organoids that will make animal experimentation a thing of the past – all need to bear the label “Made in Germany”. We must build viable bridges to the future with technologies, like “miniaturization” in electronics that enables higher integration density in industrial assemblies, or nanotechnologies that maximize performance, and tap the potential of emerging quantum technologies. To play a formative role in shaping economic added value in a globalized world, Germany must, at last, pave an entrepreneurial pathway for its universities to promote the efficient development of pioneering ideas from its laboratories and workshops into transformative technologies and globally scalable business models.

Value creation in a post-COVID-19 economy will be increasingly oriented on a social paradigm shift. The pandemic has forced the planet to stop and take a breath. It has intensified society’s increasing skepticism of blind trust in technology. Instead, there is a growing sensibility for the common good, a sense of shared responsibility for the world and an emerging neo-ecological consciousness regarding our treatment of the environment – we have finally gotten the message that we, too,

are “only” nature. Moving into the future, we will need experts committed to human-centered, responsible and socially viable technological innovations, products and services across all technology sectors: energy & climate · resources & environment · mobility & infrastructure · health & food · information & data security. “Trusted Human-Centered Engineering” requires not only natural science, technology and medicine but, more than ever, their thorough integration with sociology, political science, philosophy and ethics as the key to a new European culture of innovation, in which entrepreneurial action, social and ethical responsibility and environmentally conscious technological innovation go hand in hand.

The accelerated pace of global transformation in the face of the pandemic and our now proven capacity for remote work using digital networks pose important questions about the working world of the future. How will global labor markets change? What demands will the education of the future have to meet to stay apace with such rapid transformation that the competencies and technological expertise acquired at universities today will already be obsolete tomorrow? What are the consequences of anticipated technological leaps for continuing professional education, if careers are to last longer in the future? More than ever before, universities are called upon to question traditional teaching methods, to reimagine effectual teaching formats and concepts for remote and in-person instruction, and to impart to students not only in-depth, specialist knowledge but to teach them to think interdisciplinarily, to become competent and confident in international circles, to act responsibly and with a sense of values, and to never stop learning, even into old age.

The post-COVID-19 era gives us the chance to (re)integrate “the old” with all their experiences and networks more intensely into our accelerating society. Longer life expectancy presents entirely unique opportunities in old age – for individuals and for society as a whole. The society of the future calls for a new kind of solidarity across the generations. On a small scale, the Technical University of Munich (TUM) has shown how this works. Since 2006, we have been awarding the honorary title “TUM Emeriti of Excellence” to outstanding, dedicated retired scientists and scholars and involving them as competent, independent advisors on strategically important university matters. TUM thus recognizes their years of experience in science and innovation and their solid international networks in business, politics and society as an invaluable resource as part of a vital culture of diversity for the benefit of a cross-generational university community, without compromising opportunities for younger scientists. Under the leadership of their spokesperson Professor Dr. Michael Molls, our TUM Emeriti of Excellence, ever young in spirit, have pooled their expertise to create this unique brochure encompassing a multitude of concise, thought-provoking ideas for the time after the historic COVID-19 crisis. These perspectives from the most diverse disciplines, backgrounds and points of view bring together the entire spectrum of competence at TUM – “universitas” in the truest sense of the word.

As TUM’s President, I am filled with pride and faith in the future knowing we have such far-sighted, competent, critical and dependable colleagues, friends and supporters in the ranks of our university community. Allow me to express my deepest gratitude for your commitment and your intellectual inspiration, embodied in this publication. It bears witness to the added value of our intergenerational university community in times of crisis and illustrates new perspectives for posterity, for whose safe, healthy and sustainable development we are responsible today –

all of us, together. ┘



**Dr. Wolfgang Schäuble**  
President of the German Bundestag

# The European Response to the Post-Corona Era

## “It All Comes Down to Politics”

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The Corona pandemic has disrupted human existence around the globe, and will leave an indelible mark on all spheres of life as we know it. European countries now face hardships, the likes of which have not been seen in our post-war history – a further stress test for an already somewhat battered European Union in the 21st century.

### For more than a decade now, we have witnessed crisis after crisis:

the upheavals of global financial markets, the threat of Eurozone collapse, fierce disputes over refugees and migration, the incipient turn in many places toward populism and nationalism. Europe is learning first-hand that democracy cannot be taken for granted, that cohesion can fade – with the Brexit referendum representing a lamentable low point.

The disintegrative tendencies of the European project have been overshadowed by the Corona pandemic. To ignore them, however, would be a mistake. For we need Europe. No one nation-state alone can provide the answers to the most urgent questions of our time. The task at hand is to correct the course of a form of globalisation that has lost all sense of proportion.

Ours is a difficult task, but not an impossible one. We must combine economic recovery with social and ecological sustainability, mitigate the consequences of climate change as best we can, and embrace the benefits of digitalisation without ignoring its risks – these are the aims of the new EU growth strategy, the “Green Deal”. Likewise, we must provide answers to the unresolved issues of migration, and reach agreement on common European strategies in a changed geopolitical context.

The pandemic has shown us where the perils of an increasingly tightly networked global economy lie. Our dependencies have made us vulnerable, and that means that we as Europeans must strengthen our resilience by investing in secure supply chains, an improved digital infrastructure and collaborative research and development. In doing so, Europe can restore lost faith in the solidarity of its member states and in the agency

of its institutions. The self-healing powers of the market alone cannot fix things. Reconstruction must go hand-in-hand with reform.

In 2014, sociologist Ulrich Beck declared, “Europe must regain the power to dream,” and there is no time like the present. Yet, to seize this opportunity will require compromise. Europe can only set upon its new course and gather pace again with united strengths – and that will require decisiveness and leadership.

**Everything leads to politics. Science provides valuable orientation aids: wellfounded analyses, concrete advice, innovative thought-provoking impulses. Anyone looking for inspiration will find a wide range of suggestions in this publication. ┘**



**Dr. Markus Söder**  
Bavarian Prime Minister

# Learning From Crisis

## A Mandate for Politics and Science

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**Corona is a global challenge requiring local action – expedient, decisive and thoroughly considered action at the level of state governance.**

A central foundation of that decisive action is scientific knowledge. While the acute situation clearly puts the focus on virology and immunology, the nature of this crisis is more than merely medical. As such, it will take the combined efforts of multiple disciplines to develop the solutions for the overarching consequences of this crisis for our society. In Bavaria, the research of top-notch scientists at the Technical University of Munich plays a key role in our search for solutions as we move into the post-Covid future.

To name but two of many possible examples, there is the large-scale study on antibody therapies for use in the treatment of SARS-CoV-2 at the TUM University Hospital rechts der Isar, or the prominent role played by TUM virologist Professor Dr. Ulrike Protzer on the expert council of the Bavarian State Government. The following prospectus, a volume of forward-thinking contributions, underscores TUM's commitment by focusing on how to find the most viable and sustainable solutions to the problems we now face.

**Thinking forward is a conviction shared by the Bavarian State Government,**

as well, which insists, despite the urgency to respond to the acute challenges of this crisis, that we do so without becoming hectic and short-sighted, that we do so always with an eye on the questions of the future and answers that will work in the long run.

Seen in this way, crisis management means much more than swift measures to alleviate suffering and distress in the short term. Crisis also necessitate that we take stock, so we are ready when the next one arrives. Which of our approaches proved worthwhile and warrant further investment of our resources? Where can we improve or change direction? It is the task of state government and the prime minister to find the answers to these questions and translate them into political action.

**In doing so, we are faced with a number of key tasks.**

We have ramped up the health care system as a whole, increased the number of intensive care beds, expanded testing capabilities, and procured medical supplies and equipment. We have geared our entire health provision structure towards combatting Corona. University hospitals are working side by side with those health care institutions already forming part of our health care planning to provide care. After the acute phases of this crisis have passed, we will need to examine our strategies to glean their lessons for the future: How will the provision of care in our hospital landscape be changed? We will remain committed to intensifying relevant medical research, also within the scope of our Hightech Agenda Bavaria initiated in 2019 and funded with a total of 3.5 billion euros. Our task now is to implement that Agenda as soon as possible. To alleviate the effects of the pandemic on the economy, we approved a 60-billion-euro recovery package to provide immediate support. More than that, we have created targeted impetus for growth, including tax relief, incentives for key regional industries, and innovative work models – enabled by advanced digitalization – that will bring Bavaria solidly into the 21st century. The pandemic has given us new insight into the areas of social, economic and political life that will take on strategic importance in the future in order to preserve the health, prosperity, social cohesion and natural resources of the people of Bavaria in the long term.

**The Technical University of Munich is at the forefront in many of these strategic areas – health, digitalization, the environment. It is a tremendous support that it accompanies the Bavarian government on the path of robust development and modernization. ┘**

# Thinking Forward

## A Task of Science!

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What luck not to be Markus Söder, Angela Merkel, or the mayor of Bergamo or New York during the COVID crisis! We, the majority of contributors to this volume, are scientists. We share with politicians a responsibility toward society but do not bear the burden of having to make policy decisions. Yet, serving as scientific advisors to politics is no easy business either. One thing the COVID crisis has made absolutely clear is the importance of dialogue between the two, a dialogue defined by mutual trust.

Are there criteria that characterize sound science?

How can politics and society discern the credibility of individual scientists?

Good science means love of truth and detail. Science is the passion to think and to discover new things using the tried and tested methods of the scientific community and, often, to consciously set them aside. Other important indicators of good science include the quality of publications and of the organs in which research results appear, international reputation and networks, membership in respected academies, awards and prizes, among other things. Guidelines for ensuring good scientific practice are described in the corresponding codes of the DFG (2019) and the universities. Successful science depends on partners, in both academia and industry. Cooperation with companies and industry is crucial, especially in application-oriented disciplines, such as technology or medicine, and such contractual agreements are subject to extensive governmental control.

Dealing with science is not always easy for politicians and the media. Occasionally, they bet on the wrong horse. The story is familiar. Purportedly great discoveries are built up only to implode as fast as they appeared. Taking heed of the criteria above is warranted when entering into dialogue with science and sorting out the good from the bad. Sooner or later, those who enter the scientific stage driven by a craving for recognition and/or financial greed are usually found out.

Science means creativity, the development of entirely new, even revolutionary thoughts. It means candid debate and discussion, hard work, and the ceaseless acquisition of new knowledge – in virology, especially in times of COVID-19, under utmost time pressure! In its complexity, research means always moving on uncertain terrain. On this score, it is much the same for politics. It should come as no surprise, then, that the contributions collected here do not represent one consistent perspective on the questions at hand and may even directly challenge one another. Good science can and must be contentious. There can be no forward thinking without controversy! To reap the rewards of the indispensable dialogue between science, society and politics, that is something we must endure.

### Ultimately:

COVID-19 confronts us with fundamentally important and novel questions, some of them humanity has never faced before. New questions require new answers. The world after COVID-19 will be a different one. Science – built on the foundation of reason and sustainability – must create prospects for and foster positive change. In this volume, we, as a collective of authors, have tried to the best of our knowledge and in good faith to provide impetus for such change. ┘



**Professor Dr. Dr. h.c. Michael Molls**  
Spokesperson of the TUM Senior Excellence Faculty;  
Director of the TUM Institute for Advanced Study (IAS);  
Professor and former director of the Clinic for  
Radiotherapy and Radiological Oncology, TUM



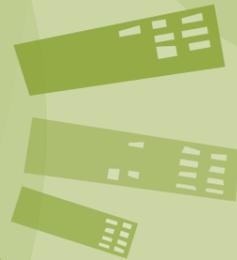
**Professor Dr.-Ing. Jörg Eberspächer**  
Co-spokesperson of the TUM Senior Excellence Faculty;  
Co-founder and member of the Center for Digital Technol-  
ogy and Management (CDTM), Munich; Fraunhofer Medal  
(2015); Professor for Communication Networks, TUM

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# THIN KING FOR WARD



# Creating a Spirit of Change for the Post-Corona Era

## Science in Dialogue with Society

**In the COVID-19 crisis, which is characterized by uncertainties about economic and social consequences, science is receiving particularly high attention. Political decisions are based on current research findings in virology, epidemiology and immunology, which can change rapidly. Politicians have learned that this decision-making strategy is successful and – with good communication to the population – enjoys high social acceptance.**

Technological leaps, new pandemics, other catastrophes and the foreseeable climate changes will tend to increase the level of uncertainty in the future. The TUM sees itself as an entrepreneurial university that does not teach and research in an ivory tower, but makes its technical and scientific knowledge available for innovations in all economic and social areas and for business start-ups. Our goal is to integrate technical and scientific knowledge in social sciences and humanities in the sense of human-centered engineering, i.e. to find scientific and technical solutions for social challenges (such as climate change or

feeding the world's population) and to integrate the perspective of the individual and society more strongly in the development of technology. This also includes an in-depth examination of the social implications of technology, including its opportunities and threats. The TUM feels committed to an understanding of innovation that is oriented towards sustainability and is in line with the UN Agenda 2030, i.e. "to make global development socially, ecologically and economically sustainable and thus to vigorously advance the long overdue transformation of national economies towards a much more sustainable and inclusive development"<sup>1</sup>

The contributions presented in this brochure relate to the topics:

- ▶ Sustainability
- ▶ Politics and Society
- ▶ Fundamental Research
- ▶ Technology, IT and Networking
- ▶ Habitats, Rurality, Urbanity and Mobility
- ▶ Economy
- ▶ Health and Medicine
- ▶ Education and the Working World
- ▶ Africa

and are to be understood as impulses. These are scientifically based contributions to economic and social development after the COVID-19 crisis in the sense of sustainable innovations. Policy advice as a dialog between science and society pursues the goal of creating trust for sustainable future development by providing knowledge. Trust is the basis of all actions in business and society and the foundation for the social acceptance of political decisions. Our brochure is therefore preceded by the initial thesis:

**“The COVID-19 crisis as an opportunity and accelerator for sustainable innovation”**

We should take this chance. If we learn from the crisis and succeed in making a fresh start, we could end up in a better position than before the crisis. For a sustainable future, the following questions should guide us:

- ▶ Decisions in case of uncertainty: To which future areas of high uncertainty (climate, scarcity of resources, energy, mobility, technological leaps) can the experience from COVID be transferred?
- ▶ Solutions for sustainable innovations: What solutions do the technical and scientific disciplines offer for sustainable innovations in terms of recycling management, energy management, health care, business start-ups, education and training?
- ▶ Digitization of the economy and society: What role do IT and digitalization play as enablers for sustainable innovations?
- ▶ Science and trust: How can progress in knowledge be communicated to politics and society that confidence in scientific findings is created, especially in the areas of basic research?
- ▶ Information versus conspiracy: There is consensus among scientists to counter conspiracy theories with facts. What contribution can science make to reducing false news in times of crisis?
- ▶ Progress in knowledge and transparency: How can knowledge processes be made transparent and successfully communicated, even if there is little prior knowledge in large parts of society?
- ▶ Society and communication: What lessons can we learn from the COVID crisis for the communication of political decisions?



**Professor Dr. Dr. h.c. Ralf Reichwald**  
TUM Senior Excellence Faculty; Honorary Senator of the TU Freiberg; Professor of Business Administration – Leipzig Graduate School of Management (HHL); Professor of Business Administration – Information, Organization and Management, TUM



**Professor Dr.-Ing. Jörg Eberspächer**  
Co-spokesperson of the TUM Senior Excellence Faculty; Co-founder and member of the Center for Digital Technology and Management (CDTM), Munich; Fraunhofer Medal (2015); Professor for Communication Networks, TUM



**Dr. rer. nat. Birgit Herbst-Gaebel**  
Microbiologist/Immunobiologist; Scientific Officer, TUM Senior Excellence Faculty



**Professor Dr. Klaus Mainzer**  
TUM Senior Excellence Faculty; Founding Director of the Munich Center for Technology in Society (MCTS), TUM; Senior Professor at the Carl Friedrich von Weizsäcker Center of the University of Tübingen; Professor of Philosophy and Philosophy of Science, TUM



**Professor Dr. Claudia Peus**  
Founding Director of the TUM Institute for Life Long Learning; Vice Dean of Executive Education, TUM School of Management; Executive Vice President for Talent Management & Diversity, TUM; Professor for Research and Science Management, TUM

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01  
**SUSTAINABILITY**



# War and Peace

**Some politicians – especially those who use military language – classified the emergence of the COVID pandemic as a declaration of war. Even the German President Frank-Walter Steinmeier, who otherwise does not choose martial language, talks about war. War against whom or what? And with what weapons? Are the vaccines against COVID-19 sufficient to win the war?**

As long as vaccines haven't demonstrated long-term success, the battle is limited to mere defense. We oblige the society and also the economy (locally, regionally and globally) to accept restrictions. For fear of infection and untimely death, the restrictions are largely respected by the population in Europe and beyond. This collective consent is referred to as solidarity. People may be ready to postpone the conduct of life they were accustomed to, but better they get prepared for life with enduring presence of dangerous viruses.

In Germany, we fondly remember the solidarity of the population in the months after the Second World War, which contributed significantly to the emergence of the German Wirtschaftswunder. The longer the tolerated limitations last, the more the unfamiliar becomes normal. "Nothing will ever be the same again" – this is the powerful message that is not only communicated by the government. Scientists, whose appeals for rethinking and a turn away from the "higher" – "further" – "faster" have so far gone unheard, also hope for this change. Will the new solidarity last beyond the period of threat?

To answer this question, we should recognize that the war we are currently waging is only superficially directed against the tiny chemical compound "SARS-CoV-2" but rather against ourselves. Our real enemy is human misconduct with all its facets, which could hardly be more different. In the face of the COVID crisis, for example, we have failed to put in place in good time conditions that are effective against the consequences of COVID pandemics. This includes in particular the technical equipment such as respirators for hospitals and protective masks for doctors, hospital staff and people shopping. We have submitted to a global dependency that has proven to be extremely dangerous. For such system-relevant areas, production authority is a sovereign task of the states all over the world, which may only be outsourced to a limited extent.

Human misconduct can also be seen in the slogan "tight is right". Under this motto, cheap products are offered in supermarkets, clothing stores and in on-line shops. However, cheap is not always a sign of quality, especially when cheap products are created through exploiting human resources and overexploiting soil, water and air. May locally produced consumer goods and direct sales by farmers and craftsmen in the period after the COVID pandemic gain the appreciation they deserve – including the interpersonal exchange (local "gossip") between sellers and customers. Gossip is part of life – in any region or culture.

On the other hand, the manufacturing industry is based on the division of labor – today and in future, with a good reason. In global terms, cross-border supply chains generate jobs, income, prosperity and ultimately peace. The Chinese strategist Sunzi writes about this in his book "The Art of War" written in 500 BC: "The true objective of war is peace", because business can only be done in times of peace. Peace and prosperity are therefore mutually dependent. Creating prosperity is, moreover, an essential objective of sustainable development. Greta Thunberg rightly pointed out that in many respects we have overdrawn the accounts that ensure the sustainable existence of our world. Excessive consumption of material goods, extensive travel by car or plane to conferences, business meetings and for pleasure, overemphasis on the ego-self at the cost of interpersonal relationships are just a few examples of the habits that had to be abandoned in the wake of the COVID pandemic.

And behold: We can perfectly do without the abandoned habits. Modern, digital communication media have made it possible to be close to one another and still keep our distance. Solidarity-based action has created a powerful counterweight to loneliness, self-exclusion and the omnipresent egoisms in politics, the economy and society. The collective sense of respon-

It is about overcoming war among one another and making peace with ourselves and with nature in a highly complex environment.

sibility for the greater common good, including the planetary ecosystem, has gained insight and significance – faster than the Fridays for Future movement was able to achieve. And, what must not be forgotten: The curfews have led to mum and dad being at home and having time for socializing and spending time with the children in a way that was previously unheard of. Our children, when they grow up, will probably fondly and happily remember the COVID period.

Maintaining all these aspects in the post-pandemic period is the task of politics, business and society all over the world. It is about cultivating the willingness to show solidarity and to appreciate the services rendered by the service providers in all layers of civil society, the economy and politics, which has grown during the crisis, and it is also about recognizing the fact that we are part of, but not masters of, the living world. It is about overcoming war among one another and making peace with ourselves and with nature in a highly complex environment.

Back to Sunzi. His doctrine can be applied one-to-one to the strategy for coping with the post-COVID period. Waging war against COVID-19 is important, but not enough. It is necessary to generate new knowledge about the intrinsic needs of society, economy and ecology through scientific research and a broad-based scientific discourse, and to consistently translate this knowledge into practical action in national and global contexts. This results, as already mentioned above, in prosperity and satisfaction. **In short: peace! ┘**



**Professor Dr.-Ing. Drs. h.c. Peter Wilderer**  
TUM Senior Excellence Faculty;  
Founder of the Institute for  
Earth System Preservation (IESP);  
Stockholm Water Prize (2003);  
Professor for Water Quality and  
Waste Management, TUM

# Basics, Research and Philosophy after Corona

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**We live in a data-driven age, whose development is accelerated by exponential growth laws of data volumes, computer and storage capacities. Some authors consider theoretical foundations to be superfluous, since in the economy more and more efficient algorithms seem to predict better customer and product profiles ever faster. During the COVID crisis, countries are staring spell-bound to a statistical quantity called the R-number, which is permanently calculated from large databases.**

Data credibility and trust in uncomprehended algorithms take the place of understanding and basic knowledge. This tendency is extremely dangerous. This attitude is dangerous because theories without data are empty and meaningless, but data and algorithms without theory are blind and beyond our control. It is true that the traditional concept of theory is changing in many ways, both in the discovery and identification of hypotheses through machine learning and in theoretical explanations through computer experiments and prediction through predictive analytics. However, the most critical thing is to understand, test and control the algorithms made possible by innovative theories. This is the only way we can be sure that in the end Big Data and its algorithms will not blow up in our faces.

## Data-driven or hypothesis-driven research?

Historically, the question of “why” is the initiating step of human thinking in science and philosophy. Why do stars and planets move in regular orbits? Is the variety of substances built up from simple basic building blocks? According to ancient Greek tradition, a fascinating idea was born, which fundamentally influenced the further development of research: The seemingly chaotic variety of sensory impressions is based on simple laws of symmetry and regularity, which can be described mathematically. This is the trend of hypotheses-driven research. Behind this stands the conviction: Only when we have a good theory can we know what we are looking for to understand and cope with the diversity of the world.

But also the data-driven research perspective is by no means new. It was the Babylonians who, by the standards of the time, recorded large quantities of data on astronomical observations, harvest results, trade, commerce and administrative procedures on countless clay tablets in cuneiform script. From the regularities in the astronomical data, astonishing predictions about planetary constellations were derived, but without being able to explain them. In modern times, with Auguste Comte’s positivism, the belief in facts and data was also applied to social sciences.

Data was assigned to numbers and thus became calculable. Laws became calculation rules to solve mathematical equations. At the end of the 18th century, for the mathematician and astronomer Pierre Simon Laplace, celestial mechanics was completely defined by initial data and equations of motion. Therefore, only the calculation of equation solutions was important in order to arrive at precise predictions. So, Laplace argues, if an “intelligence” were given all these data and equations, the world would have to be completely calculable for it. This “intelligence” assumed by Laplace goes down in history as Laplace’s demon. Today it is obvious to imagine a super computer being that “demon”. According to Chris Anderson, an influential American science journalist, the only

thing that matters is fast algorithms and large amounts of data. But are laws really superfluous, a relic from a time when laws of nature were still understood as “God’s thoughts” in the language of mathematics, as they were with Galileo and Newton? Is arriving from Nietzsche’s “God is dead” to the “death of laws” an irreversible trend of the modern world? But masses of data and numbers alone are just as meaningless to us as the billions of sensory impressions that bombard our sensory organs every day.

During its evolution our brain was trained to compress data and reduce complexity. Instant decisions depend on this ability. This was not only true in the struggle for survival during the Stone Age. Even in today’s business world and in politics, we are often under pressure to make reflex decisions. Super computers and Big Data seem to serve this trend for rapid decision.

## Plea for fundamental research:

Occasionally, however, we also imagine connections and patterns that are based on only apparent correlations of events. Weather rules of our ancestors were often no better founded than the gambling behavior of stock exchange speculators. But the patterns and correlations of Big Data remain random if we do not understand the underlying relationships. Naturally, a COVID-19 or cancer patient in his or her extreme distress reaches for the straw of a statistical correlation between a not yet understood drug effect and possible prolongation of their life. The many years of research into the biochemical laws underlying this correlation may be too late for them personally. Ultimately, however, only these laws offer reliable and reproducible therapy.

In fact, we can only come to reliable explanations and solutions to problems on the basis of evidence and laws. At CERN, particle collisions produce gigantic masses of physical data. But only a good hypothesis like that of the theoretical physicist Peter Higgs told us what the algorithms in the case of the Higgs’ particle should be looking for to explain cosmic expansion in the first place. In life sciences, we are confronted with complex masses of data, for which the explanation of legal relationships and causal structures through bioinformatics is still in its early days.

In any case, drugs in medicine are of little help if we only rely on statistical data effects without having understood the legitimate relationships. This ultimately also applies to the development of a vaccine against COVID-19. What happens in the economy when we only rely on uncomprehended key data was shown by the economic crisis of 2008. ►

## In this respect philosophy must “reinvent” itself:

Since ancient times, philosophy has been the origin of the sciences, which have become more and more specialized over the centuries. Newton, the founder of modern physics, held a chair of natural philosophy, while his compatriot Adam Smith, the founder of economics, held a chair of moral philosophy. Today, philosophy still enquires about the basics of our knowledge and its interdisciplinary connections in the different disciplines in order to be able to decide and act responsibly. Therefore logic, the foundations of science and ethics have belonged together in philosophy since antiquity. Problem- and practice-oriented interdisciplinary networking with the sciences constitutes the special profile of philosophy in the globalized knowledge-based society. The decisive factor is that philosophy and scientific theory are anchored in the individual subjects of engineering, natural sciences, social sciences and economics. It is only through constant research and teaching contact that philosophers are prevented from losing ground and withdrawing into the clouds of abstraction, hiding in the history of the discipline and detaching from science. Only in this way, however, can the necessary fundamental discussion in the sciences be stimulated by philosophy. But this requires philosophers who have been trained in mathematics, computer science, natural and technical sciences (MINT) and who are recognized as competent in these disciplines (which is unfortunately not sufficiently taken into account in the German practice of appointing philosophers).

This contribution is a plea for reflection on the foundations, hypotheses, laws and history that lead to the world we live in today. The world of software and fast computers was only made possible by logical-mathematical thinking, which is deeply rooted in philosophical traditions. Anyone who cannot see through this web of thoughts is blind to the performance capabilities of Big Data, but also to the limits of its application in our everyday and professional world. In the end, it is a matter of strengthening our power of judgement, i.e. the ability to recognize connections, to connect the “particular” as Kant put it, with the “general”, in this case the flood of data with reflection, theory and laws, so that an increasingly complex world dominated by automation does not get out of our hands.



**Professor Dr. Klaus Mainzer**  
TUM Senior Excellence Faculty; Founding Director of the Munich Center for Technology in Society (MCTS), TUM; Senior Professor at the Carl Friedrich von Weizsäcker Center of the University of Tübingen; Professor of Philosophy and Philosophy of Science, TUM

### Literature

**K. Mainzer, Die Berechnung der Welt. Von der Weltformel zu Big Data,**  
C.H. Beck: Munich 2014

## Conclusion

The COVID crisis shows that instead of uncomprehended hasty actions, a thorough understanding of epidemic models and molecular structures is indispensable. Basic understanding is the prerequisite for scientifically based judgements. In an age of global crises such as pandemics and the environment, young people rely on science in their demonstrations. Let's not disappoint them! This does not seem to have been understood and accepted everywhere in politics. Neither “deals” nor parliamentary majorities can be achieved with nature. At critical parameter values it strikes back irreversibly and destructively. Therefore, a new type of politician is needed, one who has understood the crucial role of science in the 21<sup>st</sup> century and takes it as the basis of political judgement and decision-making. ┘

# Innovations, Technology, Sustainability

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## Introduction

The thesis I want to defend in this paper is:

**Innovative intelligence is humanity's most effective economic resource. Intelligence can be exploited without limits, but must aim unconditionally at sustainability.**

Instead of relying on non-sustainable resources for economic gain, economy, and in its wake politics, can profitably focus on value creation through the exploitation of intelligence. The present unfettered exploitation of many of the world's natural resources is poisoning our living environment almost beyond salvation, while the exploitation of human intelligence and creativity toward a sustainable mode of living, i.e., by the creation of intrinsically valuable products, processes and habits, appears to be the only way leading to both economic gain and creation of an ever improving quality of living (QoL) for earth's ecosystem.

## Intelligence as a clean and inexhaustible resource

Intelligence can be defined as the ability to foresee (develop scenarios), based on knowledge (science and technology). It has been a spectacular driver of evolution. In the most primitive form, an organism that is capable of sensing its environment, controlling it, and propagating this faculty to its offspring, is able to guarantee its survival much better than its just more powerful competitors. Due to its advanced form of intelligence in many layers of understanding, humanity has conquered the earth evolutionarily. However, humanity's failure to safeguard its environment and keep it in good shape, makes one doubt whether the comprehensiveness of humanity's collective intelligence is adequate and truly advanced!

Nevertheless, and given its evolutionary power, intelligence is bound to become the driving force towards a healthy future for the symbiosis of the earth and humanity. The question is how best? What is the technology going to be – “technology” understood in its etymological sense as “knowledge of art and craft”? Intelligence can obviously be used for better but often it is used for worse. Humanity has conceived and built weapons of mass destruction, and has also developed so called useful technology that gradually destroys our invaluable natural environment. This observation immediately puts

the social breeding ground in which technology is created and developed in focus, and what steers value-creation therein. In other words, the underlying culture and the resulting social behavior and economics.

The issue is to insure that intelligence is used to drive human's activities and endeavors in a direction that improves the “quality of life” (QoL) of the whole humanity-earth conjunction, seen as a comprehensive, symbiotic system. Intelligence comes in levels of comprehensiveness. It originated as a purely local and immediate faculty of primitive organisms, capable of adapting to their environment and even controlling it to some extent. Very soon, organisms discovered that they could obtain a better control on their way of living by cooperation and increasing the comprehensiveness of their endeavors for mutual benefit. An intelligent organism can overcome its weaknesses by creating a much bigger span of control through the use of proxies, both from their own kind or by exploiting the functioning of other organisms or even nature in general to their perceived benefit. Using proxies, they could enhance not only their own survival, but, even much better, their QoL. Cooperation can be very successful, but it necessitates the thriving of the symbiosis as well. Only ever more advanced intelligence is capable of insuring comprehensive survival, or, to quote Teilhard de Chardin in *Le Phénomène Humain*: “Voir où périr” [to see or to perish].

Humanity has developed its own ways of cooperation. In short, the central drivers can be summarized as “culture” and “economics”, both seen as the basis of effective cooperation. Culture is our repository of understanding, and economics what makes the exchange of effort and reward possible. Both have been created and are driven by intelligence: Culture sets the goals of the cooperation and economics provides the means. Their strength is what they enable, their weakness is in their very drastic limitations. Culture strays when it becomes jingoistic and economy when it pursues narrow interests at the detriment of the overall QoL. The combination of the two is deadly. ►

## The economic drive

Economics provides humanity's main method for making the creation of culture, well-being, social interaction and cooperation possible. "Good" economics would provide the means to attribute reward to performance in a fair and balanced way. Exchange of capital for performance allows for indiscriminate, goal directed cooperation between people. In the past, capital was associated with some "intrinsic" value, based on rarity (like gold). Nowadays, capital is merely data (bits) attached to an "owner" on a computer. Its "rarity" has become fully artificial, only protected by regulations and habits, enforced by governments and protected by practice and international agreements. Therefore, the question of the effectiveness of capital towards safeguarding a sustainable earth and (even much better) promoting its healthy development, has become a critical cultural and hence political issue, requiring new, comprehensive means of controlling the use of capital and the ensuing retributions.

It should be clear that present day economic habits are far from functioning properly towards the goal of creating the necessary QoL for our symbiosis with our Earth. A first big challenge for our human intelligence is to understand what inhibits the smooth flow of capital to valuable activities, and, next, how to control the situation. There is too much reward for capital itself (capital begets capital without productive contribution) on the one hand, and on the other, what our earth gives as almost invaluable resources is not rewarded at all and hence squandered on a massive scale (the same is true for such invaluable human contributions as motherly care or the dedication of e.g., teachers and nurses).

"Good" (healthy) economics should reward activities that enhance the earth's and people's well-being and not deflect capital to worthless endeavors (like speculation or depletion of valuable natural resources). It is true that the stability of the monetary system is an important property, which safeguards its effectiveness. However, it is also true that the concentration of capital in few undeserving hands prevents productive use and leads to unwarranted creation of ever more self-serving capital.

This unproductive situation threatens the overall stability as much as uncontrolled inflation of capital supply (as is happening in the wake of the Corona crisis). The proper creation and use of capital is an issue of major importance, requiring the best efforts of our economists and politicians, see e.g., the work of Ostrom, Raworth or Piketty.

## Technology and innovation

"Technè" is ancient Greek for "art" or "craft", and "logos" stands for "knowledge". Technology is the repository of humanity's intelligence on the transformation of knowledge (science) into actuation (industry). The keener and more comprehensive our intelligence, the better our technology will be. The best combustion engine may be a wonder of technology, but not a wonder of good engineering from an ecological perspective.

I claim, from historical experience, that the following thesis is true: "Every environmental problem has been created by a short-sighted technology, but can be corrected by more advanced intelligence." In otherwords: Intelligence is an inexhaustible natural resource, capable of creating any technology deemed necessary, if properly directed. This process will never end. Every new technological effort contains its own limitations that will have to be corrected by novel technological efforts. For example: In the early 2000's, photovoltaics (PV) came up as an alternative technology for the noxious burning of fossil fuel. Solar radiation is a clean and inexhaustible energy resource. I remember vividly how many economists and politicians went frantic claiming that PV would never become economical, because of being too "expensive". Soon it became the cheapest possible source of energy, thanks to an innovative combination of technology and large scale economics. However, its deployment shows sustainability problems of its own, namely the questionable use of materials and industrial processes. A new technological challenge, which is gradually being solved towards even cheaper PV etc.

Intelligence is an inexhaustible natural resource, capable of creating any technology deemed necessary, if properly directed.

## Culture

Intelligence, economics and technology are means to an end. Ends and goals are determined by culture, in particular our "ethics": what we deem valuable, what we want to live for. Our main motivation in life is partly inborn, partly learned and partly determined by circumstances – a complex combination. Many of us have an inborn caring instinct for our fellow humans and our natural environment. Just like intelligence has proven to be evolutionarily productive, so has care (and one is highly dependent on the other). There is a lot of cooperation in nature, and we would not exist as sensible and intelligent beings without grooming by loving parents, teachers and care givers.

And we want to provide the same loving care towards our whole earth environment, in order to keep it fit and healthy. Engineering, and in particular the conception and design of novel systems, is an important part of our culture and plays a central role in economics. The most successful companies thrive thanks to stringent quality control on designs and production methods. But these are often too narrowly defined. All our companies have to make comprehensive ecological sustainability the very first, sine qua non, quality criterion for their products (together with safety of course).

To achieve this – and intelligence dictates it should – the basic cultural attitude with respect to economy and industry, shared by people, companies and institutions throughout society, has to change. Is such a massive re-direction possible? I claim that "going sustainable" has great economic potential, when done cleverly. "Good" economic practice aims at rewarding valuable activities, not at sustaining or even rewarding detrimental and hence unsustainable habits. Economic growth should measure true value-creation and not mindless consumption! ►

# Yes,

we can design for a sustainable world, and in a highly profitable way!

## Ecological ethics

**QoL** is “what is good for life”. Intelligence plays a central role in understanding “what is good”. It foresees consequences based on trustworthy knowledge. Many excesses of our present economic behavior have – finally – led us to understand that only a carefully deployed balance between human activities and the earth’s symbiotic response to them will yield a “good”, i.e., healthy future for both. Just as we now consider medical practices in the Middle Ages barbaric because of lack of knowledge and poor judgment, so our descendants will consider the way we have been handling our Anthropocene equally barbaric.

The improvement of our symbiotic QoL requires that we stop unhealthy and mindless practices, like unsustainable mining, burning of fossil fuels, polluting our pristine resources, unsafe use and disposal of poisonous materials, massive monocultures at the cost of much needed biodiversity etc., and that we concentrate our development efforts towards value improvement of our global earth system. How to do that best is a major challenge to humanity’s intelligence and its ability to act towards the realization of its ethical goals.

Well directed and urgent action is needed! Our culture and ensuing politics have to become serious about the development of a shared global ecological ethics (including the continuous worldwide development of human health) and economic practices have to be redirected and rewarded accordingly, as discussed earlier.

But the task for us, engineers, is to put sustainability as a central quality requirement in all our engineering efforts, with priority above the usual criteria like efficiency, robustness or quality/prize ratio. ─



**Professor Ph.D. Patrick Dewilde**  
Founding Director of the TUM Institute of Advanced Study (IAS);  
Distinguished Affiliated Professor of the TUM;  
Professor Emeritus for Electrical Engineering,  
Delft University of Technology

# COVID-19 – Does Sustainable Development Finally Get a Real Chance?

## Where Are We, Where Do We Want to Go?

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**We cannot continue our economic management after COVID-19 the way we have done so far. This statement is frequently heard in the current situation in identical or similar wording. However, there is often a lack of concrete and realistic alternatives. How are we intending to continue, and then, do not some things get shaken or overturned?**

The paradigm of sustainable development was approved by the international community in Rio de Janeiro in 1992. It was intended to replace the globally prevailing mainstream of neoliberalism. This initially led to a great euphoria. It was based on the hope that sustainable development, if consistently implemented, could make an important contribution to solving or at least reducing the pressing problems or crises. But already at the follow-up conference in 2002 a great disillusionment was noticeable.

There was a gap between hope and concrete development: In many cases, the problems were left to be suppressed or lamented, and for the most part the familiar paths of unsustainable development were followed. In some cases, actions were limited to a few reforms. Comprehensive transformation, as laid out and demanded in the mission statement, has so far failed to materialize. But if the view that “things cannot go on like this” strengthens and solidifies, we have to concretely demonstrate how things should go on and what this leads to. First and foremost, this requires rational or honest stock-taking.

Sustainability has so far been introduced into various sectors of society with varying intensity and intention. In the economy, much of the production and products are already proven to be sustainable without experts or consumers in general always being able to understand why a production or product is advertised as sustainable. In this context, many companies have so far considered it part of their image cultivation to present themselves on the Internet and in glossy brochures, as a sustainable company and thus as progressive and responsible. At the same time, there certainly are companies that feel a serious commitment to the mission statement and are well on the way to its implementation. In science, there are a number of disciplines, such as architecture or (construction) engineering, but also the social sciences, which are increasingly discovering sustainability. So far, engineering sciences have primarily turned to ecological sustainability, i.e. more environmentally friendly technologies. I.e. this includes developing and manufacturing production plants or machines and products that are more environmentally friendly. This is then a

matter of higher energy efficiency or resource-saving production. There are some promising developments in these fields. Some scientific disciplines, such as law, are still predominantly “sustainability blind”.

The education sector, which should particularly focus on sustainable development, as pupils and students should be familiar with the subject in their future working lives, still approaches the issue with restraint or only in fragments. When asked about their knowledge of sustainable development, the majority of pupils or students often have only rudimentary ideas on the subject, if at all. But here too, there are universities that play a pioneering role, such as the University of Lübeck or the Eberswalde University for Sustainable Development. But so far they are still rather the exception than the rule.

In politics, a certain ambivalence can be observed: On the one hand, Germany has an ambitious national sustainability strategy, and even federal states often have their own sustainability strategies at state level, which are identified in the foreword as an important basis for policy-making. A new style of politics is always called for. In political statements or discussions, however, politicians hardly ever refer to this. Even the political styles, which should be geared, for example, towards greater participation, have not yet developed consistently towards sustainability. One important reason is: You cannot win elections with sustainability.

The media have also not been sufficiently aware of the issue to date. Of course, some issues related to sustainable development are vigorously discussed. In such discussions, the focus is on climate change, whereby, for example, the dramatic decline in biodiversity and its massive consequences deserve much more attention. But also climate change is often insufficiently or limitedly perceived and discussed. For example, the relationship between climate change and economic growth, a very complex issue, has been largely ignored. The causality is clear: Increasing economic growth tends to exacerbate climate change and progressive climate change tends to have a negative impact on economic growth. ►

At the same time, growth is an important prerequisite for a positive development on the labor market, for the stabilization of the social security systems and for the state's income, which is of great importance for the increasing tasks: Our budget economies are extremely dependent on growth, as the current COVID crisis shows. So all this doesn't really match up. Nevertheless, it also applies that: Some media repeatedly deal with sustainable development in the context of well-founded articles that focus on the holistic approach and illustrate possibilities for implementation.

A first conclusion is: Sustainable development on the basis of Agenda 2030 and the 17 SDGs calls for a fundamentally new style of thinking and policy. It is a matter of including and combining the aspects the ecological, economic and social dimensions in one's thinking, which then also leads to a completely new way of thinking about stability. In doing so, the stability formula must take the limits of the resilience or endurance of nature and/or ecological systems as a basis and accept them as irrevocable. No doubt: The new, complex model of sustainable development needs to be further filled with content and context, even though many areas such as innovation, consumption, digitalization, labor market and international trade have already been subjected to thorough "declension" according to the requirements of sustainable development.

The available publications and reports also provide examples of how "sustainability concepts" can be implemented and what obstacles need to be overcome. A key demand, primarily to politicians but also to other social actors such as scientists, consumers and producers, is that a coherent sustainability concept be developed and implemented as part of a consistent process. After COVID-19, we need a so-called "economic stimulus package" to secure our economy. Let us develop and implement a "sustainable economic stimulus package". This would promote the dynamics of sustainable development. ┘



**Professor Dr. Michael von Hauff**  
Chairman of the Institute for Earth  
System Preservation (IESP);  
Professor for Economic Policy,  
International Economic Relations  
and Sustainability, TU Kaiserslautern

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The central thesis is:

There is no alternative for humanity to the paradigm of sustainable development, which is more promising for national but also global stability in the sense of an ecological, economic and social balance, including justice, which can lead to an improvement in the quality of life for all, according to the motto:

**Leave no one behind.**

# Protection of the Environment, Biodiversity and the Climate: Findings from the Corona Crisis

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**In the midst of the COVID crisis, the eleventh Petersberg Climate Dialog took place on 17 and 18, April, 2020. This year's event was a strong wake-up call that humanity is not only threatened by the COVID-19 virus. We, including the entire living world, are also threatened by global warming caused by humanity itself and by the reduction of biodiversity on earth.**

As James Lovelock points out in his recently published book "Novacene", in borderline cases this can lead to a loss of the self-regulating capacity of the global ecosystem. The consequences would be far more dramatic than the pandemic caused by COVID-19. Sooner or later we will be able to fight the virus with a vaccine. A certainly different kind of a vaccine is available as well to overcome the effects of environmental degradation, biodiversity reduction and global warming is already available. German Minister of the Environment, Svenja Schulze, pointed this out in her opening message. The vaccine is called "behavioral change". Humanity is called upon to subject the behavior of each individual, the economy and politics to the principles of sustainability.

In the period from the Second World War to the present day, Germany has not experienced such a serious challenge to its society as this globally rampant pandemic. Although the health implications, and certainly not the economic and social consequences, can be fully assessed at this stage, the measures and regulations already implemented are unique in post-war German history in terms of their severity and impact on the lives of all citizens.

In addition to the health effects, which are of a magnitude that has not been observed in Germany since the Spanish flu of 1918, there are now increasingly the economic and social consequences of the previous policy of spatial distance and isolation. What is to be done after the crisis?

There is now a widespread call for government support to revive the economy and launch major state-financed investment schemes. But if taxpayers' money is being used for this recovery, then the state, as guardian of the common good, should be able to help determine the direction in which the recovery of the economy should go after the crisis: It cannot simply be a matter of reviving the economy in the old style. Now there is also an opportunity to gear investment and development programs towards the goal of sustainability. The basic need for ecological sustainability addressed in this chapter is primarily concerned with three overarching objectives that must be pursued in parallel: decarbonization, dematerialization and denaturalization.

Decarbonization mainly affects the energy sector, but also involves the agricultural and food sectors. Decarbonization does not mean renouncing all carbon, but limiting the amount of carbon emitted into the air and other media. The aim is to achieve climate change that is still bearable for humans and the environment. Dematerialization means that the production of goods and services should be able to manage with fewer raw materials and commodities and that the materials used should be embedded in a circular economy. Reuse, recover and recycle are the key words here. And renaturalization means that we have to treat land much more ecologically and leave it largely to natural cycles in order to be able to make use of its ecological services in the future. The keyword here is conservation of biodiversity. ►

## A post-COVID agenda for a sustainable economic and industrial policy

So what needs to be done? It is important to seize the opportunity of a new beginning and to have the business community and politicians develop and implement a program with a clear sustainability objective. This includes the following points:

**Focus on resilience:** The global economy is largely determined by the goal of efficiency. If an economy is to be sustainable, it must invest more resources in building resilient infrastructures. The concept of resilience implies the need to be more robust than before the crisis. To make resilience a guiding principle in managing the economy, governments must provide the right incentives for economic actors, as society as a whole will benefit from improved resilience. This includes the three elements of redundancy, diversity and adaptable management. The crisis has clearly shown that the blocking of international supply chains for important and critical equipment such as protective clothing and face masks (80% of which are produced in China) led to major bottlenecks, which contributed massively to the spread of the crisis. Relying only on a single product line or service can lead to collapse if no alternatives are available. And being trapped in administrative routines, institutional bunkers and procedural rules can make the situation much worse than a flexible and systems-oriented management style. This also benefits the environment: Unnecessary transport routes are avoided and money flows are shifted to services that support infrastructures for services of general interest.

### Focus on the key drivers of the pandemic:

The COVID-19 pandemic has already shown that hotspots of infection risk mainly are major events, local and long-distance public transport, gastronomy, schools and daycare centers. Increasing resilience cannot be limited to refraining from the activities mentioned above, especially since at least schools and daycare centers are essential for a sustainable society. Increased reorientation of commuters away from public transport and towards private transport, triggered by health risks, would prevent the expansion of public transport, which is indispensable for sustainable mobility. Gastronomy and major events are important prerequisites for social bonding, cohesion and thus for social sustainability. New, resilient concepts must therefore be developed in order to be able to implement the above-mentioned activities sustainably and in a way that they do not represent health risks.

### Combination of economic aid and sustainability policy:

The measures envisaged for the recovery of the economy after the crisis should include monetary incentives (taxpayers' money) to initiate or promote resilient and sustainable practices. If taxpayers' money is used to boost the economy, it should be accompanied by clear rules. The energy industry must continue to focus on replacing fossil fuels with renewable energies, industrial production must have switched to climate-neutral production processes by 2050 at the latest – the sooner the better; and agriculture should launch an ambitious program to reduce climate-damaging gases and ensure sustainable soil management. Finally, the tourism industry could also focus on more green tourism and sustainable mobility. For it makes little sense to combat the global crisis caused by the coronavirus through investments that add fuel to still existent global crises, such as climate change. You don't cast out the devil with Beelzebub.

**Green Marshall Plan:** In 2008, governments helped the banks to avoid an imminent collapse of the financial sector. At that time the financial institutions were supported and revitalized with many billions of tax money. In the light of the COVID-19 pandemic, now would be the time to dedicate this assistance, which was then given to the banks, this time to building environmentally sound and sustainable economic practices. For the role of the state is not limited to providing ad hoc assistance in the event of a crisis. The current crisis should be taken as an opportunity to help economic actors financially, to shift production and services to sustainable practices, and to gear economic revitalization directly towards the criteria of a sustainable, circular economy. In particular, the sustainability goals (SDGs) adopted by the UN could serve as guidelines for the new economic recovery programs. Tackling global challenges requires responsibility, strong institutions and an effective legal framework. The model of the "minimal state", which is popular in many economic circles, does not meet the needs of collective leadership in a modern risk society (Ulrich Beck). We need a targeted green Marshall Plan for an economic structure geared to sustainability.

**New lifestyles:** Staying at home more and having to work from home can also be seen as an experimental test for lifestyle change. Less consumption, less traffic, more dependence on virtual communication, more time with family and relatives can lead to a reconsideration of one's own lifestyle. Routines in daily behavior are usually very stable over time. But when routines change for compelling reasons, new routines may emerge and gradually become established. Particularly if the crisis lasts longer, we can expect people to rethink what is good for them. This will provide an opportunity for all citizens to put their own consumption and mobility behavior to the test. Were we really suffering, when we were forced to travel less and consume less? At the same time, it should be a task of the state to provide incentives for a less consumption-oriented lifestyle. This could include better leisure facilities close to home or the expansion of virtual opportunities for social contacts, hobbies and social exchange.

**Outlook:** In addition to all the burdens and negative consequences of the COVID crisis, however, the positive insight has also emerged that almost all countries in the world have clearly given priority to humanity and solidarity when weighing up the protection of life, especially of the elderly, against economic well-being. From saving lives, maintaining critical infrastructure and building mutual aid and solidarity (at least within local and regional communities), to supporting those who have lost their jobs and livelihoods in the crisis, there is a clear shift towards the ethics of individual care. During the crisis, economic values, such as efficient production and increased consumption, were only considered secondary values in helping cater for the social needs of those struggling with the disease. This could also be an opportunity after the crisis – to reflect on the priority of values in our society. The economy should serve society and not vice versa. This reorientation of value priorities is not in contrast to business or economic activities, but could rather serve as a starting point for the design of sustainable economic structures and the fulfilment of social and cultural needs for sustainably produced products and services. ─



**Professor Dr. Dr. h.c. Ortwin Renn**

Scientific Director at the Institute for Advanced Sustainability Studies (IASS), Potsdam; Professor of Sociology of Technology and Environment, University of the German State of Brandenburg; Head of the Sustainability Advisory Board of the State of Baden-Wuerttemberg; Honorary Professor (Distinguished Affiliated Professor) of the TUM



**Professor Dr.-Ing. Drs. h.c. Peter Wilderer**

TUM Senior Excellence Faculty; Founder of the Institute for Earth System Preservation (IESP); Stockholm Water Prize (2003); Professor for Water Quality and Waste Management, TUM



**Professor Dr. Wolfram Mauser**

Chairman of the National Committee for "Global Change Research" of the DFG (2003–2008); Member of the "High Panel on Science, Technology and Innovation for Development", UNESCO; Professor of Geography and Geographic Remote Sensing, LMU Munich

# Does Nature Think About the Future?

In the background of the topic of “sustainability” is the conflict between a conservative and an invasive/technocratic position.

According to the **conservative standpoint**, the state of sustainability can only be achieved if human civilization holds back until its influence is small enough to be compensated by the diverse natural systems of the so-called ecological balance. According to the **invasive standpoint**, the obvious overstraining of these systems on the contrary requires global technical interventions of unprecedented dimensions (“geoengineering”) in order to stabilize the ecological systems and prevent their foreseeable chaotic derailment at the “tipping points”. The dissent between these two standpoints is fundamental, and it will manifest itself in considerable conflict as soon as the common adversary, namely the group of problem deniers, disintegrates in the face of catastrophic environmental problems. For the conservative side, due to the complexity of nature and the limits of knowledge, the only option is to return to what has already proven to be good. Large-scale technical interventions in nature are virtually the continuation of the misconduct of civilization that led to the crisis in the first place. The goal to be striven for is nature not yet impaired by man. The opposite side sees a romantic idea of nature behind such attitudes, which is considered good for ideological reasons. For exactly these reasons, the enormous sacrifices associated with a withdrawal of civilization would be ignored. Moreover, nature is not good per se.

On the contrary, nature itself has already caused several global mass extinctions in the history of the earth. And last but not least, the current ecological crisis has reached a stage where it can no longer be stopped by mere withdrawal. The term “sustainability” evokes the association of a planned approach, in which the stability of future circumstances is intended, for

example as in “sustainable management”. The question can therefore be asked whether nature, under whose custody the representatives of the conservative side want to place themselves, provides for an equivalent of such planned sustainability. If so, a compromise between the two sides could be established. Planned sustainability means thinking about the future. This gives the title of this essay: Does nature think about the future? This question brings together the entities of thought, being and time. Various philosophers were concerned with the mutual interpenetration of these entities. The conceptual constitution of reality and the historicity of concepts since Hegel should be mentioned in this context.

Hegel traced the phenomenon of contradiction, which apparently belongs to the realm of thinking, from consciousness back into being. Accordingly, being is not consistently determined or free of contradictions. Contemporary Hegel successors substantiate this assertion on various levels: Slavoj Žižek on the basis of quantum mechanics, Adrian Johnston (2018) on the basis of neurobiology. In fact, on all levels – at least latent – conflicts are evident in what seems to be harmonious on the surface, for instance between the selection and the inheritance of genetic information (Hamperl et al 2017), between genes (“selfish genetic elements”) within an organism (Scott & West 2019) or more generally between all entities designed for self-proliferation (cells, symbionts, neuronal processes, members of animal states) within the respective common superstructure. But if nature is familiar with the contradiction in itself, then it has an essential prerequisite for planning, i.e. for weighing up options. The trinity of being, time and thinking is of course also reminiscent of Heidegger (1962) according

to whom the enowning (Ereignis) unconceals time and being to the thinking. His track shall not be pursued further in this context, but Heidegger must be mentioned, since he is one of the pioneers of the conservative side. Aside from the ecological argumentation, he described the modern technical shaping of the world and its inhabitants as a trap that holds man captive in the inauthentic.

The question whether nature thinks about the future can be translated into the question whether in cosmos an effect of the future on the present is possible. Gödel (1949) affirmed the latter in principle by presenting a non-expanding rotating universe with closed time loops as a theoretical solution of Einstein's field equations. However, the mentioned properties of this universe contradict the empirical cosmological findings. No less interesting are versions of the so-called anthropic principle from in field of fundamental physics. These range from the weak assumption that our place in the universe is subject to the conditions of our existence as observers to the strong assumption that the cosmos, in order to be as it is, had to lead to the (possibility of the) emergence of conscious observers. Since nature is “insofar designed for the mind”, the anthropic principle proves to be related to Hegel's objective-idealistic system and is philosophically covered by it (Wandschneider 2011). In both, however, nature by definition is precisely what thinking does not yet accomplish itself, so that no further help in answering the question of the present essay can be expected from them. Instead of a cosmological view, nature in the following is to be understood as the earth system, i.e. the sum of all biological and geological processes taking place on earth. Time is understood classically, i.e. universally and uniformly

running in only one direction. Thinking should be understood as informed planning. So, can processes be found in nature that correspond to such planning?

“Galore” will be the answer, because everyone has at least heard of the squirrel that lays down supplies for the winter. But does the squirrel actually consider the future when it is stocking up, or does it not perhaps simply follow an instinct. Probably the squirrel would not stop stocking even if it was moved to an area where it does not experience winter. However, the reference to instinct loses credibility when monkeys forge coalitions for future conflict or when ravens plan future bartering (Kabadayi & Osvath, 2017).

One could therefore conclude that in nature the concern for the future is widespread. But the last mentioned examples are rudimentary forms of what is fully developed in humans (just as approaches can be found for all psychological phenomena of humans already in the animal world), and as far as humans are part of nature, this naturally includes planned action. However, in the present essay a boundary is drawn between man and nature; otherwise the conservative option mentioned at the beginning of this essay of placing oneself under the custody of nature would lose its meaning. Accordingly, conscious planning, as is the case with highly developed animals, will not be considered further here. Rather, the question is whether there is a representation of the future in biological processes that have nothing to do with the consciousness we are familiar with. This is not to be expected at the level of the individual organisms, because the future of the individual organism is hardly relevant in evolutionary terms. ►

Organisms invest only a limited part of their resources in the self-preservation of the “disposable soma” (Kirkwood 1977), because the evolutionary optimum requires that resources are mainly used for reproduction through rapid growth and investment in early and numerous offspring. The genes of such individuals who invest too much in long-term stability and too little in reproduction are lost. Seen in this light, nature would not be a model of sustainability. Instead, it resembles the capital investor, for whom profits are less interesting the later they come in, and who is therefore inclined to accept a higher risk and even long-term damage for a quick profit.

Accordingly, a species spreads invasively when it encounters tolerant conditions, and can thus damage the whole ecosystem (incl. itself). But if we consider the evolution of a species as learning, in which information is accumulated in the genes about the circumstances in which the species exists, shouldn't we assume that this learning process covers the time dimension, and at least the species as a whole somehow prepares itself for extrapolated future circumstances? The diploidy of sexual species can be interpreted in this sense, inasmuch as recessive variants represent a pool that can be drawn upon when environmental conditions change. However, these variants have arisen by chance or, at best, are due to previous circumstances. However, the author is not aware of the fact that a future circumstance extrapolated from past and present circumstances would have an influence on the evolution of a species – which could be regarded as an analogue of planning. Here, too, the short-term investment in the reproduction of direct descendants is evolutionarily superior to a long-term investment in later generations.

Even one level higher than that of the species, one could ask whether the Earth system as a whole is operating sustainably according to plan. Supporters of the “Gaia” hypothesis tend to make this assumption, but without being able to theoretically or empirically substantiate the teleological assumptions that resonate in it (Wood & Coe 2007). In addition, as critics put it, several episodes of mass extinction in the history of the earth show that Gaia had characteristics of the child-killing Medea (Ward 2009). However, the assumption of a global system in which stabilizing processes are established over long periods of time can be substantiated by evolutionary theory (Wood & Coe 2007, Doolittle & Inkpen 2018). During these long periods, the earth system appears to be sustainable for those who live in it for a relatively short time. However, there is no indication that it is planning for possible future developments.

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**Professor Dr. Konrad Oexle**  
AG Neurogenetic Systems Analysis,  
Institute of Neurogenomics, Helmholtz  
Zentrum München; Institute of Human  
Genetics, Klinikum rechts der Isar, TUM

In summary it can be said that biology does not know long-term planning sustainability. Thus, nature does not think about the future (although philosophical and fundamental-physical considerations suggest that things beyond biology could be more complicated). In referring back to the initial question of the present article, it is therefore unfounded to hope that Mother Nature already knows. If you take refuge in her lap, you may even run the risk of finding her in Medea mood. So while we cannot follow her plans, because she has none, it is by no means the case that a sustainable policy should not primarily orient itself towards the processes and structures of natural self-regulation as they have last established themselves in geological terms. In this sense, any invasive policy should be conservative and, like a doctor, should be as closely as possible oriented to the physiological structures of the organism to be treated. ┘

02

# POLITICS & SOCIETY



# Decreasing Importance of the UN

## Rise of Informal Organizations

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**75 years ago, the free nations of the world met in a General Assembly to negotiate a postwar order that would secure world peace, promote global prosperity, alleviate poverty and unemployment, and promote free trade as well as human rights worldwide, all in the spirit of Immanuel Kant.**

┌ The conviction to learn from mistakes made in the past led to the creation of new international structures.

Even if these goals seemed very idealistic, the founders of the United Nations were absolute realists. After the experience of the economic crisis of the 1930s, the rise of fascist aggressor states and the horrors of the Second World War, statesmen such as Winston Churchill and Franklin D. Roosevelt were determined to create new international structures to deal with problems that were inherently transnational. The conviction to learn from the mistakes of the past led to the creation of new international structures that would enable better multilateral cooperation in the future.

Today more than ever it is important to remember the origins of multilateralism institutionalized through the United Nations. Because international organizations such as the United Nations are now in a state of permanent crisis and their authority is constantly being called into question. At the opening of the United Nations General Assembly in 2018, Secretary-General António Guterres noted that “multilateralism is under attack from many directions”. Guterres spoke emphatically about the importance of a “renewed commitment to a rule-based order” as a means of solving pressing global challenges. His criticism was directed both at governments that aim to reduce the scope of global governance within established institutionalized and legal structures and at those that create new organizations that compete with existing international organizations. The plea for a renewed commitment to a multilateral and rule-based world order was answered in different ways. The US president took a hostile approach and condemned “globalism” and “mandates that affect sovereign interests”. Most other governments, however, took a different perspective and criticized the “sovereignty-focused” politics of the United States of America. For example, the German Foreign Minister Heiko Maas stressed that the world “needs more international order, more reliability, more trust and our common rules”.

Politicization, and thus also the questioning of the authority of international organizations, has increased since the end of the 1990s and can be explained, among other things, by the fact that an assessment of their performance is at best mixed. Abuse of power in the form of rape by UN blue helmets in Bosnia, dysfunctional internal organizational structures, expensive international bureaucrats, inability to reform the UN leadership structure with its five veto powers (a post-war relic), lack of legitimacy and little criticisms mechanisms are some of the most common accusations. As a result of this politicization of the actions of international organizations, the last two decades have seen a decline in multilateralism in the form of underfinancing and the establishment of alternative forums at bilateral or regional level. In the case of the UN organizations, the declining importance has led to a diversity of informal and partly private organizations in international health, environment, development and human rights issue areas. The multitude of stakeholders and support programs, especially in health and development politics, is anything but sustainable. For example, the World Health Organization (WHO) has had to look for private donors and increasingly enter into public-private partnerships to fill the financial gaps. The budget of the WHO is now mainly financed by the Bill & Melinda Gates Foundation and pharmaceutical companies. This dependence on external/private donors has the unintended consequence that short-term results and achievements have moved to the center of attention and long-term disease control in the form of basic health programs has been pushed into the background. ►

**As a result of the COVID crisis, the WHO has come under constant pressure for its poor crisis management.** The USA, together with Australia, is now demanding accountability from the perpetrators of the crisis, for China's cover-up attempts and for the WHO's controversial handling of the pandemic. The US President is withholding funds from the already severely underfunded WHO until the UN agency's actions during the pandemic is reviewed. At the end of April 2020, U.S. government even blocked a joint G-20 initiative to empower the WHO – in the form of a mandate extension and the provision of additional material resources to coordinate the international fight against the coronavirus pandemic. The Director-General of WHO, Tedros Adhanom Ghebreyesus, on the other hand, pleaded for an investigation of the pandemic and a review of the role of WHO after the end of the pandemic. UN Secretary General Guterres declared accordingly on 14 April 2020: "After we will have defeated this pandemic, we will look back and understand and investigate how such a disease originated and how it was able to devastate and spread around the world, and how all those involved reacted to the crisis."

The successive disengagement of the world power US from the stage of international politics will also inevitably lead to a change in the multilateral world order. The rise of new powers had already led US President Obama to focus his foreign and security policy on the Pacific region. For Europeans, this meant taking more responsibility for a sustainable security policy in

Europe. With the election of Trump as US President and the constant criticism of defense spending by European NATO countries, the German Chancellor Angela Merkel also realized that "the times when we could rely on others without reservation" are over. The party-political politicization of the USA has not stopped at international organizations. Thus, in 2019, at the suggestion of the USA, the World Bank critic David Malpass was appointed head of the World Bank. At the World Trade Organization (WTO), the USA is blocking the appointment of important posts at the Court of Appeal, thus undermining the functioning of this institution. This led to the early resignation of Brazil's WTO Director General Azevedo. For critics, this is ample evidence that the Trump administration may be trying to weaken international organizations from within.

**How can international organizations emerge stronger from these challenges?** The current fragility of the multilateral system can only be overcome by strengthening multilateralism. International organizations are central pillars of world politics by providing technical assistance on the ground, acting as mediators between states, helping to overcome nationalism and territorial borders, making global governance more efficient, providing a neutral framework with rules and procedures for the exchange of information, and acting as "arbitrators" to mediate interests and resolve conflicts. It would therefore be of central importance and an important signal to the world community if states were to return to multilateral forms of cooperation and restrict unilateral action. ┘

António Guterres UN Secretary-General, 14 April 2020

After we will have defeated this pandemic, we will look back and understand and investigate, how such a disease originated and how it was able to devastate and spread around the world and how all those involved reacted to the crisis.



**Professor Dr. Eugénia da Conceição-Heldt**  
Founding Dean of the TUM School of Governance; Reform Rector of the Hochschule für Politik München at the TUM; Professor for European and Global Governance, TUM



**M.A. Tony Müller**  
Research Associate and PhD Student at the Chair of European and Global Governance, TUM

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# Competition of Regimes in the Course of the Corona Pandemic: Crisis Response and Sustainable Adaption in a Comparison Between Democracy and Autocracy

## COVID-19 as a challenge for all countries

Contrary to Francis Fukuyama's expectation of the "end of history" with the fall of the Soviet empire and the final victory of democratic systems, even before the outbreak of the COVID-19 pandemic the world found itself in an intensified competition between the western, liberal, constitutional democracies on the one hand and the emerging autocratically governed countries (China, Russia, Singapore etc.) on the other. This race for supremacy and interpretative sovereignty is now also being continued in the context of the pandemic, when China, for example, emphasizes its (supposed) success in containing the pandemic via the WHO, which is now in a considerable relationship of dependence with China, and further secures it by supplying aid to countries strongly affected by the epidemic (including numerous democracies). At the same time, established democracies are faced with the challenge of not only justifying massive interventions in the civil liberties of their citizens, but also preventing a drift into autocratic states (Pandemic Backsliding, see Lührmann et al. 2020).

The COVID-19 pandemic, which originated in China and then spread rapidly through its neighboring countries, Europe, the USA, Latin America and finally Africa and Central Asia, is probably the first truly global simultaneous crisis to generate an external shock event that governments of all countries must face.<sup>1</sup> Four main phases of the crisis can be distinguished: While the first phase was initially concerned with identifying a local outbreak of the virus, allowing individual cases to be tracked and creating a general awareness of the problem, the second phase was in most countries under the impression of robust (relatively undifferentiated) efforts to contain an exponential spread of the virus ("flatten the curve") under conditions of great uncertainty regarding the central characteristics of the virus. After the flattening of the (first) wave of the virus, the complexity of political decision-making in the third pandemic phase has noticeably increased, since, in addition to preventing a further wave of infection, the social and economic consequences of the crisis must now be taken into account to a greater extent. The detailed balancing of different economic, social and medical interests is likely to continue until the infection rate in a country either drops to virtually zero, herd immunity is achieved or an effective drug/vaccine is found. This will

be, at the latest, the beginning of a further fourth phase, which will focus on the long-term lessons and consequences of the crisis. Thus, the crisis may well act as a catalyst for a long-term transformation process towards a more resilient and sustainable social and economic system if the window of opportunity for reform is actively used by the political decision-makers in a country. Overall, the question arises as to which political model will prove to be better equipped to deal with the changed circumstances and new challenges posed by COVID-19 in the short, medium and long term. Both democracies and autocracies have specific characteristics<sup>2</sup> that can prove to be either advantageous or disadvantageous in the individual phases of the pandemic.

## Response to the crisis – Comparison of regimes

For the first phase, it should be noted that the global spread of COVID-19 is due to a failure of the Chinese leadership to have detected the local outbreak of the virus in Wuhan in time and to have taken appropriate emergency measures. Because local cadres had not initially reported the outbreak with the necessary urgency<sup>3</sup> valuable days and weeks passed, during which the autocratic regime was primarily busy intimidating and locking away doctors and journalists who warned of the virus, in order to cover up the outbreak and possible negative consequences (Burkle 2020). This has contributed significantly to the global spread of the virus beyond China. A similar pattern of denial and criminalization of the virus was observed in the following weeks in numerous other autocracies, such as Iran and North Korea.<sup>4</sup> Even if not all democracies immediately grasped the full extent of the challenge (the USA or Brazil under populist leadership can serve as negative examples here), transparent and free press reporting in democracies opened up the possibility for an early (or earlier) crisis response (Wurster i. E.). This is in line with the experience from previous pandemics that democratic transparency can facilitate a timely medical emergency response and at the same time allow citizens to maintain their trust and willingness to cooperate despite drastic measures (Knowledge@Wharton 2020).

After the COVID-19 crisis could no longer be concealed, some autocracies, as far as they had a developed state capacity to act, were able to play out an (alleged) strength of the autocracy: uncompromising enforcement of interests by means of repressive measures. China, for example, took a ruthlessly efficient approach to the pandemic by completely sealing off the city of Wuhan with its eleven million inhabitants and expanding medical and hospital capacities in record time, in some cases under very questionable working conditions (Merkel 2020). Even if autocracies can impose and enforce quarantine measures in a very rigid form (Knowledge@Wharton 2020), they have not always been successful in containing the virus, as the case of Iran shows. Democracies naturally found it much more difficult to curtail individual liberties in such a drastic way (Tisdall 2020). Massive restrictions on freedom of movement and social and economic activity were indicated during this pandemic phase

and were implemented, albeit to varying degrees. However, the success of the containment measures varied considerably. While Germany, Austria, Denmark, South Korea and Taiwan were relatively successful in keeping the number of infections and deaths low, other established democracies such as Italy, Spain, Great Britain and especially the USA had to cope with the (partial) collapse of their health care system with all its negative consequences.

It is remarkable that among the autocracies, too, it is above all those with a state that is capable of action and intervention-oriented (Singapore, China) that have been successful in their containment efforts (see on the developmental state Pepinsky 2020). It was shown that, in addition to the effective implementation of quarantine measures, accompanying instruments (high testing volume and sufficient number of intensive care beds) played a central role in virus control. Countries with a broadly developed (mostly publicly financed) health care system (Scandinavian countries, Germany), which also allows access for socially disadvantaged groups, have proven to be more successful than those with strongly privatized, non-egalitarian systems, as they prevail above all in liberal market economies (USA) (Pepinsky 2020). If treatment capacities are not widely spread, not only do more infected people die, especially the poor and disadvantaged, but it also has an impact on the degree of polarization and conflict in society (increase in protests and resistance) and reduces confidence in government measures, which in turn can have a negative impact on virus containment.<sup>5</sup> While autocracies can impose willingness to conform with open repression, at least in the short term, in democracies, good arguments are required as well as trust in the state's ability to act. If these conditions are met, even in the more individualistic societies of the West, it is possible to achieve high approval ratings for drastic measures. The more collectively oriented Confucian societies of East Asia traditionally find it easier to do so.

As soon as the first wave of infection has abated, in the next pandemic phase, we have the task of organizing a widespread return to normality by means of loosening the reins without provoking a relapse. This requires differentiated and balanced measures that take into account medical, economic and social aspects at the same time (Tisdall 2020). Democracies can exploit the advantages of a broader consideration of interests, a stronger orientation towards participation and the ability to correct mistakes (Wurster 2013; Wurster i. E.). If it was sufficient in the short term to simply impose behavioral adjustments (which is the strength of autocracies), longer-term behavioral changes and "compliance" (voluntary precautionary measures) can be achieved much better if the interests and needs of the citizens are heard and taken into account in (democratic) decision-making. The accountability of democratic governments to their voters and the involvement of different social groups increases the pressure to find appropriate solutions to problems and to quickly recognize and correct undesirable developments (on the ground). This is an inestimable democratic advantage, especially in a phase marked by permanent uncertainty. ►



## Sustainable adaptation and transformation

Learning lessons from the crisis will become a key factor in the race of regimes for economic and power politics, but also social and ecological advantages once the acute pandemic situation has ended. The crisis offers a “window of opportunity” to break up encrusted structures and initiate a fundamental transformation (Schreurs and Wurster 2019) towards more resilient and sustainable economic, health and social systems. Especially for democracies, which are often trapped in path-dependent developments due to powerful distribution coalitions (Olson 1982), the possibility opens up to overcome internal resistance and to unleash the enormous innovation potential resulting from a strong political competitive orientation. Fundamental transformation processes can now be initiated, for example in the organization and financing of medical care systems, in working life (working from home), in setting economic priorities or in environmental and climate protection. Extended freedom and participation rights in democracies can also provide the sounding board for new, common welfare-oriented initiatives (such as the Fridays for Future movement), in the promotion of which autocracies show a structural deficit —



**Professor Dr. Stefan Wurster**  
Professor for Policy Analysis, TUM

1. This even applies to the (pre-)totalitarian regimes of North Korea, Turkmenistan or Uzbekistan, which initially attempted to avoid serious pandemic control by suppressing information, invented success stories or “banning” the virus.
2. While democracies are supposed to guarantee political equality and participation rights, competition and government control on the basis of free and fair elections, in autocracies popular sovereignty is restricted in favor of the rule of a small elite. Public control through a system of “checks and balances” does not take place here, making likely political decisions against the interests of a majority of the population, as well as the suppression of opposition groups.
3. This reflects a fundamental problem of autocratic rule. The threat of repression emanating from the regime creates a climate of permanent fear among both regional cadres and ordinary citizens which makes it advisable to avoid passing on negative information to the political leadership. However, this leads to a distorted perception of reality (insufficient political feedback loop), which makes political decisions based on real facts more difficult (Wurster 2013).
4. To this day, the statistics from China and other autocracies cannot be fully trusted, either because they are misused as an instrument for securing power and regime propaganda or because they cannot capture the full extent of the pandemic due to insufficient state capacities for action (insufficient testing capacities). The latter problem can however also occur in democracies with weak statehood (for example in Africa or Latin America).
5. In principle, social inequality in a country can in itself undermine compliance with quarantine measures, as people at the lower end of the socio-economic scale cannot afford to stay at home because they have to earn a living (Knowledge@Wharton 2020).

## Conclusion

Although it is not yet clear at this stage which countries will emerge stronger from the COVID crisis in the medium and long term, it does not seem at all certain that this global crisis will be followed by a phase of autocratic domination. Rather, democracies that are open to participation and which, in addition to a high degree of state capacity to act, also have a sufficient degree of trust and social capital in their societies not only, seem to be (more) able to develop balanced crisis reaction strategies, but also have the potential to use the crisis as a starting point for a sustainable transformation of their societies.

In order to be able to accompany and inform these processes constructively and critically, we need not only further medical knowledge in the fight against the pandemic (and its consequences), but also analyses from the natural, economic, social and political sciences, which provide unbiased results on the basis of shared scientific standards. The important asset of academic freedom that, in the past, distinguished democracies fundamentally from autocracies, must be defended both against their enemies inside (conspiracy theories, fake news, disparagement of science) and outside (attempts of manipulation by autocratic states).

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# TechnoSociety by/after Corona: Conditions for Communication and Organization

**What kind of society do we actually live in? This is the questions sociologists constantly ask, yielding continuously new answers. Because: It is one of the challenges of our profession that the subject we are dealing with is highly dynamic: A society that is constantly changing. Its diagnosis therefore is a never-ending task. The following considerations are based on research work conducted at the Friedrich Schiedel Endowed Chair of Sociology of Science.**

Currently, it is popular to speak of the “Coronavirus Society”. We propose a different term, that is to see the current events as a particularly revealing chapter of “TechnoSociety”, which is characterized by ever new interactions and interdependencies between technology and society. Which technologies? On the one hand, the current changes are, of course, based on “hard” technologies – such as the Internet, video telephone platforms or medical technologies. On the other hand, they are also based on “soft” social technologies which transform our social relationships, modify organizational processes, communication and consumption patterns or lead to a different use of digital technology.

There is a lot going on there right now! Therefore we must come to an understanding on these interactions and interdependencies – and actively shape them. And it strikes the eye: COVID sheds new light not only on the conditions for communication between science, politics and the media in times of great uncertainty, but also on the many different techno-social “solutions” that are present in society. This offers great opportunities for increasing the acceptability of mainly digitally supported solutions right now if we work on practicable techno-social arrangements – and do so together, in a responsible manner. Let’s start with the understanding between ...

## Science, politics and media in times of COVID

### If this wasn’t clear before, it is now:

We live in a thoroughly knowledge-based and technologized world – after the post-factual age had been proclaimed, confidence in science has now increased significantly, according to the “science barometer” named “Corona Spezial” from Wissenschaft im Dialog [Science in Dialogue] the initiative of Germany’s major research organizations. People now understand even better that research takes time, progresses step by step, and that detours as well as different statements belong to the mode of operation of science: E.g., different data situations or calculation methods might lead to this – and generate further, better research approaches. **But:** What are the consequences for political decision-making?

### What we can also learn from this situation:

Increased confidence in science is one thing, the other is confidence in politics, which is relying on (always provisional!) knowledge in order to make decisions for social life that, in part, have major consequences. Politicians and scientists are once again experiencing the need to improve their mutual understanding. Politicians must respect the fact that knowledge is preliminary, possibly uncertain and questionable. Scientists must understand that even their elaborately produced knowledge is always interpreted in political contexts before it leads to political decisions.

**Last but not least**, the COVID case also teaches the media once again what makes good reporting. It balances considerable non-knowledge and enormous pressure to act. It is therefore important, on the one hand, not only to cite serious sources, but also to identify clearly if something is contestable. On the other hand, it is important neither to trivialize the dangers of the virus nor to be alarmist. Not least because what the media report ultimately has consequences for political agents and the culture of political discussions. The media have a say on who should be allowed to discuss publicly problems that need solutions and how problems are presented and discussed. Do they back expert discourses (“speaking truth to power”) or do they present COVID as a virus that infects society in all its complexity? And consequently also has to be treated by all of us together (“society speaks back”)?

### To put it short:

It is not only as per today that science, politics and the media are in a tense context of responsibility that needs to be constantly re-considered. COVID is demanding a lot here – not least “physical distancing” demands new, digitally supported forms of information and debate: on the regional, national, and international level. To name but two examples: “Europe

by Satellite” or press conferences on streaming services – all this is possible, but significantly limits the intensity of political debate and detailed follow-up by the press. Other sites of debate, for example in the social media, increase the opportunities of understanding, but also of conspiracist “echo chambers”.

So distancing and digitalization are the two keywords not only in science-based communication and decisions on COVID. They also form the “space of solutions” for all attempts to organize our social life in a “corona-sensitive” manner. This includes everyday and professional areas of life, whether we think of education, care or work: Everywhere in the interspace of (physical/ social) distancing and digitalization techno-social solutions emerge.

## Education

### Digital teaching and learning

**There were good reasons why school lessons were held at school – so far:** This appeared to be the best way to ensure educational equity. However: In a society that is completely penetrated by technology, this should in principle also be achievable outside school. Yet, although digital teaching and learning has been on the education policy agenda for a quite a while, its implementation has been realized slowly and inconsistently: For example, the “Digitalpakt Schule” [“Digital Pact for Schools”] has provided around 5 billion euros to improve the technical and pedagogical digital infrastructure, but schools have so far only called on around 650 million euros

### However, the problem is more of a techno-social one:

Parents are expected to play the role of substitute teachers at home. But how does digital teaching and learning actually work? Technically “almost” everything seems possible: lessons via video chat, individual feedback and customized support for the students. Whether and how successfully digital technologies can be used, however, still depends very much on the individual commitment of both, teachers and parents. Therefore, due to the slow implementation of “digital” teaching and learning and an unresolved entanglement with classroom teaching, there is currently a threat of an increase in unequal educational opportunities for children, depending on the capacities of both, teachers and parents. **Nevertheless, the possibility exists** that SARS-CoV-2 as Corona-shock leads to a systematic and fair digitalization of schools. ►

## Care

### Social Robotics

Robots should – such the vision – find their way into more and more areas of life beyond the classic factory environment, such as care, therapy or private households. Until now, this vision has been met with many reservations; in addition to the fear of “dehumanization” of care, there were also very practical problems. Even under laboratory-like settings specially designed for robots and with test persons specially instructed in how to use them, care robots are still reaching their limits. They still seem to be quite far away from stepping into “real life”.

However, the fight against COVID is now a powerful argument for robotics in care: It facilitates distance which reduces the risk of infection, and this especially for those who, due to their age and/or underlying health conditions, are particularly at risk. In order to take advantage of this opportunity, we must currently also be prepared to accept difficulties such as increased work and time involved in human-robot interactions. Speaking of human-robot interaction: This includes the recognition of the achievements of the nursing staff and the design of work contexts that are both practicable and acceptable. The COVID-19 case is showing that assistive robots achieve their momentum precisely by shifting social, political and medical priorities in their favor, but also by making the special value of human proximity even clearer.

## Work

### Home/Office

Finally, the COVID crisis is also supporting the trend towards digital work. Especially working from home is experiencing an unexpected boom. This is because social distancing which is necessary to prevent the spread of the virus also forces physically distanced, digitally mediated work. And it is becoming apparent that for some activities, for which physical presence was previously considered absolutely mandatory, virtualization is now possible under the pressure of the crisis – for example, in education and care.

**However, the risks and problems of digitalization are also becoming more apparent, as research in the field of sociology of work has already shown in recent years:**

For example, digital working and interacting lacks the many informal elements that are so valuable for productive exchange in work. Also the dissolution of boundaries between work and life while working from home and under COVID conditions poses new challenges for employees, such as the coordination with the entire individual and family lifestyle. Distant or close, digital or not, at home or on the ground, in whole or in part – we now have to gain experiences, explore alternatives and shape novel conditions for all fields of work.



**Professor Dr. Sabine Maasen**  
Former Director of the Munich Center for Technology in Society (MCTS), TUM; Member of the Scientific Commission of the German Council of Science and Humanities; Professor of Sociology of Science, Friedrich Schiedel Chair, TUM



**Dr. Barbara Sutter**  
Academic Councilor and Head of the Department of Sociology at the Chair of Sociology of Science, TUM

# An Opportunity

Despite their difference, all examples have one thing in common: Now, a society seems possible that is able to benefit from its opportunities with all social agents: science, politics and the media, but also teachers, nursing staff, employees, employers and parents. The coronavirus offers the opportunity to bring together the belief in the changing power of new technologies and the experience of the possibilities of social innovations and also to jointly address their unavoidable risks (e.g. the so-called “COVID denial”). For even beyond COVID, especially in the climate and democracy crisis, it is clear that improvements in these domains will only succeed if technical and social changes are interacting. *A TechnoSociety fixated on technological change could now become a TechnoSociety.* ┘

# “Science as a Vocation”

## Needs Time for Thoughtfulness

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Even before he came to the LMU in the summer semester of 1919, as a Full Professor of Social Science, Economic History and National Economics, Max Weber was considered the most creative German-speaking social and cultural scientist of his time. He was known to a wider academic public not least because of his programmatic lecture “Science as a Vocation” given at the invitation of the “Association of ‘Free’ Students” (which means not organized in corporations) of both Munich universities on November 7, 1917 in the “Steineckesaal” at Adalbertstr. 15.

— Only by strict specialization can the scientific worker become fully conscious, for once and perhaps never again in his lifetime, that he has achieved something that will endure.

Over 100 years later, under the conditions of the COVID-19 pandemic, there are strong reasons to remember the text which has been translated into many languages and is still much read worldwide. Here, Weber developed an understanding of the tasks and limits of science that can be considered as “sustainable” in a concise sense. At the same time, he named paradoxes of institutionalized scientific knowledge production in universities, academies and research centers, which, especially with regard to basic research, are still irrefutable today. In an open, free society, whose democratic institutional order is based on the recognition of the inviolable dignity of every individual and their fundamental rights, freedom of science and freedom of opinion in general are guaranteed by the constitution. The scientific system, which has been developed in many different ways in all complex industrial societies in recent decades and continues to expand, is fundamentally dependent on such guarantees of freedom. Nevertheless, intentionally free research is constantly threatened and subjected to hard constraints by the functional imperatives and intrinsic logic of other social subsystems. “The economy” for instance, expects for understandable reasons a production of knowledge which can be used easily and fast for marketable, profitable goods and services. The taxpayer would like to know why the state invests so much money in the deeper investigation of prob-

lems that often seem to them remote from everyday life, even life itself, and irrelevant. “Politics”, especially in times of crisis and new uncertainty, hopes that the voice of science is able to proclaim as clearly, loudly and unambiguously as possible helpful solutions to overcome current challenges. Very high expectations of “Science” are also repeatedly formulated in the media: It is supposed to provide as soon and quickly as possible patent remedies, now mainly for a vaccine, provide an authoritative answer to the old question “**What shall we do?**”, and in general provide “relevant orientation knowledge” – to use a fashion term in use since the 1990ies. **But can science actually have all these functions? Or isn't it rather foredoomed when confronted with all these expectations by politics and society?**

In “Science as a Vocation” Weber described the specific power of scientific findings and, what is important, its insurmountable limits. His audience were students and young scientists who, under the impression of their traumatic experience of the carnage in the First World War, hoped that a new, better science could lead to a comprehensive cultural renewal. Not only the old religious institutions such as the Churches had failed in this war between the great Christian peoples of Europe ►

but also science, whose leading representatives had revealed themselves as brutal nationalists and largely placed their research at the service of war propaganda and the physical destruction of the respective enemy. Weber reacted to these expectations of the younger generation with deliberate provocation. He rudely rejected their hope that a completely new and better science would finally be able to give a sense during the current crisis and integrate the diverse and heterogeneous individual findings, gained through highly specialized detailed research, into a closed synthesis. University is the wrong place for those who expect a “holistic vision” and seek deep mystical experiences. A prophetic habitus and attitude of moral know-it-all should be banned from the lectern. In a scientific system based on the division of labor which attempts to gain a more precise insight into extremely complex and often contradictory cultural and natural objects of knowledge by constantly differentiating between disciplines and refining research methods, the individual researcher must be prepared to radically concentrate on what is special about him or her. “Only by strict specialization can the scientific worker become fully conscious, for once and perhaps never again in his lifetime, that he has achieved something that will endure. A really definitive and good accomplishment is today always a specialized accomplishment,” Weber explained.

Anyone who embraces modern science must be able to tolerate paradoxes. First of all, there is the paradox elementary for all methodologically reflected research that hard-earned better knowledge and analytical innovations raise new questions. Research is a notoriously unfinished process in which the insights of today must be questioned tomorrow: “Every scientific ‘fulfilment’ raises new ‘questions’; it asks to be ‘surpassed’ and outdated.” Scientists are therefore well advised to avoid the gesture of pride in knowledge and omniscience and to be reflective, thinking about their own fallibility. Quick fixes are the opposite of sustainability. The only sustainable way is if criticism and especially the willingness for self-criticism ensure the possibility to revise what is currently known. The cognitive mode of sustainable science is, to use a term from the ancient religious languages of mankind, humility. For despite all the gigantic investments in the scientific system, we know very little about what is crucial.

For a scholar of the humanities and cultural studies, it is always surprising to see how even elementary questions about the functional mechanisms of life are still unresolved even in large-scale scientific and especially life science research. **Crises are opportunities**, as the old saying goes.

Even if it is currently used inflationary and sometimes instrumentalized to make people forget or even euphemize the hard, cruel and destructive aspects of the pandemic – the “lockdown” and the confrontation with a disease that really affects all people could, in the positive case, also lead to more intellectual attention being invested in elementary basic distinctions, especially the differentiation between knowledge and the limits of possible knowledge.

In times of crisis, scientific institutions and individual researchers are under increased pressure of public expectations. “Politics” needs advice and “the media” depend on competent experts as interview partners to provide the public with information. Which is why it is tempting to provide quick, catchy answers to difficult, often not completely resolved questions. Science is only sustainable if it is able to resist this temptation and make it clear in public communication that it also has limited insights and that there is much not (yet) known. Science requires an ethos of self-limitation. An institution like the “Leopoldina” not only damages its own reputation but also undermines confidence in science as a whole if it is only able to offer trivialities in “ad hoc papers” on ways to end the “lockdown” – according to the justified criticism of Jürgen Kaube in the FAZ.

Good scientists know about the aspects of contingency, and even unavailability in all finding processes. “The idea is not a substitute for work. And work, in turn, cannot substitute for or compel an idea,” Weber had tried to explain to his student listeners in 1917. Sustainable science is more than the mere accumulation of knowledge and data. It is problem-driven and requires theoretical orientation. One may deny whether people, and even more so human societies, really learn a lot from crises; quite a lot of historical examples give cause to doubt that.

**But if there is anything to learn at the moment, it is this: Science needs time to concentrate on what is decisive, i.e. basic research. It requires calm for reflection and thoughtfulness. It can be sustainable to exactly the extent that it is able to maintain such freedom in all hectic day-to-day business and the usual hustle and bustle of project-oriented everyday research. ┘**

Research is a notoriously unfinished process in which the insights of today must be questioned tomorrow: “Every scientific ‘fulfilment’ raises new ‘questions’; it asks to be ‘surpassed’ and outdated.” Scientists are therefore well advised to avoid the gesture of pride in knowledge and omniscience and to be reflective, thinking about their own fallibility.



**Professor Dr. Dr. h.c. Friedrich Wilhelm Graf**  
Leibniz Award (1999); Permanent Fellow  
at the Wissenschaftskolleg zu Berlin;  
Professor for Systematic Theology and Ethics,  
LMU of Munich

#### Literature

“*Wissenschaft als Beruf*” [“*Science as a Vocation*”] of **Max Weber** is, usually in combination with the equally famous speech “*Politik als Beruf*” [“*Politics as a vocation*”] from January 28, 1919, available in numerous paperback editions. As a critical and commented edition as part of the complete edition under the responsibility of the Commission for Social and Economic History of the Bavarian Academy of Sciences: **Max Weber, *Wissenschaft als Beruf 1917/1919. Politik als Beruf 1919***, edited by Wolfgang J. Mommsen and Wolfgang Schluchter in collaboration with Birgitt Morgenbrod (Max Weber Complete Edition Volume I/17), Tübingen 1992.

## Informing, Not Missionizing – Also in Times of Corona.

About the Relationship Between  
Politics and Media

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**“We don’t have time now, we have to watch the press conference of the Chancellor to see how things are going with COVID”, my school age daughters are shouting through the house. And later again: “Keep quiet! There’s a report on the radio about the latest infection figures!” These really are special times.**

Media and politics need each other. And they need an understanding for each other in order to be able to fulfil their mission.

You rarely see so much voluntary attention (even from young people) for politics and quality journalism. Neither politics itself nor journalism or representatives of media education have been able to arouse this interest before. Similar to the spread of the coronavirus, the desire and need for background information has risen exponentially. The demand for information on the subject, on medical facts, on necessary measures, their explanation and their effects – all this needs to be satisfied so that democratic participation is possible. For politics not to leave behind the people. This situation is an opportunity for all sides that must be used. Politics can show that it has the power and the opportunity to make things happen and to give the lie to those critics who think that politicians are only executors of individual interest groups. The quality media – above all the public service – in turn can show that they take their mission seriously and fulfil it. That they are capable of countless special efforts. From COVID podcasts and special programs to online dossiers and print supplements. Because this supply of serious information and thoroughly researched backgrounds ensures that social discourse is possible at all. The urgency of the social debate is demonstrated by the unprecedented temporary restrictions on fundamental rights, school close-down, travel bans, economic disruption, etc. However, this discourse is only

possible on the basis of sound sources, careful research and extensive explanations. While it is true that the quickly typed post for spreading conspiracy theories brings a lot of clicks and quick success, it is comforting to know that the offers of reputable news providers are currently also recording record usage. Regardless of their distribution channel.

And yet not everything is running smoothly, important questions remain open: How many press conferences of responsible politicians should actually be broadcast on the radio, on TV and online? Sometimes without much opportunity for the press to ask questions? How many special broadcasts and individual interviews with the Chancellor, with ministers and prime ministers are appropriate and legitimate? When should you ignore them deliberately and only report the results and instead interview the opposition or other critics? How much space should one actually give to those virologists and doctors who do not advise the government but perhaps see things differently? How much time to important or prominent doctors who may only have little expertise on COVID? And shouldn't press conferences of the Leopoldina, of the political opposition, of critical non-governmental organizations etc. be broadcasted, as a kind of counterbalance? ►

┌ There is still a demand for critical journalism, also in times of COVID.

**In the beginning, it was easy:** Although the opposition had not ceased its work, it had deliberately allowed the government to take the lead in order to enable quick decisions. A few heckles, and that was it. Surveys also often showed a high satisfaction of the people with the government's actions. In some cases, politicians received approval ratings as never before.

At the same time, however, the media still have their control function. Even now. And it is not always easy to fulfil. This already starts with simple questions: Do you rather take the figures of the Robert Koch Institut or of the Hopkins University? Is it still legitimate, in times of the coronavirus pandemic, to say everything in a commentary (in which one can basically demand everything, if it does not violate laws or human dignity) – or are there now limits based on social responsibility? Here is one simple example: In principle, it is legitimate to call for the compulsory use of masks for everyone or to call for the purchasing of masks at a very early stage. However, at the beginning of the crisis, it would have inten-

sified the problem of excessive purchasing of masks and put at serious risk medical and nursing staff as well as the residents of homes. Moreover, compulsory use of masks as well their effectiveness were controversial. Now, this compulsory use is now widely regarded as sensible and is a matter of consensus. Even such harmless and open-ended considerations could be reinterpreted by media critics and representatives of conspiracy theories in their own sense.

And also what is called “constructive journalism” (the school that wants to report mainly on positive developments) has a tough time. Here, we also can see a latent accusation of too much proximity between those in positions of responsibility in politics and society and the representatives of the media when subjects or measures are supposedly presented too positively.

And there is another aspect in the current crisis: Media and politics need each other. And they need understanding for each other in order to be able to fulfil their mission. While it is true that politics is increasingly using their own social media channels, they still need the media to generate an understanding for their acts and at the same time identify moods and problems. The media in turn are dependent on understanding from politicians,

perhaps more than in the past. The public broadcasting services are making great efforts to provide quality and at the same time have to fight for future-proof financing. And this decision is up to politics. Private providers, in turn, are complaining about declining advertising revenues due to the COVID crisis and could also be dependent on public support. In both cases this is a structural problem. To describe this as a journalistic problem is the wrong conclusion, in good times and in bad. Reporting on successful examples, on correct and good political measures is just as legitimate as critical analysis and a sharp commentary. And there have always been social challenges that have been reported on very critically, while at the same time the decision on the future financing of the broadcasters was pending or the framework conditions for private media providers were tightened.

There has always been critical journalism in the Federal Republic of Germany. In recent years, a number of broadcasters, newspapers and online providers have invested massively in investigative units. There is still a demand for critical journalism, also in times of COVID. There is no reason why this should change now of all times. And the following professional criteria also apply and help in the daily news business: Informing, not missionizing! Analyzing what actually happens and at the same time be sensi-

tive to moods, concerns and criticism of the people – whether in a personal conversation or via social listening tools. And then report in a fair and well balanced manner, let all important sides in the social discourse have their say and, from time to time, set different, own topics. Make a clear distinction between commentary and news, and admit and make transparent own mistakes, if they happen.

If all this is respected, chances are that not only the propagators of fake news and conspiracy theories will be heard in times of crisis, but also the quality media. At the same time, new and maybe unexpected forms of journalism could emerge. Virologists with podcast are the new media stars. Journalists as well as politicians and society should be okay with that. └



**Steffen Jenter**  
Bayerischer Rundfunk,  
Head of the editorial  
office of the news  
program B5 aktuell

# Science Advises Politics and Society

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On the one hand, the TUM is an agent in science-based policy advice; and on the other hand, TUM analyses the interdependency between politics, society, economics and technical sciences, especially at the TUM School of Governance. Science-based statements are prepared by the academies of science and other institutions and made available to the political community. Topics are either generated internally or suggested from outside institutions (e.g. Federal Ministries) to the academies. Usually the process takes several months, but during the COVID crisis the academies responded within weeks or even days with different formats.

┌ In the short time available, scientists can only provide a “qualified opinion”.

## Leopoldina

The German National Academy of Natural Sciences Leopoldina, founded in 1652, is a classic scholarly society with around 1,600 members from almost all scientific fields. As the National Academy of Sciences it has two special tasks: representing German science abroad and advising politicians and the public. The third Leopoldina ad hoc opinion with the title “Coronavirus-Pandemie – Die Krise nachhaltig überwinden” [“Coronavirus pandemic – a sustainable solution to the crisis”] was published on 13 April 2020 (following previous papers on 21 March and 3 April). This opinion deals with the psychological, social, legal, educational and economic aspects of the pandemic and describes strategies that can help to return gradually to normality.

**Here the problems of policy advice at very short notice become apparent:** In the short time available, scientists can provide no more than a “qualified opinion”, as the “Spiegel” notes (in its online edition on 14 April 2020). When FAZ editor Jürgen Kaube polemizes in the FAZ cultural section (14 April 2020): “In fact, their text is mainly an aggregation of generalizations, invocations of values and trite demands signed by theologians, materials engineers, catalysis researchers and social historians,” this also shows the tension of dealing with a complex topic in a multidisciplinary way and finding a suitable group of experts for this purpose.

## acatech

acatech, the German Academy of Science and Engineering, is particularly close to the TUM, not only in terms of location (with its office at Munich’s Karolinenplatz). The national academy and “voice” of Engineering Sciences at home and abroad, which is funded by the Federal and regional authorities, advises politics and society on future issues relating to engineering science and technology policy and sees itself as an independent and public-interest oriented discussion platform on the opportunities, risks and challenges of new technologies. Numerous TUM members are also acatech members.

Innovation requires a strong science system, companies that put science into practice, good governmental framework conditions and an innovation-friendly social climate. acatech therefore integrates the expertise of leading technology companies into its work alongside science and addresses new topics of technological, economic and social relevance at an early stage and in a practical manner. More than 500 scientists come together in the General Assembly, more than 100 members in the Senate, which bundles suggestions from industry/business and society and provides strategic impulses for the work of the Academy – especially with regard to challenges for Germany as a technology location in global competition.

Under the title “Corona-Krise: Volkswirtschaft am Laufen halten, Grundversorgung sichern, Innovationsfähigkeit erhalten” [“COVID crisis: Keep the economy running, secure basic services, maintain innovative capacity”] (27 March 2020), a group of experts from the Academy has presented a guideline for action along three strands of crisis management: intervention, stabilization, stimulation. It contains proposals on how direct crisis intervention can be strengthened, how economic sectors relevant to supply can be stabilized and what stimuli can be used to prepare the return from crisis to growth. ►

acatech and the experts of the network also provide advice to politics and society in other formats. For example the sociologist and risk researcher Ortwin Renn (Managing Scientific Director of the Potsdam IASS and Distinguished Honorary Professor of the TUM) explains in his article “Gute Kommunikation in der Krise” [“Good communication in the crisis”] (<https://www.acatech.de/allgemein/gute-kommunikation-in-der-krise/>, 15 May 2020) findings from perception and behavior research in order to draw conclusions for successful crisis communication. This topic – together with perspectives from consumer policy, psychology and socio-economics – was included in the “acatech am Dienstag” [“acatech Tuesday discussion”] series with which the academy highlights current and controversial technical topics. This resulted in a comprehensive picture of the opportunities and challenges of communication in the COVID crisis.

Using the diversity of disciplines for the dialog between science and society is the basic theme of science communication and policy advice. The basis for this is sound and reliable information. “Digital journalism in times of the COVID crisis” was therefore another hot topic at “acatech am Dienstag”: Does the COVID crisis change the way people inform themselves and form their opinions? Where does “digital journalism” stand today, what new formats can we expect and how will journalists be trained in the future? Communication scientists as well as the director of the renowned Deutsche Journalistenschule (German School of Journalism) were able to offer multi-perspective answers to these questions on the dialog platform of the Academy. —



**Privatdozent Dr. Marc-Denis Weitze**

Head of Communication/Society, German Academy of Science and Engineering (acatech); teaches at the Oskar-von-Miller Chair of Science Communication, TUM

#### Literature

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## Conclusion

Impulse papers giving political advice, some of them produced at very short notice, were able to stimulate discussion in politics and society on how to deal with the COVID crisis. It then became apparent that science-based political advice is less about communicating the latest findings in virology or epidemiology, but rather about highlighting the implications of the crisis and possible options for action for the economy, politics and society on the basis of analyses of the relevant scientific disciplines and stakeholders.

# Science Communication

## More Important than Ever in Corona and Post-Corona Times

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**When, on 17 April 2020, two American astronauts and one Russian cosmonaut returned safely from their stay at the International Space Station to Kazakhstan they found a planet that had been fundamentally altered by the coronavirus pandemic. The concern grew that the next Soyuz crew with the American astronaut Chris Cassidy on board could have contracted the virus from the now deceased from COVID-19 chief of the Russian Human Space Flight Program at the traditional farewell celebration. Such a case was unprecedented.**

This example shows how far-reaching the consequences of a pandemic can be if it is not limited to the earth's crust, but could even have effects in close orbit. The COVID crisis has made it clear to the public as never before how important scientific research and the implementation of the latest scientific findings are in these times. Only an understanding of the biomedical basics enables the identification of ill persons and the initiation of preventive measures. Thus it was possible, for example, by sequencing the viral genome, to establish in record time test capacities using the PCR method. On this basis, it is possible to take measures to halt the spread of the pandemic. Similarly, only an increase of research efforts will facilitate to develop treatments and a vaccine for prevention.

The history of technology teaches how important scientific progress is for the well-being of a society. Science and technology communication enables broad sections of the population to understand and participate in social discourse. Thus it is a prerequisite for participation in the democratic process and contributes to a prosperous social coexistence. In addition to media support for current research, this requires formats and locations for sustainable science communication. Central places of personal exchange such as museums are ideal for this purpose, because they enable an understanding of established scientific principles and the presentation of historical processes allows options for future action to be identified. In order to enable as many people as possible to participate in scientific progress, Oskar von Miller, together with Walter von Dyk, then Rector of the Technical University of Munich, and Carl von Linde, the inventor of the refrigeration machine, founded the Deutsches Museum more than 100 years ago as a place of communication regarding science and technology in society. Nearly 100 million visitors have so far been able to learn about the basics of the natural sciences and the discoveries and inventions of researchers and developers and their market implementation in products. This has a model character for the further life of many young visitors and is therefore at the beginning of the value chain.

With regard to the COVID pandemic, for example, the historical accounts in the Department of Pharmacy show how research has moved from the unknown causes of the medieval plague, through the tragedy of the Spanish flu, to the knowledge of today's molecular biology and medical vaccine development. It is with astonishment that one must realize how a virus, as the most primitive form of life, then and still today in the coronavirus pandemic, is affecting us humans, the most highly developed form of life. Therefore it is worthwhile to want to understand the interconnections of nature with enthusiasm.

If one considers how extensive and timely the reporting of scientific findings in times of COVID is, one could interpret the resulting gain in knowledge for the general public as a collateral gain of the pandemic, so to speak; but at the same time one has to take note of the phenomenon that a growing number of people are developing their very own theories of the causes and handling of the pandemic, which are not based on scientific findings and evidence-based medical research. The public debate in the area of conflict between personal freedom, legitimate economic interests and the prevention principle for general health is becoming more heated. In a democratic society this is true to a certain extent. However, it is disturbing to what extent a significant proportion of citizens distrust scientific knowledge and question it as a basis for socio-political decisions. As if the immense successes of the scientific method, especially of medical research to improve the human life situation of the last 100 years, had not existed. What could be the reasons for this and how should the scientific community, and in particular science communication, respond?

**In principle, a much broader understanding of science in our society is needed. It is necessary to communicate the latest research results on a daily basis. However, the COVID pandemic makes it clear to us that this is far from enough. ▶**

## In the future, science communication must focus on two thematic fields:

On the one hand there is the question for the tolerable level of scientific complexity which can still be communicated reasonably and does not create more confusion than it helps to enlighten. A perpetual problem of any science communication is therefore the question how much detailed knowledge should be communicated and to which degree it is legitimate and – depending on the audience – necessary to generalize. Furthermore, every scientist who communicates and every journalist who reports on science should be aware that they are not only reporting on objectively established facts but that their selection of facts alone creates facts. Moreover, there is a risk that statements are reproduced truncated and can thus have contrary effects to the intended communication.

How much detailed understanding is actually required to be able to make political decisions on the basis of scientific advice? A current example is the momentous discussion about the behavioral restrictions associated with the R reproduction number. Most people can't make anything of the fact that R is a fit parameter for simulating a mathematical curve based on an experimentally collected database (with all the statistical uncertainties). So the simple explanation commonly given that this figure indicates how many people are on average infected by one infected person, together with the request to keep it at about 1, is better understandable. However, problems arise when someone wants to understand exactly how it is related to the theoretical infection rate without medical measures of about 66% of the population, assuming that one infected person infects 3 people on average and the reproduction rate should be reduced to 1 (i.e. 66% reduction).

### Here is another example in this context:

How can it be simply understood that one square meter of surface can be covered with comparatively only one micro-droplet of viral molecules, while an exhaled aerosol contains billions of them, and what can be deduced from this in terms of hygienic measures and infection prevention? Therefore, science communication on an equal footing involves to evaluate which level of detail furthers the understanding of the whole. To convey the essence of things therefore requires a balance between the complexity of the problem and the

counterpart's ability to understand. The following statement is attributed to Albert Einstein: "Make everything as simple as possible, but not simpler."

On the other hand, the scientific method of how to turn uncertain knowledge into scientific progress should be better communicated. The scientific-objective view of the world is not the only one, and the researcher not only an uninvolved observer of objective reality, because every experiment and every communication of knowledge involves interpretation. This is most evident in the world of quantum mechanics, where every measurement is an intervention in reality. Interpretation and embedding in a theory are far from neutral. The theory of gravity can describe how a stone falls to the ground, but no law of nature can describe the consequences that society draws from it. In science, controversies are part of the methodological toolkit, so there is no direct link between scientific knowledge and measures to be taken. In the current COVID situation, this begins with the discussion about the correct determination of the figures and continues to the disagreement about what measures should be derived from this.

Scientific progress in knowledge is based on the possibility of falsification. New findings can revise yesterday's knowledge every day. This is not a weakness but the strength of the science system. Measurements are nature's answer to the experimenter's question, and as soon as they are available, they are embedded in a theory that can be discussed controversially, with different consequences for practical action. Even in a deterministic system, the surrounding conditions, the initial states – if they can be completely determined at all – are decisive for a result that can turn out surprisingly different with the smallest variations. However, communicating this fact has not been as successful as it should have been so far. It is the mission of a new kind of science communication to convey the need to deal with uncertain knowledge and still have to act politically. It facilitates participation in the latest findings, but also the evaluation of options for action, so that in the future, our society can react even better to challenges like the coronavirus pandemic. ┘

┘ Furthermore, every scientist who communicates and every journalist who reports on science, should be aware that they are not only reporting on objectively established facts but that their selection of facts alone creates facts.



**Professor Dr. Wolfgang M. Heckl**  
Director General of the Deutsches Museum;  
Professor for Science Communication,  
Oskar von Miller Chair, TUM

**Literature**  
Marc-Denis Weitze und Wolfgang M. Heckl,  
*Wissenschaftskommunikation, Schlüsselideen,*  
*Akteure, Fallbeispiele*, Springer Verlag, 2016

03

# FUNDA MENTAL RE SEARCH



# The Importance of Fundamental Research in Times of Corona

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**Fundamental scientific research frequently doesn't get the wide publicity that it deserves. The benefits of fundamental research are unclear to lots of people. Sufficient investment in fundamental research is of inestimable value, as it plays a decisive role in overcoming our problems, and not just in the field of medicine.**

The current pandemic, caused by the SARS-CoV-2 coronavirus, clearly demonstrates how essential fundamental research is to fighting and overcoming it. This includes the detailed analysis of the basic properties of the virus, the development of safe testing procedures for identifying infections, the diagnosis of the progression of the disease, and, of course, the development of effective medicines and vaccines. Basic insights from the fields of physics, chemistry, biochemistry and many other disciplines play a decisive role in this. The development of the methods available today was always achieved in cooperation with a large variety of insights gained from fundamental research. You'll find a few examples of this below.

## Clarification of the structure of the virus

Many fundamental discoveries made more than 100 years ago are the basis for the latest measuring instruments, which today allow us to analyze the structure of biomolecules in detail. This includes X-ray structural analysis, which played a significant role in decoding the DNA molecule in 1953, as well as, nuclear magnetic resonance spectroscopy, which is based on the knowledge – gained in the 1920s – that, in addition to their basic properties of mass and charge, electrons and protons also have a magnetic moment – the spin, and of course electron microscopy, which today can map molecules with atomic resolution, and whose foundations were being developed as early as the 1920s. The development of the corresponding analytical instruments is based on several hundred, sometimes even a few thousand results from fundamental research, which has frequently been awarded with Nobel Prizes over the past 100 years. All these methods are now making significant contributions to the detailed analysis of the structure of the SARS-CoV-2 virus. To name just one example: In February this year, the synchrotron radiation source BESSY II in Berlin managed to decode the structure of the main protease of the virus, which is involved in its multiplication.<sup>1</sup> Knowledge of the spatial structure is critically important to finding active agents to block the protease.

## Virus genome

The double-helix structure of the DNA molecule was decoded nearly 70 years ago with the help of X-ray diffraction. This was the foundation for gene research and, together with many other discoveries, ultimately lead to the development of techniques for DNA sequencing, i.e. reading nucleotide sequences in DNA molecules. Thanks to the further development of modern so-called "next generation sequencing" (NGS) procedures, the genome of the SARS-CoV-2 virus was decoded very quickly. As a result, the special properties of this strain of coronavirus were known to scientists throughout the world shortly after the appearance of the virus. This knowledge is the basis for quick diagnosis and the development of drugs and vaccines.

## Medical diagnosis

Sensitive test methods for identifying infected people rely on fundamental molecular research. Approx. 50 years ago, biochemists discovered enzymatically-active proteins, so-called "reverse transcriptases". These proteins are able to transcribe genetic information from single-strand RNA molecules as double-strand DNA molecules. The method developed from this is reverse transcription together with polymerase chain reaction (RT-PCR). The conversion of viral RNA strands into DNA enables the molecules to be replicated and thus enables sensitive detection. The SARS-CoV-2 virus genome sequence determined by the NGS is the basis for this identification procedure.

Computer tomography (CT) is an indispensable, high-resolution imaging process in medicine. This modern method of diagnosis is also based on a large number of fundamental research results stemming from the discovery of X-ray radiation at the end of the 19<sup>th</sup> century by Wilhelm Conrad Röntgen. The absorption of the X-ray radiation is measured from many directions and used to reconstruct the three-dimensional structure with a computer. That means that pathological changes in the lungs caused by COVID-19, for example, can be made visible in spatial resolution. The X-raying process is continuously being developed. As an example, a new process is being tested at the Technical University of Munich which exploits scattering, unlike the attenuation of X-rays.<sup>2</sup> The scattering is particularly strong on interfaces and supplies complementary information for investigations of lungs damaged by COVID-19 in comparison to usual processes. ►

## Computer simulation, data analysis

The development of high-performance computers in use today to carry out complex modelling and process huge amounts of data are based on the understanding of the electronic properties of solids, which was developed in the first half of the 20<sup>th</sup> century. The fundamental understanding of semi-conductive, metallic and insulating materials lead to the development of transistors and integrated circuitry in the 1950s, which, together with many thousands of other discoveries and inventions, enabled the realization of modern, high-performance computers. Algorithms and methods of calculation were also developed which today make it possible to model and simulate highly complex processes in precise detail. These methods are applied to a wide variety of problems associated with COVID-19 and the coronavirus epidemic. Some of the problems are so complex that they push the limits of even our most high-performance computers. Fundamental research is currently working on quantum computers which may be able to work on these complex issues more efficiently and provide solutions for fighting the coronavirus pandemic.

There are many other important processes which are all based on many years of fundamental research. Scientists from a variety of subject areas use these methods to better understand the virus and the disease, to reduce or stop its spread and to develop medication and vaccines in a targeted way. Intensive research is being carried out worldwide to better understand the pathogen and its effects on people and society. International and interdisciplinary collaboration is crucial for the success of this research. This type of problem-oriented research is now receiving a lot of public attention in the context of the coronavirus pandemic. It is largely recognized how important research is for our health and for the future of our society. This also applies to all the other big problems facing mankind, be that climate change, energy provision, nutrition, and much more. However, these problems are not as immediately noticeable as the effects of the current coronavirus pandemic.

It is therefore to be feared that once this pandemic is over, everything will go back to normal. At least there is still hope that the current health crisis will help the majority of the population realize how important research is and that the knowledge gained from it should be the basis for any decisions. Money invested in science and research is money well invested, even if the fruits can often only be harvested much later. ─



**Professor Dr. Gerhard Abstreiter**

TUM Senior Excellence Faculty;  
Leibniz Prize (1987);  
Stern-Gerlach Medal of the German  
Physical Society (2014);  
Former Director of the TUM Institute  
for Advanced Study (IAS);  
Professor for Experimental  
Semiconductor Physics at the TUM

1. **"Das Coronavirus und seine Ausbreitung erforschen"**, Physik Journal, Deutsche Physikalische Gesellschaft, May 2020, page 6

2. <https://www.tum.de/nc/die-tum/aktuelles/pressemitteilungen/details/36030/>

International and interdisciplinary collaboration is crucial for the success of this research. This type of problem-oriented research is now receiving a lot of public attention in the context of the coronavirus pandemic.

# Fundamental Research from the Perspective of Biology and Medicine

## The COVID-19 epidemic bears many similarities to influenza (flu) epidemics, with the important difference that people have not yet developed defense mechanisms against the SARS-CoV-2 virus.

The common feature of both infections is that they are more severe in people aged 60 or older and that the death rate increases strongly after the age of 80. This is explained by a weakened immune system at old age and the increasing frequency of chronic pre-existing conditions. Vaccination with a vaccine adjusted every year is recommended as basic prevention for influenza. This measure is likely to reduce mortality in older people, although there are no critical, meaningful clinical studies for this assumption. The high mortality rate in older people has not yet been eliminated as flu jabs result in a decreasingly effective immune response with increasing age. At present, new vaccines against Covid-19 are introduced, but no curative drug therapy is available. This unsatisfactory state can only be remedied through enhanced fundamental biological and medical research. A two-track approach should be adopted in which both biological fundamental research and clinical applications are supported. It should be noted that there is a need for both short-term and long-term research. The following issues should be prioritized:

### A) Why is the immune system weakened in older people?

The promotion of fundamental biological research should be increased. Research into the immune system should be the initial focus:

- ▶ How do we develop immunity against the SARS-CoV-2 virus?
- ▶ How do we prove immune status? How does humoral and/or cellular immunity develop?
- ▶ Are neutralizing antibodies formed if someone is infected naturally? How long do they remain and how can they be detected?
- ▶ Are the available vaccines effective? How long lasts the protection against the infection?

Long-term research should address the question: Why does the immune system react more weakly in old age? There are a whole range of explanations for this, e.g. reduced regenerative capacity of immune cell progenitors in bone marrow, loss of a functional thymus and reduced hypermutation of antibody genes in the B cells. These changes can begin as early as the

middle of the 20<sup>th</sup> year of one's life and become relevant to diseases from the age of 50. The currently relatively unilateral commitment to investigating the interaction of the immune system with the development of cancer also helps with this question in part but will only be of limited use for research into the causes of infections in old age. In addition to a better understanding of the immune system, research into the biological foundations of life needs to be better funded. We don't know which microorganisms/pollutants will threaten us in the future.

Viruses need an entry point into host cells to multiply. A good example of this is the docking and entry point of the SARS-CoV-2 virus: the Angiotensin II Converting Enzyme 2 (ACE-2) on the cell surface. Up to this point, this enzyme has been of no interest when it comes to research and was more a curious by-product of the research into the metabolism of angiotensinogen, the precursor to angiotensin II, which plays a key role in the occurrence and treatment of high blood pressure. However, the knowledge published about ACE-2 is now proving to be extremely important, as it is not only enhancing our understanding of how the SARS-CoV-2 virus interacts with the body, but it has also fundamentally shaped our understanding of COVID-19. This "niche research" also facilitated the production of soluble parts of the ACE-2 enzyme, which is currently being tested as a harmless "virus catcher" in treating COVID-19 infections. Other examples of the significance of this "niche research" are the "entry" inhibitor Camostat, an inhibitor for the protease TMPRSS2 and approved for treating pancreatitis, Favipiravir, an inhibitor of the viral inhibitor RNA-dependent RNA polymerase and approved as emergency treatment for influenza, and the nucleotide analogue Remdesivir, which was tested during the Ebola pandemic.

The threatening appearance of the current SARS-CoV-2 pandemic shows that more general, diverse biological and medical fundamental research should be promoted. A broad understanding of the regulation of the human body is essential for facing the imponderables of the future.

### B) What treatments can be developed to combat it?

The current treatment of COVID-19 follows the existing guidelines for treating Severe Acute Respiratory Syndromes (SARS). These guidelines are not bad; however, they primarily describe measures for stopping occurrences of infection and ensuring the body is provided sufficient oxygen. So long as patients can develop effective infection defenses themselves, they can be helped. However, we only have limited knowledge of how we can stimulate infection defenses in a targeted way, or how to

limit them in the event of excessive cytokines being released. Initial approaches indicate that the use of tocilizumab, an antibody against the interleukin-6 receptor (IL-6), may be helpful in the event of severe pneumonia. However, recent clinical studies showed that tocilizumab does not improve the disease in severe pneumonia, whereas dexamethasone, a glucocorticoid, reduced the mortality in patients with severe COVID-19, who required oxygen support. There are no clinical studies investigating how we can strengthen the immune system in a targeted way in old age.

While expensive studies on immunological cancer control are financed, clinical studies investigating treatments for other diseases are underfinanced because there is a broad general interest in them only during an epidemic. The funding of projects researching infection immunology is particularly poor as the majority of funding in this field goes to research into new antibiotics against resistant germs. The effectiveness of the targeted funding of research projects is demonstrated very well by the funding of research into the HIV epidemic. Enormous sums were spent on understanding the course of the disease and on new virostatic agents against this disease. The successes are convincing. The COVID-19 pandemic could also be overcome with similar resources.

The limited funding for clinical studies outside of the field of oncology must be changed in the long term. It is important to focus on the altered immune reaction of aging patients in particular. The currently favored hope of facilitating a better life for elderly people through "artificial intelligence systems (AIS)" could turn out to be wrong as a life focused on better service will not change the underlying mechanisms. Part of the resources provided for AIS should go to clinical studies. ─



**Professor Dr. Franz Hofmann**  
TUM Senior Excellence Faculty;  
Max Planck Research Prize (2002);  
Professor for Pharmacology and  
Toxicology, TUM

# Mathematics and Statistics: Making the Invisible Visible

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Even before the coronavirus crisis, we had the feeling that we were in a period of transition. Worldwide networking and interaction are increasing due to globalization. We live in a pluralistic world in which there are many competing ideals and interests influencing each other. Wherever we look, we find evolution, diversification and instabilities leading to increasingly complex organizational structures, organizational forms and technical achievements. We cannot predict what our world will look like after the coronavirus crisis. But, starting with digitalization, change is likely to accelerate.

This forces us to consider, more seriously than ever, the aims and measures by which we wish to shape the transition into the future. It's clear that science in general, and mathematics and statistics in particular, are becoming increasingly important to our efforts to cope with current and future challenges.

Mathematics is one of the oldest sciences. It developed from the investigation of geometric shapes and arithmetic with numbers. It is based on the fundamentals of logic and deals with shapes and patterns (in the broadest sense) and with order in the sense of structures and rules according to which patterns are constructed and formed. It has been dealing with that kind of issues of varying complexity for thousands of years, and usually finds precise and clear answers. One important aim of mathematics is to systematically figure out relations between various, sometimes very abstract, patterns. Patterns often become visible this way only. We live in a universe full of patterns. However, they are sometimes so subtle that they do not become visible without mathematics. Ultimately, mathematics deals with the real world, the world in which we live. The abstract items mathematicians deal with can be thought of as a type of "skeleton" of things and phenomena of our world. Mathematicians consider a specific aspect of an object of investigation and leave aside all special features. They investigate the purely abstract skeleton. Especially in a world becoming increasingly complex, it is often in abstraction only, that a solution can be found for an issue or problem. This makes it possible to distinguish the important from the unimportant and makes the core of a problem apparent. Furthermore, abstraction occasionally makes similarities between two phenomena apparent, when at first glance the phenomena would appear to have absolutely nothing to do with each other. You can think of mathematics as a kind of glasses which we use to be able to see things that would otherwise be invisible – sort of like a mental equivalent to an X-ray unit.

To mention a few specific techniques: Small variations can be made visible using differential calculus, which goes back to Newton and Leibniz. Among other things, this technique can be used to determine an optimal value for a specified quantity, which varies depending on certain parameters. Corresponding newer mathematical concepts even allow for systematically finding a "fair" compromise in the sense of suboptimal values for several, non-independently varying quantities. For instance, if there is a so-called Pareto optimum, then none of the suboptimal values can be improved – even by a minimal amount – without worsening at least one of the others. Conflicts between various objectives are constantly occurring – just look at the drawbacks which various coronavirus countermeasures suffer from. By making visible any small temporal and/or spatial variations using differential equations, it is further possible to mathematically model numerous systems and processes in the real world in order to study them and to predict their behavior. In particular, for parameters, threshold values can be determined where the behavior changes qualitatively. A big advantage of mathematical models is that you can reduce them step by step using mathematical methods, meaning that important aspects of their behavior are maintained and come to light successively. Today, computers make it possible to advance to ►

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You can think of mathematics as a kind of glasses which we use to be able to see things that would otherwise be invisible.

completely new dimensions. You can now work out solutions within a short period of time wherefore you would have needed weeks or months before. You can analyze large collections of data and make them usable for insights or forecasts. Computer simulations make complex shapes and patterns visible for everyone. It's important, though, to understand why something happens and is correct, and not just to be told by a computer or algorithm that something is the case. Thanks to the application of non-linear mathematics, for instance, it's been known since the 1960s that highly irregular dynamical evolution and high sensitivity to the smallest modifications of the initial conditions may occur in the long-run – even in the case of deterministic processes, whose temporal development (dynamics) is exactly determined by the initial conditions in accordance with the causality principle. This is expressed by the term known as the butterfly effect: A butterfly flapping its wings in Australia can cause a hurricane in Europe a short time later. Or, in other words: Small events can give rise to big effects. Considering the errors which are always inherent in models, measurements or the collection of real data, it makes the long-term prediction of the specific temporal behavior of corresponding systems based on such data difficult, even by means of powerful computers. However, the theory of non-linear dynamics enables one to identify special patterns, e.g. using fractals, and to make a certain order apparent in the behavior of systems which at first glance seem to be ruled by arbitrariness and formlessness – i.e. chaos. Chaos in this sense is ubiquitous, starting with the weather and the dynamics of our solar system through to the dynamics of populations or entire ecosystems.

As soon as you understand how a system works, you no longer have to remain a passive observer. You can try to control or regulate the system and to get it to do what you want it to. This is used for the efficient control of many technical processes and devices, including space probes, and for the control of natural processes such as the spreading of the coronavirus. Indeed, the growth rate of the number of infected individuals over time has been pushed down to manageable levels in many of the countries affected by the COVID-19 pandemic through quarantine and social isolation measures. It's to be appreciated that politics has consistently followed the advice of science or rather virologists in those countries, despite the drastic consequences such measures have. You cannot negotiate with a virus. If a population in which almost no one is immune is seized by a viral epidemic and no measures are taken against population mixing or to protect against infection, then the number of infected individuals will grow exponentially fast for a while. That is (mathematically) secure knowledge. Analogous to, for example, the movement of individual planets around the sun, this is a deterministic process, which can be described and predicted using relatively simple mathematical models.

More recent branches of mathematics also include statistics, an offshoot of probability theory. Roughly speaking, it deals with the mathematics of uncertainty. It is a frequently misunderstood and misused branch of mathematics. Used correctly, though, it can make significant contributions to the prosperity of human society. Astonishingly, one can also find mathematical patterns for random events. They appear in statistical quantities such

as mean or average values or long-term trends. Their predictions concern the probability that an event will or won't occur. They help to draw significant conclusions from a limited, sufficiently comprehensive dataset instead of making arguments using apparent patterns arising from random correlations. Projections can often predict election results with astonishing precision, and clinical trials can prove the efficacy or safety of treatments and medication. In addition to deterministic processes, we also have to accept stochastic processes in order to master uncertainties and growing complexities in the modern world. In contrast to deterministic processes, their temporal and spatial behavior not only depends on the initial conditions but also is influenced by random factors. Insurance companies calculate the expected extent of damage using statistical mathematical models and fix their premiums accordingly. By banks and investors, models of that type are used as a basis for assessing investment risks. Regarding COVID-19, statistics for instance helps to answer questions such as: What is the probability of a larger outbreak in a relatively small community? How should general intervention strategies be adjusted to local circumstances?

There were more developments in mathematics in the 20<sup>th</sup> century than ever before, and this tendency continued into the 21<sup>st</sup> century. Mathematics is well-equipped to deal with the challenges of the post-coronavirus age. It is more in demand than ever: The semiconductor and automotive industries, materials science, the design and operation of high-speed networks, artificial intelligence, robotics, medical and genetic engineering as well as environmental protection and climate change mitigation are just a few areas of application. Mathematics can be used universally. The problems and phenomena of the real world can be translated into the language of mathematics, thus making a solution accessible using mathematical methods. Today, mathematics is used successfully in nearly every field, and not just in traditionally related subjects like physics, engineering and computer science. It can be used as a problem-solving tool across disciplines. Core competencies in the classic fields alone are often insufficient to make relevant progress in complex situations. In such cases, experts from many scientific disciplines, including various branches of mathematics, must be brought together to collaborate in interdisciplinary groups of researchers more frequently. Interdisciplinary collaboration is also necessary when it comes to fighting viral epidemics. Let's hope that politics continues to take scientific advice seriously. Skepticism towards science is counterproductive. ┘



**Professor Dr. Jürgen Scheurle**  
TUM Senior Excellence Faculty;  
Founding Director of the Center of  
Mathematics, TUM;  
Professor for Advanced Mathematics  
and Analytical Mechanics, TUM

┘ Considering the enormous complexity of the social challenges to be overcome, reliable scientific measures are essential as foundations for making expedient, responsible decisions.

# The Power of Mathematical Models in the Light of Natural Reality

What are mathematical models and how do such descriptions of nature make it possible to predict specific phenomena in terms of concrete numbers that can be verified experimentally? First and foremost, it should be clear that only mathematics allows for a quantitative description of nature. Nevertheless that clarifies neither what a mathematical model is, nor its explanatory power. To this end, we will analyze two examples of the mathematization of natural reality: Newton's ubiquitously present second law and the SIR model of epidemiology as the simplest mathematical description of the COVID-19 pandemic.

Isaac Newton formulated his laws in 1687. (For background information, see the classical work of Dijksterhuis<sup>1</sup>.) Newton's second law – commonly known as “force equals mass times acceleration” – describes how a particle with mass  $m$  and velocity  $\mathbf{v}$  moves in 3 dimensions under the influence of a force  $\mathbf{F}$ . Several insights were gained thanks to Newton's attempts to grasp a phenomenon of nature mathematically. Firstly: Force  $\mathbf{F} = (F_1, F_2, F_3)$ , like  $\mathbf{v}$ , is a vector with 3 components as the space in which we live has 3 dimensions.

Now we need a totally new concept, a core concept, momentum  $\mathbf{p} = m \mathbf{v}$ , which took physics two millennia to discover<sup>1</sup>. It was Simon Stevin (1548–1620) who discovered – almost a century before Newton – the importance of momentum in his collision experiments on a frictionless table: The total momentum is conserved. That means that for two disks with momentum  $\mathbf{p}_1$  the sum  $\mathbf{p}_1 + \mathbf{p}_2$  remains constant before and after the collision.

Imagine you are an observer around 1600. Along comes Stevin who joyfully tells that total momentum is conserved in collision experiments. You would turn up your nose and ask yourself: What does this nonsense mean? Mass  $m$  has dimension kg and now I need to multiply  $m$  by a weird vector of dimension m/s in order to get the momentum  $\mathbf{p} = m \mathbf{v}$ . Then along comes Newton in 1687 who gives the whole thing a meaning by posing  $\mathbf{F} = d\mathbf{p}/dt$ , Newton's second law, where (à la Leibniz)  $d/dt$  means differentiation with respect to the time  $t$ , a new mathematical idea he came up independently of Leibniz.

$\mathbf{F} = d\mathbf{p}/dt$  is what most people know but need not have seen yet because for a particle with mass  $m$ , position vector  $\mathbf{x} = \mathbf{x}(t)$ , where  $\mathbf{x}$  generally depends on the time  $t$ , and velocity vector  $\mathbf{v} = d\mathbf{x}/dt$ , we get  $\mathbf{F} = d\mathbf{p}/dt = m d\mathbf{v}/dt$ , mass times acceleration, as  $\mathbf{p} = m \mathbf{v}$  and  $m$  is constant. Newton's second law is a universally applicable law of nature.

It is worth noting that, simply put,  $\mathbf{F} = d\mathbf{p}/dt$  describes the change in momentum  $\mathbf{p}$  under the influence of force  $\mathbf{F}$  over time. Mathematics allows us to solve the differential equation  $\mathbf{F} = d\mathbf{p}/dt$ ; rarely explicitly, but always numerically. The equation  $\mathbf{F} = d\mathbf{p}/dt$  immediately explains the conservation of momentum as Newton also postulated his third law: *actio = -reactio* during collisions. The sum of all forces on and in the plane of the (frictionless) table therefore = 0 so, that  $d(\mathbf{p}_1 + \mathbf{p}_2)/dt = 0$  and  $\mathbf{p}_1 + \mathbf{p}_2$  is conserved. Done.

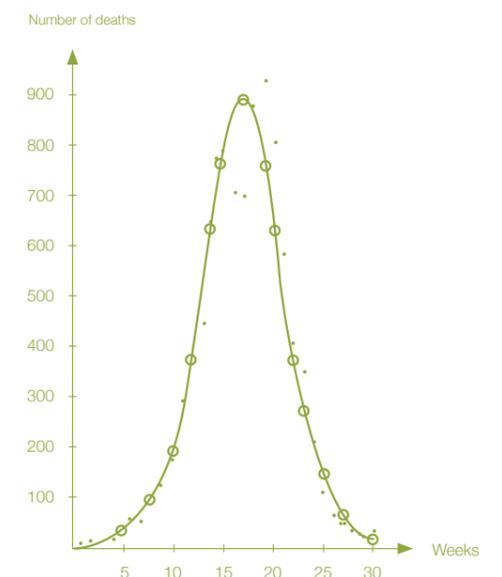
In summary, Newton discovered the importance of the core concept of momentum to mathematically describe the time evolution  $\mathbf{F} = d\mathbf{p}/dt$  of momentum  $\mathbf{p}$  under the influence of a force  $\mathbf{F}$ . It could hardly be simpler and more natural once one had the “right” terms available, but can Newton's laws be derived? The simple answer is no. Thus, one of the two main theses of this short essay is<sup>2,3</sup>: We need suitable core concepts to mathematically describe natural phenomena. The second thesis is<sup>2,3</sup>: Laws of nature are only applicable on a certain scale in space and time. That is the scaling hypothesis. For example, Newton's laws are only applicable on a macroscopic scale, but not on an atomic scale. That is where quantum mechanics

holds. And, on an even smaller scale, there is quantum field theory for elementary particles.

For neurobiology, for example, it could also be shown<sup>3</sup> that mathematization or, if you like, quantification depends on suitable core concepts and that laws only hold on specific scales. Many of these laws and their mathematical formulations are fundamental, which means that they cannot be derived. Rather they have to be postulated, which then allows for a detailed quantitative description that ensues from the fundamental laws. Anyone driving over a bridge assumes that it will hold. This is exactly what a mathematical description does. The fact that humans make mistakes doesn't call the validity of laws of nature into question. However, core concepts need to be discovered, which can take a while; like the two millennia it took for Newton's second law.

The relevance of a mathematical description of natural reality comes about clearly when predicting the time evolution of natural phenomena such as epidemics and pandemics. We will therefore turn to the SIR model, one of the most famous epidemiological models, published by Kermack & McKendrick in 1927 (Proc R Soc Lond A **115**: 700–721). They tested their brilliantly presented theory with the time course of the 1906 plague in Bombay (Mumbai since 1995); cf. their equally famous fit in the figure below.

The plot is typical. Certain inaccuracies and delays in data transfer at the time should not be disregarded. The epidemic passed “spontaneously”, but politics can change the parameters ( $a$  &  $r$ ) over time and usually does so with clear success if the population – scale of the theory – sticks to life-saving restrictions. ►



**Fig. 1:** Kermack & McKendrick's 1927 fitted death rate values (vertical, per week; this is  $dR/dt$  below) in the 1906 plague in Bombay; the death rate was over 90%. Open circles are the fit. Dots are the original data points.

The SIR model is based on three variables:  $S$  as the number of those vulnerable to the disease (Susceptibles),  $I$  as the number of those who have fallen ill (Infected) and are infective over a finite period ( $1/a$ ), and  $R$  (Removed) as those removed from the pool since they are no longer infectious (immune or dead). Accordingly, this approach gives us three equations,

$$dS/dt = -r IS, \quad dI/dt = -a I + r IS, \quad dR/dt = +a I.$$

The contact term  $\pm r IS$  is an analog of the chemical mass action law. As  $d(S + I + R)/dt = 0$ , the total number ( $S + I + R$ ) does not change, as it should. The SIR model has been verified extensively. If we rewrite the middle term,  $dI/dt = I(-a + rS)$ , we see that as long as  $(-a + rS) < 0$ ,  $dI/dt < 0$  is valid and  $I$  shall decrease. We call  $S_0 = a/r$  the threshold because if  $S < S_0$  is true,  $(-a + rS) < 0$  remains true and  $I$  decreases. If, on the other hand,  $S > S_0$  holds,  $I$  will continue to increase, often even exponentially, until a maximum is reached, and we get an epidemic or, even worse, a pandemic like COVID-19. Kermack & McKendrick, as shown above, demonstrated the typical curve in 1927. The (universally applicable) threshold theorem of epidemiology contains the threshold  $S_0$  and has already been formulated above. One can expand the SIR model significantly<sup>4</sup> or consider that the infected may not actually become immune. At the moment, it's still up in the air whether COVID-19 can be immunized against for a longer period of time. Otherwise, vaccination is as against the flu or one ends up with the SIS model<sup>4</sup>, but the basic  $\{S\} \rightarrow \{I\} \rightarrow \{R\}$  idea does not change. However, SIS is a cyclical model  $\{S\} \rightarrow \{I\} \rightarrow \{S\}$ . An example is meningitis, which is rare and less infectious. Importantly, one can now run through alternatives; see for instance <http://covidsim.eu/>

What is the point in understanding the world we live in through mathematical models? This question can now be answered succinctly in the context of the coronavirus pandemic. Mathematization allows us to see, clearly and precisely, that the threshold  $S_0 = a/r$  should be as large as possible so that  $I$  is always decreasing instead of increasing. Political objective: Keep the contact rate  $r$  as low as possible and the inverse infection time  $a$  as large as possible. To put it plainly: Reduce contacts and isolate the infected as soon as possible. The former implies “lockdown” – and if regulations are relaxed again, that means test, test, test in order to keep  $a$  as large as possible or  $1/a$  as low as possible.

Isolating the infected as soon as possible may mean minimizing effective contact rates by using a tracing app. As it has turned out that SIR-type models portray reality quite well, the categories  $\{S\}$ ,  $\{I\}$  and  $\{R\}$  are the core concepts allowing mathematical description. They give us a quantitative view of the future and show us that politics acting without vaccination can create an unstable equilibrium at best.

Now for the good news: The threshold theorem of epidemiology also shows that small errors are allowed as long as  $S < S_0$  remains true. In other words, a couple of infected people won't spoil the broth. This also means that a vaccine, if one exists, “only” needs to immunize a sufficiently large number of those susceptible to the disease, so that  $S < S_0$ . Thus, not everyone must be made immune. For many infectious diseases, e.g. polio, 2/3 of the total population is sufficient. Those not vaccinated may well become ill, but there won't be an epidemic. ─



**Professor Dr. J. Leo van Hemmen**  
TUM Senior Excellence Faculty;  
Professor of Theoretical  
Biophysics, TUM

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4. N. F. Britton: *Essential mathematical biology*. Berlin: Springer 2003; Ch. 3

What is the point in understanding the world we live in through mathematical models? This question can be answered succinctly in the context of the coronavirus pandemic. Mathematization allows us to see, clearly and precisely, that the threshold  $S_0 = a/r$  should be as large as possible so that as long as  $S < S_0$  the number  $I$  of infectives is always decreasing instead of increasing. Political objective: Keep the contact rate  $r$  as low as possible and the inverse infection time  $a$  as large as possible. To put it plainly: Reduce contacts and isolate the infected as soon as possible. The former implies “lockdown” – and if regulations are relaxed again, that means test, test, test in order to keep the mean infection time as low as possible, and... vaccinate.

# Promoting Research, Organizing Cooperation

## No Different after Corona than Before?

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**The lives of scientists – how could it be any different – have changed as dramatically as the whole of society in the last few months. I’ve taken the liberty below of providing some thoughts from the personal perspective of an “applied theoretician”, between engineering and computer science, and with lots of references to natural science. For all my subjectivity, I believe that my experiences are not significantly different from those in many other scientific fields.**

### At first glance, we can see the drama in our diaries:

What has not been cancelled in the months since the beginning of the “shutdown”? If you take a look at the Chair, your head will spin when you see the research-related activities (we aren’t looking at academic teaching here, although it is equally important!) which are not taking place, or at least aren’t taking place as planned. This isn’t just the case for the period of the toughest contact restrictions; it’s often also the case well into next year. Dozens of conferences and workshops are cancelled, umpteen review meetings at home and abroad are not happening, lab visits to partner institutions have been delayed for doctoral students, external meetings for appeals committees, doctoral examinations at other universities, committee meetings at the DFG, EU audits, guest invitations for awards ceremonies, academic department meetings and trips to prepare for new research collaborations have all been cancelled. And that’s to say nothing of the cancelled meetings at our own university!

On the other hand, haven’t we also discovered that crisis management via digital media and, to a significant degree, real collaboration in research are possible even under restricted mobility conditions – and much more so than we could have imagined a few months ago? Online meetings have been an option for years, but one we’ve only used on the rarest of occasions. We’re now finding that online meetings can “function” with 5, 10, 50 or even 100 participants. We’re learning that we need other communication structures which cannot be simply taken on by classic formats. More concentration is required, and the preparation of these meetings can always be improved. Nevertheless, we’re noticing how much we miss non-verbal communication when we’re all sitting in front of a computer screen. How important informal meetings at the coffee machine, at lunch or in front of the conference room are. On the other hand, we’re also often realizing that short online meetings between a few participants are much more efficient than communicating through a flood of emails flying back and

forth asynchronously and without any coordination. So, there are anticipated drawbacks, but there are also newly identified opportunities when it comes to digital communications. The take-away for the post-coronavirus age should be that not every meeting should be held in person by “default”, and that online meetings should at least remain under consideration.

And what’s more, doesn’t the experience of the last few months also show that much is settled simply because it doesn’t take place? Is it really necessary to hold dozens of meetings with similar topics all over the world every year when you often have the same speaker telling a near-identical audience exactly the same thing they’d been told a few weeks prior in a different location? Many of us have rightly bemoaned “conference business” but have nevertheless been unable to escape the compulsion to travel. However, a scientific system that uses the number of lectures, publications and citations as a measure of scientific excellence is hardly balanced. The spate of new journals – some of very dubious quality – are contributing to this imbalance: More is being written than is being read, and fast papers are preferred to scientific thoroughness. This “excessive” production deprives excellent science of the thing that it needs most: **the time to research!** ►

Time gained – maybe that’s what some scientists can say they have gained from this crisis. Time to think without having your next meeting, your next trip, or your next lecture already on your mind. Time to let your mind wander and see things from a totally different perspective. Rediscovering leisure as the foundation of creativity – all of these could be important experiences in the limitations of these extraordinary months.

If we manage to appreciate the value of free time for creative research again, then we should probably also think about what had been so time-consuming beforehand – and how we can organize research “post-coronavirus” so that we don’t lose this value again. There are two characteristics in particular which seem responsible for the fact that our scientific system is time-consuming and thus does not create value to the highest-possible level: the breathlessness of our funding instruments and the overemphasis of control over trust.

Just one example for structural breathlessness: The vast majority of research at our universities is carried out using competitive third-party funds. As much as we appreciate this essential funding, we are very often faced with the problem that doctoral students work on three, four or more research projects until they have finally established the foundations for their dissertation. There is barely time to cover one of these projects in detail. Too much energy is spent on applications, reporting and fine-tuning with partners. Can you really define every milestone in advance? Doesn’t a monthly schedule get in the way of real creativity? Really new things often come about by chance from an apparent mistake. Supposed failures are often the foundations for real scientific breakthroughs. Our scientific system and we as “successful” scientists should give young researchers more freedom to find their own way and break new ground on their own. The DFG still often provides funding for three years, with the option to extend that to five years. The courage to go on for longer and manage details

less should be the norm, even with “departmental research” and industry collaboration! Then the result of some research projects would be “created something new” instead of “target achieved”!

This other model of a framework for research is closely related to the second time-consumer: the excessive desire for control. This control starts with the examination of detailed specifications of criteria – which are often unrelated to the research – in national and international funding applications. A research project won’t become excellent or relevant for society because the right buzzwords are added by professional application writers and the reviewers are able to tick the right boxes! Even industry projects don’t usually achieve a great transfer of knowledge or expertise if the division of intellectual property rights has been negotiated down to the smallest detail in advance by lawyers! The work-life balance of younger researchers certainly won’t improve if – as is likely to be the case in future collective wage agreements – too much or too little working time is ruled out due to time being recorded down to the minute. The vast majority of scientists are – and I am deeply convinced of this – intrinsically motivated by their own work and know best when, where and how to make their research creative. There are examples of the organization of research, especially in cooperation with international partners, based on risk-taking and trust instead of detailed planning and control – the Institute for Advanced Study at TUM is one such example. In a large-scale fellowship program, researchers of the TUM, together with outstanding international partners, are given the necessary time and financial support to explore new areas of research, particularly on the border between the classical disciplines. The key characteristics of this fellowship are that visionary ideas are measures of value, instead of detailed, elaborate work programs. The fellowships are not short-term; they rely on guest scientists staying at TUM for the long-term. The IAS provides a framework for a broad, interdisciplinary

┌  
Really new things  
often come about  
by chance from an  
apparent mistake.

networking in every scientific field at the university, and scientists at every stage of their careers are encouraged to take their research in radically different directions to usual.

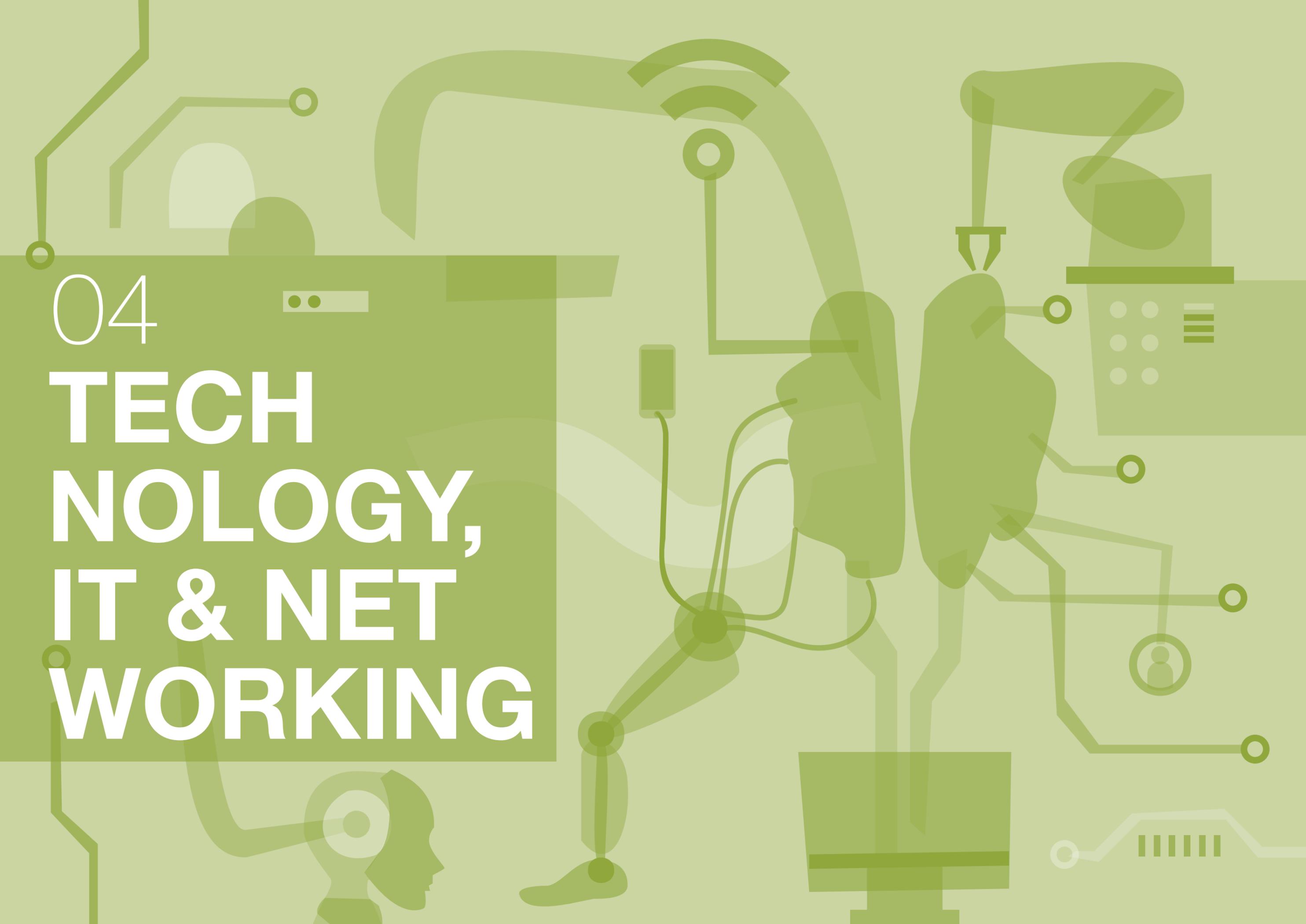
Hence, small-scale control should be replaced by trust – trusting the system, that the best research doesn’t come from framework plans from above, but from the researcher’s own imagination and curiosity. Trust from us “senior scientists” in our colleagues, in our national and international partners and, last but not least, in ourselves, that our enthusiasm for science and free thoughts are the foundation for new knowledge and sustainable scientific advancement. If the time and leisure that some have found in these weeks of shutdown could trigger a rethink of our habits in our working lives and the structure of our research funding systems, then the coronavirus crisis would have a lasting positive effect on science. We’re looking forward to creative hours with our international partners on the piazza or in the beer garden anyway. └



**Professor Dr. Ernst Rank**  
Konrad Zuse Medal (2009);  
Former Director of the TUM  
Institute for Advanced Study (IAS);  
Professor for Computation in  
Engineering, TUM

04

# TECH NOLOGY, IT & NET WORKING



# Biotechnology in Times after Corona

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Right at the beginning of the coronavirus crisis, immediately with the lockdown, discussions started about whether the world and society would ever be the same again. These discussions were not just limited to the negative aspects of the pandemic. The sudden decrease in greenhouse gas emissions has been seen as a positive side effect of the crisis, the overexploitation of our planet's resources seems to have come to a stop because of the globally reduced production capacities and the reduced demand for consumer goods brought about by the restrictions in peoples' ways of life could pave the way for a shift to increased sufficiency.

┌ Society's point of view on biotechnology is increasingly changing due to coronavirus and the related opportunities and advantages will now become clearer and clearer.

The switch to virtual communication platforms will have lasting effects and will eventually dominate both our professional and private daily lives simply because they are so efficient. This first effect will be followed by many others and their ramifications will be noticeable in all sectors of our society and will influence many areas of the economy.

## Biotechnology

Biotechnology will also experience a change as a result of the coronavirus pandemic. This change will perhaps have less of an effect on the technologies and potentials within biotechnology, as they were already enormous before the crisis. Instead, society's point of view on biotechnology will undergo a change due to Corona and the related opportunities and advantages will now come to the fore and become clearer and clearer.

### How is this assessment justified?

First of all, it is important to note that there is no such thing as "one" biotechnology. In expert circles, there is a differentiation made between different types of biotechnology with a color scale. Red biotechnology refers to anything that is medical-related, green biotechnology is for plant production and finally white biotechnology covers any type of biotechnology used in the production of chemical raw materials or fuels. What the different types of biotechnology have in common is the molecular tools and principles that they apply, like, for example genetic engineering. However, they are not all equally accepted by the general public.

## Red

Perception of red biotechnologies has immediately profited due to the coronavirus crisis. The fact that the complete genome of the virus became available in such a short time and then that the further development of the virus through mutations has been able to be tracked, is the result of the fundamental biotechnological research carried out during the last few decades. The total testing capacity (over 60 million official tests have been carried out globally since the start of the crisis<sup>1)</sup> relies on the use of molecular biology enzymes and methods and would not have been possible without biotechnology. The simple need to break the chain of infection shows just how important it is to quickly identify infected but asymptomatic people. However, a rapid confirmation of non-infection is just as important, as this means that the quality of life and the maintenance of infrastructures can be ensured if so-called "system-relevant" people do not have to remain in quarantine. The speed of these biotechnology-based tests is enormous (results in just a few hours), so that in our time actual logistics and sample transport become limiting.

Even more impressive in terms of the potential of red biotechnology, is the race between international companies and academic institutions to develop a COVID-19 vaccination at breathtaking speed. Without the achievements made in biotechnological research, we would have had to rely on the so-called herd immunity method. Now there is now hope that a vaccine will be made available within a year after the appearance of the first case of coronavirus. ►



**Professor Dr. Volker Sieber**  
Rector of the Campus Straubing for Biotechnology and Sustainability, TUM; Professor for Chemistry of Biogenic Resources, TUM

#### Literature

1. <https://www.worldometers.info/coronavirus/>, last accessed on 24.05.2020

## White

White biotechnology, also known as “industrial” or “chemical” biotechnology, could be one of the big winner of the Corona crisis. It primarily focuses on the sustainable production of chemicals and fuels using renewable raw materials and energies. It is thus a major driving force for the biobased economy. Chemical biotechnological methods can be used to manufacture materials that have the same technical properties as the omnipresent polypropylene and other fossil-based polymers, but they are also biodegradable and do not accumulate in the environment. However, the production costs of these biobased materials are still relatively high and as such they cannot yet assert themselves over more established fossil-based ones. One advantage of chemical biotechnology is that the production process uses less energy and is much safer. Biotechnological processes can also be carried out in small, technically simplified plants and therefore the chemical production can be decentralized further, accommodating the amount of biogenic raw materials spread across the area. This is exactly where the link to Corona lies. Due to the collapse of global production chains, there have been calls for an equalization of production capacities and an increased regional distribution. Conventional chemical production is usually done at large sites that have direct access to the natural resource (this is particularly the case with crude oil). Chemical biotechnology, however, can meet this need for equalization and can distribute production and value chains across the country, creating a more sustainable economy.

## Green

At first glance, green biotechnology seems to be the area least affected by the coronavirus pandemic. Its possibilities lie in the provision of improved crops, such as grains that can tolerate drought stress or potatoes that have a starch composition suitable for specific technical applications, for example. Recent drought periods in Germany have shown the need for the former type of product. Ensuring a sufficient supply of food is the top priority, but this should be done in a sustainable way without an unnecessary use of energy and chemicals. Nevertheless, the cultivation of genetically modified plants in Germany would probably largely be tolerated if they would be the only solution to produce the much-needed coronavirus vaccination. The potential of genetically modified plants must outweigh the risks that they pose to the environment, and rightly so. However, this weighing up must be conducted fairly and without polemics, based solely on scientific evidence ...

...

**The coronavirus crisis has shown that scientists are also important in the political sphere and that initially unpopular decisions can be made based on a thorough factual analysis. Hopefully this connection will remain strong, or perhaps even become stronger, after the pandemic has ended. As such, it is clear that the crisis may also have positive side effects in general, but also more specifically for and with the (increased) use of biotechnology in all its colors. ┘**

# Energy

## Post-Corona

**The drastic restriction of social interaction, the almost complete shutdown of the tourism industry and the partial standstill of industrial production as consequences of the coronavirus crisis have led to a significant decrease in energy requirements and with it, a reduction in environmental pollution.**

Global demand for crude oil has dropped by a third, storage facilities are overflowing. If you buy oil now, you'll actually get paid for it. Fascinating images show the direct effects of this on our environment. In a picture taken from the International Space Station (ISS), for example, you can clearly see that China is producing significantly less smog. The "dirtiest city in world", Los Angeles, is suddenly enjoying clear blue skies. In

Germany, the sky is free from the condensation trails produced by airplanes. The reduced use of transportation (cars, lorries, airplanes, ships, public transport) and the reduced operation of production facilities is reflected in the consumption figures – the demand for electrical energy in Germany has dropped by 20%. The pandemic will perhaps even allow Germany to meet its climate target in 2020!

This "success" has come at a price, with restrictions on our freedom and economic costs that cannot yet be estimated, and as such it is therefore perhaps limited in time and may not even be sustainable. The big question is whether these changes will stay when our lives and the economy return to normal "post-COVID".

**Will we see some type of catch-up effect with even more tourism to distant countries, or will there perhaps be an increase of tourism to European countries with less of an environmental impact?**

**Have we had such positive experiences with video conferences that we will do away with expensive and time-consuming business trips?**

**Can economic value creation be maintained even with a larger number of workers working from home and can the use of transportation be reduced?**

The world of work can also be completely redesigned: The reconfiguration of our working and home environments offers opportunities for us to significantly reduce the energy required for transportation to and from work and to gain valuable time with our families. It is a huge program that includes the economy and science, but the end result could be a considerable reduction in traffic and "friendlier" working environments.

Some of the causes of the global warming that we are experiencing today are known. For example, the increase in greenhouse gases (the amount of CO<sub>2</sub> in the atmosphere has increased by 10% in 20 years), the melting of the polar ice caps at the North and South Pole which reflect solar radiation and the decrease in their reflectivity caused by particle contamination. An inevitable consequence of this is an accelerated reduction in the burning of fossil fuels (coal, oil and gas) in all areas of the energy transformation, such as in mobility and transport, industrial production and building technology.

For the first time ever, there is the opportunity for real global participation in the development of science and technologies if digital formats continue to be developed further. And this is not only valid for university education. For example, we still do not have a good online "training" to become an electrician, but the effects of having one would be huge. If new technologies, such as photovoltaics, were to be used even in the most remote regions of the world, this would result in a revolution that could catapult us into a new energy age much faster. For this, the Technical University of Munich would have to set up a program in partnership with the relevant chambers of crafts and there has never been a better time to do this than now. However, the desire to bring production back to Europe will cause energy demand to rise again to begin with. **But the opportunities**

**need to be used properly**, e.g. with the manufacturing of silicon, which still uses a lot of energy and CO<sub>2</sub>. If we could restart the production of photovoltaic panels in Europe based on "green" silicon, this would also be a very important step towards creating a sustainable energy industry. The increase in digitalization and the creation of intelligent vehicles will at first also lead to an increase in electricity demand.

The rise of electricity as the main final energy source is almost inevitable for reasons of efficiency: Renewable energy mostly produces electricity and it would be best to use it directly. The transportation of electricity is becoming more and more efficient and even if it is transported over thousands of kilometers, considerably less energy is lost than during a conversion into another physical condition, such as hydrogen for example. Despite the wish for local production, a global electricity system that is always operated according to the motto "Energy from the world and sufficient on-site power" should be considered. For this, systems that are highly networked but that still offer a maximum level of local security should be designed. A versatile use of electricity can only be achieved through new intelligent systems and as such, electricity and communication systems must be combined to allow for things such as the anticipatory production of warm water, for example. With this alone, more than 10 GW of power can be switched on and off in Germany if the heat storage and forecasting system are networked intelligently.

The transportation of people and goods is still predominantly done by means of motor vehicles, airplanes and ships that burn fossil fuels. Today, the electrification of whatever means of transportation is politically endorsed and encouraged with strong financial incentives, which have to be generated first. However, there are still technical limitations to this, even if they have not yet been reached. Due to the fundamental laws of physics battery capacities cannot simply be expanded at will. Batteries also need time to charge and power grids cannot be created quickly enough and are often faced with opposition from locals. However, the actual crux of the matter is how sustainable, e.g. greenhouse gas-free, the electricity generated for transportation is. Already today in France, with its largely CO<sub>2</sub>-free nuclear energy, an electric car has a significantly smaller carbon footprint than a similar vehicle with a combustion engine!

Electricity must be generated in a climate-neutral way, with all available options being used, but particularly photovoltaics and wind energy. As the time of generation and the demand do not match here, new approaches must be found to bring together generation and consumption.

**There are many possible options:**

the creation of international power grids, the coupling of the electricity sector with the heating and transport sector, the building of electricity storage facilities, such as pumped-storage power plants, or the more efficient use of batteries. Unfortunately, none of these solutions can be implemented overnight. Here, long-term planning is necessary. Another option is using biomass, such as wood, maize, rapeseed and biogas. ►

With biomass, nature conservation and climate protection must be taken into account and only waste from the agricultural sector should be used so that there is no competition with food production.

Perhaps our experiences of the coronavirus crisis will accelerate the decrease of the use of fossil fuels. Daimler has announced that they will concentrate on the development of hydrogen-powered vehicles in their lorry-building area of business in the future. This will have significant consequences for the cleanliness of the air, however, at the same time a suitable filling station infrastructure needs to be built. There are currently less than 90 H<sub>2</sub> filling stations in Germany, but this number needs to increase to at least 1,000 to ensure a comprehensive coverage. H<sub>2</sub>-powered cars would also benefit from this and it means that significantly more H<sub>2</sub>-powered cars, like the Hyundai Nexo and Toyota Mirai, have to be developed and put on the market (Daimler and BMW are currently working on this). When it comes to transportation, it is essential that our strong dependence on cars is re-examined and maybe alternative options, such as the Maglev for example, are reconsidered.

Hydrogen, or other synthetic fuels, will become necessary in some industrial sectors and even for some modes of transport, e.g. for airplanes and large ships. Where this hydrogen will ultimately be produced is not yet known, but it doesn't seem like a large part of it can be generated in Germany. Regions with good conditions for solar and wind energy will certainly lead the way in this area in the future. However, we do not yet know what form the energy will be transported in. At the same time, hydrogen competes with synthetic fuels. Their production is complex, but in terms of transport, synthetic fuels are more similar to fossil fuels. The opposite is true for hydrogen.

A switch to a hydrogen economy would of course require lots of time and money, but some countries have already decided to go this way. In 2017, Japan adopted their "Basic Hydrogen Strategy" which is expected to make the hydrogen economy in the country grow by a factor of 60 by 2030. The number of filling stations should increase from 111 to 1,300 and the price of green hydrogen should end up being 5 times cheaper, meaning that traveling 100 km in a hydrogen car would only cost the equivalent of around € 2. And of course not only the energy supply for cars, but for all transport systems, as well as for industrial sectors and building technology, will eventually switch to hydrogen. Countries whose fossil energy supplies are running out are working on becoming hydrogen producers (e.g. as is the case in Oman).

The competition between electricity, hydrogen and synthetic energy sources is now on. There will certainly be no clear winner, but long-term decisions that cannot be easily reversed and a prioritization must be made here.

The coronavirus crisis has become a real stress test for our economies, but it is unclear whether this will lead to a positive fresh start. Perhaps the experiences during the crisis (carbon footprint, air cleanliness, reconfiguration of working environments) are an additional incentive to make and implement such considerations. The combination of electrification and digitali-

zation offer a huge opportunity in terms of energy supply. When all of this is combined with new forms of work and transportation, it would be a big step toward a sustainable energy future and may even signal the end of the oil era.

**But one major question remains unanswered:**

How can this be done in a democratic society which is built on the initiatives of individuals and their freedoms, in an economy based on making profit? Will individuals be prepared to reduce their consumption, or will there be a paradigm shift that will allow consumers to have a higher quality of life through sustainable consumption? Europe and its member states must put the right framework conditions in place, demand the development of sustainable solutions but also allow for the freedom to implement them and for a competition of ideas. Political constellations also play a part in this competition. For example, for the moment Germany has excluded the largely CO<sub>2</sub>-free generation of electricity through thermonuclear fission or fusion, while for other countries like France or our Eastern neighbors, this is an important part of the diverse and sustainable conversion of energy in their countries.

**In any case, this crisis has taught us how important it is to identify dangers in good time. A world in which climate change is well advanced can no longer simply be put back on the right path with a lockdown. ┘**

┘ The competition between electricity, hydrogen and synthetic energy sources is now on. There will certainly be no clear winner, but long-term decisions that cannot be easily reversed and a prioritization must be made here.



**Professor Dr.-Ing. Georg Färber**  
TUM Senior Excellence Faculty; Founder of the company PCS (1969); Elektronik Innovationspreis (1985); Professor for Real-Time Computing, TUM



**Professor Dr. Thomas Hamacher**  
Director of the Munich School of Engineering; Professor for Renewable and Sustainable Energy Systems, TUM



**Professor Dr. Winfried Petry**  
TUM Senior Excellence Faculty; Former Scientific Director of FRM II, TUM; Professor for Functional Materials, TUM

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# Hydrogen

## Time for the Breakthrough

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### Climate change as motivation for the use of hydrogen

During the coronavirus crises, public life and traffic came to a temporary standstill. Seeing mostly empty motorways might make you think of the car-free Sundays that were common in the 1970's, however the causes could not be more different. During the oil crisis, a drop in oil production by producing countries led to a supply shortage and exposed the vulnerability of industrial societies because of their hunger for energy. At the time, the fear of an approaching peak oil and continuously increasing prices led people to think about how crude oil could be replaced by hydrogen from renewable sources and the term **hydrogen economy**, used to describe an energy system based on hydrogen, was born. Today we know that reserves of fossil resources are significantly larger than was previously

thought due to new extraction techniques like fracking, and we also know that a major supply shortage is therefore not to be expected for the time being. The peak oil has been postponed and for the moment we are experiencing more of glut of supply at a time of low demand. Regardless of this, hydrogen is back on the political agenda and all over the world high hopes are resting on this energy source as an aid in the fight against anthropogenic climate change. The oil reserves should therefore not primarily be seen as the limiting factor for the combustion of fossil fuels, rather, the changes in the climate caused by the emission of carbon dioxide and other greenhouse gases dictate that we leave the majority of the fossil fuels still available in the ground. The related ideas about converting our energy system to one that functions with renewable energy have not only given the concept of a hydrogen society new impetus. Now, the implementation of this idea seems to be well within reach at some point during the next decades thanks to the various measures planned by governments and the industrial sector.

### Concept and characteristics of a hydrogen economy

With the help of an electrical current, water can be electrolytically split into its constituents – hydrogen and oxygen. The hydrogen can then either be used chemically in various manufacturing processes or can be used stationary or in vehicles to generate an electrical current. Both combustion and the electrochemical conversion of hydrogen with oxygen only produce water vapor. As long as the electricity used for the electrolysis was generated from a renewable source, a hydrogen-based energy cycle such as this would be fully sustainable and free from harmful emissions.

The production and the conversion of hydrogen into electricity can both result in losses. Throughout the entire production and use cycle, an electrical efficiency of 30–40% is achieved, resulting from the multiplication of the efficiency of the electrolysis (70–75%) and the generation of power in a fuel cell (around 50–55%). Deriving a general disadvantage from this in comparison to pure electrical use is however wrong for a variety of reasons. To start with, the heat produced as a **by-product** is sought after as it can be used for a wide variety of applications, for example for supplying buildings with electricity and heat, or for operating vehicles which also need thermal energy to heat or cool the interior in addition to drive energy. Furthermore, there are certain limits to a purely electrical transfer of energy, taking into account the timing of energy production and demand, the distances to be covered and the type of energy consumption.

As will be shown below, hydrogen and electricity should not be seen as opposing or competing technologies, but rather as highly complementary forms of energy. Thanks to its varied application possibilities, hydrogen can significantly contribute to the decarbonization of our energy system, particularly in areas that are very difficult to electrify.

► Unlike electricity, hydrogen is a material energy source. This means that it can be stored, transported, imported and stockpiled. In all energy systems, this represents an important, if not indispensable, function, especially if the future energy system will be largely based on fluctuating renewable energies. Today, Germany imports around 70% of its energy needs in the form of crude oil, natural gas and coal. In 2019, renewable energies were only able to cover 15% of the primary energy consumption in Germany, although this was still a ten-fold increase from 1990. In view of the emotionally-charged debates surrounding the construction of renewable energy plants, for example with regards to the distance of houses from wind turbines, it is neither realistic nor desirable that a country like Germany will manage without energy imports in the future.

► In a renewable energy system, the degree of efficiency is only of indirect importance, as in principle there is an unlimited availability of renewable energies. Ensuring a cost-effective exploitation is much more important here. Ideal locations for generating electricity, where electricity can be generated for the lowest price per kWh, tend to be near to the coast or offshore areas for wind power or areas close to the equator for solar power due to the particularly favorable meteorological conditions. Concepts for importing renewable energy in predominantly electrical form, like the “Desertec” concept which was developed and discussed around ten years ago, have mostly been discarded due to the many conceptual difficulties (security of supply, timing of the energy, political risks, decarbonization of non-electric energy consumption, etc.).

It is therefore wrong to only consider the local chain of energy producers and consumers when looking at the efficiency and to not include the timing in the considerations. Instead, hydrogen allows for a significant expansion of the balance group, in that cheaper renewable sources of energy can be included which would otherwise not be accessible because of their location or the fluctuations in the amount of energy generated over time. ►

► **Hydrogen is incredibly versatile and can be used both energetically and materially.** It does not necessarily need to be converted back into electricity to be used, and instead can be used directly in chemical processes:

- Steel production is an enormously energy- and emissions-intensive industry. In Germany today, around 7.5% of climate-relevant emissions come from steel production (around 67 million tons of CO<sub>2</sub> per year). This particular application seems predestined for the use of green hydrogen, which could be used instead of fossil coke to reduce the amount of iron oxide. Well-known steel producers, such as Voestalpine and Salzgitter, are currently developing and testing out promising new steel production processes which use hydrogen.
- Hydrogen has been used in a wide variety of manufacturing processes, such as metalworking, fertilizer production and refinery processes, for decades. As > 90% of this hydrogen has been obtained from fossil fuels until now, the gradual shift to green hydrogen will lead to a massive reduction in greenhouse gases. In Germany alone, the use of green hydrogen will save up to 10 million tons of climate-damaging gases per year, equivalent to around 1% of annual emissions.

► The term “hydrogen economy” not only includes the use of molecular hydrogen, but also a range of hydrogen-based synthetic energy sources. One advantage of these sources is that they are significantly easier to transport in comparison, particularly because existing infrastructures can be used. In contrast, molecular hydrogen is a very low-density gas in ambient conditions and it becomes explosive when mixed with oxygen, this makes it very difficult to build a nationwide infrastructure to transport it. Therefore, many different hydrogen derivatives can be considered depending on the type of application. These derivatives can differ significantly with regards to the manufacturing process, efficiency, cost and areas of application:

- Synthetically manufactured hydrocarbons, such as methane, methanol and higher chain molecules (e.g. similar to diesel)

– can be used analogously to their fossil counterparts either in chemical processes or by being burnt with atmospheric oxygen.

- Ammonia – can be used as a basic substance in fertilizer production and in various chemical syntheses.
- Liquid organic hydrogen carriers (LOHCs) – can be used for the simple and secure storage of hydrogen so that it can be transported and stockpiled in existing fuel infrastructures.
- Hydrogen can be used in transportation, especially in payload transportation, as an emission-free fuel. So far, the decarbonization of this sector, which with 163 million tons of CO<sub>2</sub> emissions in 2019 is the third largest emitter of greenhouse gases after the energy and industrial sector, has not been successful. Over the last 30 years emissions have remained stubbornly high. While with cars, battery-electric drive concepts offer the potential for a future reduction in emissions, the situation with land-based commercial vehicles, which account for 35% of road traffic emissions, and in the maritime sector poses a significantly greater challenge due to the limited storage capacity of batteries. For example, simple calculations using the rule of three show that for a long-distance transport lorry with a range of 1,000 km, the battery alone would weigh around 16 tons which would significantly reduce the payload of the lorry. On top of this, there is also the challenge of building a charging infrastructure that can reliably provide the amount of power required. In comparison, due to the quick refueling and comparatively long range, hydrogen would provide an experience similar to that which we have with today’s fuels. Various manufacturers already offer hydrogen vehicles or are currently developing them:
  - Hydrogen lorries: Hyundai “Xcient Fuel Cell”, Toyota FCET (fuel cell electric truck), Nikola Motors “Nikola Tre”, a recently founded joint venture between Daimler and Volvo
  - Hydrogen buses: Van Hool “A330”, Solaris “Urbino 12 hydrogen”, Toyota “Sora”
  - Hydrogen trains: Alstom “Coradia iLint” (already in use in several federal states in Germany), Siemens “Mireo plus H” (in development)

## Current initiatives and outlook

The initial optimism that hydrogen could make a significant contribution to our energy system in the coming years and decades can also be linked to a large number of government initiatives, a few examples of which are listed below:

- As it currently stands, many federal states in Germany have announced extensive activities and measures, like in Bavaria with the “Bavarian Hydrogen Strategy” (published 29.05.2020), which provides for the construction of 100 hydrogen filling stations and the industrial use of the energy source in Bavaria, amongst other things.
- At a national level, the “National Hydrogen Strategy” sets the foundations for a German hydrogen economy. The post-coronavirus stimulus package from 03.06.2020 contains 9 billion euros for the implementation of the strategy as well as the ambitious target “to make Germany the world’s supplier thanks to the most modern hydrogen technology.”
- As part of their 750 billion euro reconstruction plan “Next Generation EU”, the European Union intensifies the previously announced strategy of the “European Green Deal”, which intends to make the EU a pioneer in the area of renewable energy and provides for the construction of a European hydrogen industry.

While there were some initial fears that the coronavirus pandemic and the resulting economic upheaval would lead to a decrease in climate protection efforts, luckily this has not been the case. Instead, it seems that major state and private sector players have used the break brought about by COVID-19 to accelerate the transformation of the energy system. The situation has given us the opportunity to lay the important foundations for a hydrogen-based energy system in the coming years and to further strengthen and expand upon the technological competences in this country. It is also important to bear in mind that many countries in Asia, such as Japan, South Korea and China, have already come to a broad social consensus to use hydrogen and, in some cases, actually initiated extensive activities and funding measures much earlier.

**It would not be a day too soon, if Germany and Europe were to now use the opportunity and lay the groundwork for a renewable energy system, in which hydrogen and electricity are not opponents, but partners. ─**



**Dr. Daniel Teichmann**  
Hydrogenious LOHC Technologies GmbH  
Founder and CEO; Circle of Excellence Deutscher  
Zukunftspreis 2018 (together with Professors Peter  
Wasserscheid and Wolfgang Artl)

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# Digitalization Under the Burning Lens of COVID-19 and What Needs to Change

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Digitization is the most sustainable technology-driven change that appeared in the first half of the 21<sup>st</sup> century. It has transformed the economy, civil society, education, science, media, state and politics. Even the far-reaching effects of the COVID-19 pandemic can be countered by digital instruments. Examples include the recording and monitoring of infection, contact tracing, working from home, remote production and maintenance, education and schooling, as well as virtual work and communication. The exceptional situation of COVID-19 however has thrown a harsh spotlight on the weaknesses in the implementation of digitalization in Europe. It has allowed us to identify in which areas the digitalization needs to be implemented quickly and decisively and which requirements need to be put in place for this.

┌ The performance of hardware has multiplied by a hundredfold in a decade, an increase that has not been seen in any other technical area.

The COVID-19 pandemic has made many people aware of exactly what exponential growth means. It has become clear which tsunami will develop if figures double within a certain timeframe. **There is a parallel to digitalization here.**

The force of digitalization is primarily due to an observation that has become known as "Moore's Law": **The performance of hardware doubles every 1½ years or so.** When you compare this to the rapid growth of the pandemic, where the number of active infections doubled within just a few days, this does not seem quite as dramatic. But exponential growth is exponential growth. The performance of hardware has multiplied by a hundredfold in a decade, an increase that has not been seen in any other technical area. The quick increase in the performance of hardware has, however, only to do with the powerful "drive belt". The hardware systems that are comparatively cheap because they have been mass produced can be used by software for a wide variety of tasks such as communication between computers. This leads to networks like the internet and today's almost unbelievable infrastructure which connects (almost) all computers in the world and allows us to easily transfer data from one computer to another. The World Wide Web has used this basic functionality of the internet to make the functionality convenient to use for a wide variety of services and data. This includes infrastructure systems such as browsers and search machines which make it possible for people to get all their questions

answered with and through the internet. With smartphones, the oldest of which only came out around 12 years ago, with cloud services that provide online computing and storage capacity, we have a powerful infrastructure, high-performing services and an abundance of data.

Software also runs on embedded systems which are increasingly being connected with the internet (keyword: cyber-physical systems, the "Internet of Things") and therefore show the current state and the future of this area. Modern software technology, including machine learning processes, helps to create high-powered systems that support people in all areas of their everyday lives.

However, the quick development of this technology has led to a dramatic global imbalance. In just a few decades, giant, globally-active digital companies (also known as Hyper-Scalers) have developed in North America and monopolize certain areas of digitalization worldwide. Examples of these include search engines, standard software, social networks, internet-based retailers and end devices such as laptops and smartphones. Even in Asia, large companies have been set up, particularly in South Korea and China, which have gone on to gain global importance, often much quicker than their American counterparts. In all regions of the world, the digitalization is largely determined by these global players. They provide residents with services that appear to be free of ►

Germany needs a blunt overview on the state of digitalization in the country. The previous approach of the economy and state, of applying a little digital “paint” without really undertaking a full digitalization, has inevitably led to an economic and social sidelining.

charge but that actually access large amounts of valuable data or that increasingly dominate marketing. As software can be scaled up and down like nothing else, it usually generates high revenues and has a huge, steadily-growing customer base.

Europe, and Germany in particular, has barely managed to keep up with their own companies. There are some specific areas where Germany is quite competitive: in business software or in embedded systems in airplanes, vehicles and production automation. However, it is becoming apparent that the internet giants are also becoming stronger in these areas too and that they often use their superior competence in software to dominate the corresponding areas faster.

When the pandemic started this year and turned everything on its head, digitalization started to play (and will continue to play) an even more important role. The contact restrictions that have been put in place almost all over the world have at least been able to be partly overcome with digital media. People no longer travel, certainly not between continents, but also not between countries and, in many cases, not even within their own country. They have been “banished” to their homes and digital media offer the only means of communicating with others. As more and more people have been working from home there has been a boom in video conference tools, but digital media has also become incredibly important for

keeping in contact with people in our private lives.

Due to the pandemic, digitalization has also become vastly more important for states and their economies and societies. But where does Europe, and Germany, stand in all of this? It has become frighteningly clear that there have been plenty of failures with regards to digitalization in Germany in the last few decades. We will just concentrate on a few particularly important points: The deficits in digitalization mentioned are only those that have particularly stood out in connection with the pandemic. But what is perhaps of greater importance is the varied opportunities resulting from digitalization – for innovation, for the acquisition of new markets, for new business models – that are going to waste.

Germany is on the way to becoming a digital developing country, a digital colony. Data of German citizens is in the hands of HyperScalers, the rapidly growing digital companies from North America and Asia. German industrial companies are largely unable to turn the corner in the direction of digital transformation.

An industry particularly affected by this is the automotive industry. It was already in crisis before the pandemic, not only due to the discussions on climate change, or the problems associated with the model changes from combustion engine to more environmentally-friendly drive sources, but also because the industry has hardly made any steps on the

### ► Digitalization in schools:

It is easy to see how far behind schools are in the digitalization process. There are a lot of teachers that know little about technology to begin with. Insufficient equipment of schools but also of the students. How can students be properly taught at home if they do not have a printer or a laptop, maybe they can only use their parents’ smartphone? There is a lack of digital teaching concepts and of teachers capable of making the most of the varied opportunities that digital media have to offer and that can therefore carry out the teaching professionally. Helpless Education Ministers in the federal states!

### ► Digitalization in public administration – eGovernment:

According to a recent study carried out by accenture, Germany is far behind with regards to eGovernment. In comparison to the 28 countries in Europe, Germany is in 24<sup>th</sup> place, behind countries like Hungary, Croatia, Greece and Romania, and just ahead of Slovakia, the Czech Republic and Poland. The dramatic consequences of this have been seen in all areas during the pandemic. Laboratories send coronavirus test results to the health authorities by fax(!). Health authorities inform infected people and contact cases by telephone. Eight weeks of discussion about the corona-virus app go by without it being made available. The numbers of the pandemic have not been digitally collected so that they can be analyzed with “Big Data” methods and so that conclusions can be drawn from them and “cockpits” can be created for the decision-makers, instead everything is mostly done “manually” – slowly, erroneously and incompletely.

### ► State of digitalization in companies:

With a high number of employees forced to make the switch to working from home overnight, it was clear to see the difference between the companies that were able to do this and keep their business running smoothly, and the companies that were either hardly or not at all prepared for this. This, of course, also concerns government institutions, such as the tax investigation department, which almost come to a stand still on a regular basis because of their prehistoric equipment. It also affects lots of small, medium and even large companies. Almost all video conferences are held via North American media (Teams, Skype, Zoom, Google Meet etc.). That throws a gloomy light on the state of digitalization in Germany. ►

# Germany is on the way to becoming a digital developing country, a digital colony.

path to digitalization. The top managers from the automotive industry, all of them trained mechanical engineers, lawyers and economists, have turned out to be incapable of finding a competent way into digitalization. Instead of consistently initiating and implementing important developments (also given the fact that nowadays vehicles are more like computers on wheels than a work of mechanical engineering), they do not rely on their own innovations. This puts them on the defensive against companies who, with their expertise in operating systems, human-machine interactions, networking, data use and mastery of autonomy, can reduce classic automotive companies to being purely suppliers who provide mechanical parts for a networked mobility sector that is dominated by digital companies. As a result, new models are produced and then stockpiled as the required software is not available on time and fully announced functionality for autonomous driving of new models is yet to happen as the automotive manufacturers are incapable of developing the necessary software.

## And politics is no better.

Digital Ministries have been created but it is not really clear what they have managed to achieve. There has been no advancements with eGovernment or with the digitalization of schools, no strategies, no competences in leading the digitalization of a

country. The development of digitalization in North America has shown that this area can also develop without state competences if the appropriate competences have been created in the economy. However, the internet was created by the US Department of Defense. The economic success of internet companies is based solely on this. The Chinese model is based on the close synergies between government power structures and technical competence which gives rise to fears that China will grow faster in this area and perhaps soon take over the market leadership from other similar North American companies.

## So what is the order of the day?

Germany needs a blunt overview on the state of digitalization in the country. The previous approach of the economy and state, of applying a little digital “paint” without really undertaking a full digitalization, has inevitably led to an economic and social sidelining. The essential elements of digitalization must be organized in a completely different way. Not only do schools need to be digitized quickly and decisively but the lesson content also needs to be adapted to the situation. At universities, a greater emphasis must be placed on dealing with digital media and understanding digitalization. In the economy, competent digitizers in the highest level of management must decisively lead companies into the new world.

## And in politics?

They must employ competent specialists for the digitalization and equip them with the necessary knowledge and skills so that they can overcome any possible resistance, for example from the administration. One of the weak points of our government is that the bureaucracy has been completely left behind. Ministerial bureaucracy in particular is unable to keep up with the speed of the developments in digitalization. One of the biggest challenges here is to find competent personnel for the administration. This will be impossible to do with the current pay rates for public servants. We need to find some completely new approaches here too. If Germany does not manage to implement this essential topic of digitalization quickly and practically, then its path is set: Germany will end up as a digital colony, whose data is completely in the hands of others who will use the colony as a market in a variety of different ways. In the end, this is not just an economic problem. The identity of Germany and Europe is at stake here. **If we lose our digital sovereignty, we will lose an essential part of our cultural values and our freedom.** ┘



**Professor Dr. Dr. h.c. Manfred Broy**  
TUM Senior Excellence Faculty; Leibniz Prize (1994);  
Konrad Zuse Medal (2007); Founding President and, until  
2019, Scientific Director of the Center Digitization Bavaria;  
Professor for Software & Systems Engineering, TUM

# Computing for a Sustainable World

## Knowledge through scientific computing

The John Hopkins University updates the data about the state of the global SARS-CoV-2 disease almost hourly and it calculates up-to-date precise graphics and medical parameters. This shows that even during the COVID-19 pandemic, today we are able to calculate and predict the world and its developments with computers. Alongside experiments and theories, computer simulations have become the third pillar when it comes to gaining knowledge in science and are used in all areas, from medicine, to natural and engineering sciences, and even through to social sciences.

There are two basic approaches used today. First, deterministic and statistical methods. Here, data-based algorithms and models provide step-by-step comprehensible results. Second, “learning” with artificial intelligence methods. Here, neural networks make evaluations of data that they have learnt through a training with many data sets and corresponding correct annotations.

A requirement for both approaches is the enormous computing speed of today’s computers. The semiconductor technology with “Moore’s Law” (duplication of the number of transistors per component, and therefore of the computer performance, every 18 months) and the parallelization represent this development in the hardware. The performance gains from semiconductor technology gradually decrease as physical limits are reached, particularly due to the miniaturization of the dimen-

sions. This will be discussed further later. However, for many applications an increase in performance – in addition to the profit gained with the acceleration of the hardware – has been and is targeted through the continuous development of new algorithms, models and associated software.

In our daily lives we rely on a graded and networked infrastructure, from “smart and networked light switches”, as an example of a component of the Internet of Things (IoT), to personalized mobile devices (smartwatches, smartphones, tablets, notebooks), centralized and decentralized servers, supercomputers and the cloud. Even science uses all levels of this infrastructure for its own purposes.

Computers, and the results that can be achieved with them, are of strategic importance for the further development of science, economics and society as almost all new products and services can be optimized when developed with simulations. The struggle of the economically most efficient nations to lead the TOP 500 list of the most powerful supercomputers by means of strategic exascale programs in the USA, China and the EU is impressive evidence of this. Exascale computers mark the next performance level and can carry out calculations with ten to the power of eighteen instructions per second, i.e. trillion arithmetic operations per second. This enormous computing power is required because the objects to be simulated are calculated repetitively through millions of individual points, as well as through their behavior and interaction with neighboring points, for a great many time steps. The hacking of super computers throughout Europe during the coronavirus pandemic suggests that industrial and scientific espionage is being used to try to obtain findings from calculations for effective vaccinations or medication.

## Potential for a sustainable world

The unparalleled success of computer and computing was not primarily driven by the goal of creating a sustainable world. When we are thinking about making the world more sustainable by means of scientific knowledge during this period, there is sufficient potential for a departure in the direction of political/strategic and technical innovations in the field of scientific computing.

### Incentives for sustainability research

The predictive power of computers must be used more to make our world more sustainable. To do this, research funding must specify relevant thematic priorities. Candidates for short-term subjects include: reasons and courses for the spread of pandemics; predictions of future mutations of the coronavirus and other viruses; analysis, diagnosis and long-term monitoring of secondary conditions. Long-term subjects include: climate change and its consequences; food; environment and preservation of biodiversity, health and mobility. In any case, the willingness of society to now invest more in science must be courageously used for scientific computing to the advantage of sustainability.

### Reduction of technological dependency

The global division of labor has led to the development and production of computers and networks for the global market almost exclusively being done in the USA and increasingly in China and other Southeast Asian countries. Unfortunately, the same goes for the development and marketing of internet-related services (Google et al.). This is particularly problematic as it may lead to a potential dependency on China and their understanding of data protection and privacy. As such, a greater differentiation and regionalization of the development and production of components for computing, and also for all other elements of the digital infrastructure, is of great interest for Germany and Europe.

### Intelligent utilization/recycling of computer scrap

Large quantities of valuable raw materials, such as rare-earth elements and even gold, are needed for the manufacturing of computing and network infrastructures. Currently, computer scrap or recycled products are not used or are only used in very small quantities. Instead, we burden the ecology of developing countries with landfill sites full of our toxic waste. An efficient recycling strategy must be developed to combat this.

### Methods to reduce the electricity consumption of digital infrastructures

The operation of our digital infrastructure (servers, networks, end devices) already represents a high single-digit percentage of global electricity consumption, and this trend is increasing rapidly. There are various factors that contribute to this. Popular services, such as the streaming of high-resolution films and videos consumes lots of electricity due to the enormous volume of data that has to be transported. Even frequent “googling” on the internet and generating Bitcoin uses as much energy as some small countries. Operating models like cloud computing

mean that data either needs to be regularly transported over other routes so that the end user can access it or that it at least needs to be copied to other locations (redundancy through caching). The development of semiconductor technologies, particularly the increase of working frequencies, has led to a power consumption of up to 400 watts (and the corresponding cooling requirements) for individual, high-powered components, for both standard and graphics processors.

As such, the world’s most powerful super computers require medium-high double-digit megawatt figures to be operated. As such, their constant operation uses as much electricity as 20,000 4-person households do in one year. Operators of large cloud data centers and super computers react in a locally optimizing way by relocating to countries with low electricity prices and low temperatures because of the favorable cooling, particularly with cold water (Iceland, Finland). A global model that includes natural and technical sciences, as well as business and political economics, and that calculates an optimized electricity consumption, taking into account all the parameters mentioned with regard to a sustainable computer infrastructure, must be developed. In this way, specifications for a legal framework can be created which allows for the further development of the digital infrastructure towards sustainability. The “Rebound Effect” and/or “Jevons Paradox” (savings in consumption of individual resources through technical or legislative changes immediately lead to an overcompensation of the savings through volume growth because of the associated reduction in price) must also be taken into consideration here. However, regardless of global optimizations, short-term technical measures for high-performing computers, server farms and cloud infrastructures need to be carried out. Examples of this include the recovery of waste heat by adsorption refrigerators and the intelligent cycle frequency control depending on the application profile.

### Reduction of electricity consumption through intelligent algorithms and the recycling of calculations and data

The research funding must provide initiatives to develop particularly energy-efficient algorithms and processes. There is potential for this through the intelligent coupling of numerical simulations and artificial intelligence processes, so “Learning from previous calculations instead of repeated recalculations”. Even the recycling of data that has already been calculated in applications with large quantities of data, like in weather and climate research, can contribute to this reduction. In addition, computer properties can be used directly. This includes calculations with varying word lengths and therefore with a higher potential for parallelism (“mixed precision”), calculations in memories and a suitable choice of storage hierarchy (in-memory computing) or calculations during the data transport (in-network computing).

### Influence of user behavior

The seemingly unlimited computing power of today’s infrastructure and the high costs of the development of efficient algorithms and processes have led to calculations in the field of scientific computing sometimes being inefficient and redundant (“brute force” instead of “smart”). Alongside the targeted support of more efficient algorithms and operating forms, it is also important to include the scientific users of the ►

infrastructures in the efforts to achieve more sustainable computing. This can be done both through information (regular indication of the electricity consumption for each application) and through the application of strict operating rules (restriction of the maximum electricity consumption per user and per program, also known as “power capping”). The stronger emphasis on new benchmarks for comparing computers can also contribute to this. An example of this is the “Green 500”, a ranking list of “FLOPS per watt”, the average number of floating points per watt for the operation of a computer when running a standard application (mostly solution of a linear system of equations). This should be used instead of or in addition to the “TOP 500”, a ranking list that is only done according to “FLOPS”.

### Extend the service life of devices

The service life of many computers that are only used as intelligent networked word processors and other computers that are not used to their full potential can be extended without the functionality for users being restricted, if the update strategy of the associated software has been geared towards a longer use of the computer.

### Efficient reproducibility

Like in all areas of science, reproducibility of results generated through numerical simulations done on (super) computers is required. For the corresponding programs, this means that they must be executable on other computers with different system software (operating system, compiler, runtime environment, program libraries, etc.) even after many years just in case the computer that was originally used is no longer available or operational. However, as a general rule, programs cannot be transferred without modifications, particularly if the properties of the hard- and software of the original target system are used down to the last detail (“tuning”), as is common with high-performance calculations. Today, the solution to this problem consists of archiving the entire application program and software environment on which the program was originally developed, so that it can be run on an operational computer by using software container technology for example. This emulation of an outdated software environment naturally produces an extremely high computing load. Efficient alternatives must be found.

### Computing with patient data

Numerical simulations in the area of medicine often rely on the use of patient data. Due to the exemplary and globally recognized guarantee of confidentiality of personal data and the protection of privacy laid out in the GDPR (General Data Protection Regulation) and in other legal regulations, patient data should only be used if processed in an anonymized and pseudonymized form so that the patient cannot be identified. Therefore, as a general rule, medical research is not done on extremely powerful super computers but on separate computer centers in hospitals or clinics. The use of homomorphic encryption or other corresponding form of encryption to encrypt patient data could theoretically fulfil the data protection requirements and allow for the use of super computers outside of the clinic or hospital as the data would

also be processed in encrypted form. However, the homomorphic encryption and the processing of homomorphically encrypted data according to the state of the art requires extreme computing effort and as such is barely used.

### Quantum calculations

In view of the foreseeable end of any further increase in performance with semiconductor technology, basic technological alternatives to today’s computer technology must be found. Quantum computing is a potential solution that often comes up in conversation as it has a very high computing power for specific applications if operated in the low temperature range. Due to the very different programming model, there need to be further intensive research and development in quantum computing. Realistic comparisons for consumption data for quantum computers and their infrastructure in comparison to computers with classic technology must also be done on the basis of further developed prototypes. Only then can a decision be made as to whether quantum computers are a realistic replacement for classic computers in a wide range of applications.

# Conclusion

We need to make targeted changes to our computer infrastructure and its use in science for a more sustainable world! This does not only apply to the replacement of many business trips with virtual communication which has actually made us more communicative internationally.

## There is still a long way to go! ┘



**Professor Dr. Dr. h.c. Arndt Bode**  
TUM Senior Excellence Faculty; President of the Bavarian Research Foundation; Konrad Zuse Medal (2015); Former Chairman of the Board of Directors of Leibniz Supercomputing Centre (LRZ) of the Bavarian Academy of Sciences and Humanities; Professor for Computer Architecture and Parallel Systems, TUM

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# Artificial Intelligence

## Its Future after Corona

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**Artificial intelligence (AI) has dominated our lives for a long time without us even realizing it. Smartphones, that talk to us, watches, that record our healthdata, work processes, that organize themselves automatically, cars, airplanes and drones, that can control themselves, transport and energy systems with autonomous logistics or robots, that explore distant planets, are technical examples of a networked world of intelligent systems. The coronavirus crisis has dramatically shown that we need AI programs – both to identify chains of infection and to develop vaccines.**

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└ But these AI methods are only successful if they can be linked with the basic knowledge and theories from the respective areas of application.

### What is artificial intelligence and machine learning?

Today we mainly understand artificial intelligence as machine learning with simplified models of the brain. In graphic models of neural networks, neurons (nerve cells) are represented by nodes and are linked by arrows, which represent synapses as signal connections between the neurons. The arrows in the model are numbered which indicates the intensity of the neurochemical connection that passes through the synapses. According to Hebb's Rule, neurons fire off an action potential or are excited when the total of the weighted inputs of neighboring cells exceeds a threshold. In addition, the neurons are arranged in layers in a way that corresponds to the structure of the neocortex in human brains.

Just like in psychology, there is a differentiation made between different types of learning algorithms. With **supervised learning**, the neural network is first taught a prototype. This could be the distribution pattern of the colored pixels of a face, for example. The local strengths of colors and shading are shown by corresponding synaptic numbers of weights. This means to train the neural network to set the numbers of weights accordingly. By comparing the image with a trained pattern, the network can recognize a single face from a range of faces (e.g. during a manhunt).

With **unsupervised learning**, the neural network is able to identify similarities in data independently so that it can then classify them accordingly. These types of neural networks can, for example, use their algorithms to detect the face of a cat without necessarily having been taught what a cat is.

With **reinforcement learning**, the system is set a task that it must then complete more or less independently. An example of this would be a robot having to find a path to a given destination independently. Once it has completed the task, the robot is always given feedback (rewards) at certain time intervals that tell it how good or bad it was at finding the path, or completing the task. The solution strategy is to optimize this sequence of feedback.

**Deep learning** simply relates to the depth of the neural network, which corresponds to the number of neural layers. What was initially discovered in mathematical models in the 1980's has only recently been made technically feasible thanks to the development of the necessary computing power. ►

## AI transforms science and research

One of the strengths of machine learning is pattern recognition, something which is now used in many different sciences. In 2018, CERN announced that the Higgs boson has finally been discovered, but not by human physicists – through machine learning. In fact, the human brain would be incapable of classifying the millions of bits of data that are generated by the collisions of protons in the particle accelerator. But before this, the theoretical physicist Higgs had to predict the existence of this particle from a physical theory (Standard Model of Particle Physics), particularly the resulting disintegration into other particles. This helped to create a “fingerprint” of the Higgs boson that could then be used to find this elusive particle – a signal event that could be picked out from billions of other background events. This was achieved by a supervised learning algorithm, like the ones used to pick a face out of a crowd during a manhunt.

In medicine, for example, machine learning can be used to identify the “fingerprint” of cancer cells in a section of tissue, by differentiating them from normal lymph nodes. Nowadays, machine learning is also used in the development of medicines to drastically reduce the development time and related costs. IBM’s Watson for Drug Discovery reads millions of pages (Big Data mining) to assess their significance for certain research targets (target identification and validation). Five RNA-binding proteins (or RBPs) that had never been linked with Amyotrophic lateral sclerosis (ALS) before were discovered in this way in just a few months (Acta Neuropathologica 2018).

### Pattern recognition is also key to fighting coronavirus.

The immune system produces hundreds of thousands of antibodies to identify and neutralize the foreign proteins of a virus. These neutralizing antibodies can be found in the blood of patients that have recovered from a coronavirus infection. But which of these antibodies are responsible for the neutralization? A computer can be used to work out the structure of these therapeutic antibodies that bind to the viral surface protein. As opposed to a vaccination, therapeutic antibodies only work in cases of acute infection and therefore do not offer permanent protection from a virus. Therefore, people in the field of bioinformatics are trying to design vaccinations in computers. This is a typical learning process: Targeted laboratory experiments can be carried out on the basis of computer experiments. By doing this, we get a precise computer model of the molecular processes and the discovery of an active ingredient is no longer a mysterious accident.

However, it should not be forgotten that machine learning is mostly just statistics with learning algorithms and neural networks – by no means mathematically spectacular, as it suggested by the media. **Every beginner statistician knows that statistical correlations cannot replace causal explanations:** If a favorable statistical correlation between a chemical substance and the reduction of a cancerous tumor is found, this is not yet a guarantee for a lastingly effective drug. In addition, you also need to have basic knowledge of the causal growth laws of a tumor and the basic laws of biochemistry. The same goes for a vaccination against SARS-CoV-2.

### Along with these examples, I would like to make a fundamental statement about the hype surrounding AI today:

Some people believe that we are already walking on water and that all the problems in the world for the foreseeable future will be able to be solved with “AI”. But these AI methods are only successful if they are linked with the basic knowledge and theories from the respective areas of application (like in the examples of physics, biology and medicine mentioned above).

## AI transforms the world of work and our everyday lives

AI programs are not only used on organisms, robots and machines. Adaptive algorithms already control the processes of a networked world with an exponentially growing computing capacity. Without them, the flood of data on the internet that is generated by billions of sensors and networked devices would not be manageable. In addition, the sensors allow things to communicate with each other and not with people. This is why we often talk about the Internet of Things (IoT).

In the industrial internet (“Industry 4.0”), the Internet of Things is applied to both the industrial and the working world. Here, artificial intelligence and machine learning is integrated into work processes. Workpieces communicate with each other, with transport equipment and with the workers involved in order to flexibly organize the work process. This means that products can be manufactured individually, at the desired time and according to customer’s wishes. Technology, production and the market come together to form a socio-technical system that organizes itself flexibly and automatically adjusts itself to changing conditions or requirements. To do this, machine and sensor data has to be connected with text documents, recorded, transported, analyzed and communicated. ─



### Professor Dr. Klaus Mainzer

TUM Senior Excellence Faculty; Founding Director of the Munich Center for Technology in Society (MCTS), TUM; Senior Professor at the Carl Friedrich von Weizsäcker Center of the University of Tübingen; Professor of Philosophy and Philosophy of Science, TUM

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## Summary after COVID

AI is often portrayed as being a threat to the human workforce. But the coronavirus crisis has shown how AI and robotics can step in when humans fail and help to keep the economy going, how digital communication and health care can be supported, and how a solution in the form of a vaccination can be found if a machine learning process is combined with human intelligence. We may be faced with another, even more deadly pandemic than this one in the future. As such, it would be ideal if potential mutations in viruses could be simulated beforehand with AI, so that we can develop a toolbox to quickly put together a vaccination – almost with AI algorithms produced in advance.

To build people’s trust in AI tools, they must be certified just like all other technical tools. We are currently working on such “DIN standards” as part of a steering group to create an AI roadmap on behalf of the federal government of Germany. Ultimately, AI should be a service for us humans. As such, we also need to strengthen human judgement and value orientation, so that we do not let our use of algorithms and Big Data get out of hand.

# The Internet

## Critical Infrastructure and Motor for Economy and Society

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When people all over the world were forced to stay home because of the COVID pandemic and could not go to work, deal with customers, or go to school or to the theater, everyone became aware of just how essential a functioning communication infrastructure is for both our professional and private lives. In particular, well-known but little used online communication and information services such as video conferencing and collaboration tools, gaming, cloud services, audio and video streaming and many others, have moved to the foreground and have literally become vital to our everyday lives.

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As such, the coronavirus has been almost an “accelerator of digitalization”.

Cara Schwarz-Schilling

Social networks have become indispensable when it comes to keeping in contact with people in our private lives. Administration, trading, teaching, the entertainment industry, the healthcare system, as well as the media and politicians all use fixed and mobile networks for business and private communication. The consequence of this has been an explosion in data traffic traveling through global networks. The effect of the shift of many activities to the “virtual world” and the substitution of physical mobility by digital communication systems may even increase after the end of the pandemic. As such, the coronavirus has been almost an “accelerator of digitalization” (WIK2020). The functionality, performance, reliability, information security, autonomy of the infrastructure and above all the unimpeded access to it are therefore of strategic importance for living and surviving in a modern society. In addition, the internet, and more generally communication technologies, are increasingly being used as “basis infra-

structures” for other “critical infrastructures” such as energy, health or transport systems. The internet is and remains the “Infrastructure of infrastructures” and is the foundation for digitalization with growing importance both during and after the coronavirus crisis.

So the question is, to what extent can the internet continue to fulfil its tasks in the future and what challenges will it face to ensure the continuation of these tasks? The internet is not a God-given structure, instead it is constantly being expanded, maintained and developed further, all of which has to be controlled and financed somewhere. The decisive factors are who decides upon the further development of the internet, who primarily benefits economically or politically and how the internet should be designed in the future. Despite its central importance, the majority of the general public do not know which rules apply to who determines the internet. ►

During the coronavirus crisis the actually known weaknesses of the digital infrastructures have emerged:

- ▶ Insufficient transfer speed, particularly in the access network
- ▶ Lack of coverage with fiber networks and mobile networks
- ▶ Too long response times due to server overloading
- ▶ Not reliable enough
- ▶ Problems with information security and privacy protection
- ▶ Insufficient network neutrality

Other weaknesses that are just as dramatic but hardly noticed by the public include:

- ▶ Purely economic interests of stakeholders
- ▶ Extensive non-transparent accumulation of data, often on the verge of legality
- ▶ Non-transparent media with content that can barely be controlled
- ▶ The dominance of non-European system manufacturers
- ▶ The dominance of non-European platform operators
- ▶ The dominance of commercial interests
- ▶ Barely any apps from the EU/Germany
- ▶ Insufficient cyber security
- ▶ A lack of global governance
- ▶ Insufficient digital literacy of governments, citizens, institutions and businesses

The mentioned deficits are only partially of a technical nature and actually lie primarily in political, economic and legal areas and they go beyond the established legal and social order.

When discussing the resulting challenges and solutions, the basic structure of the internet has to be kept in mind. There are three main levels:

- ▶ Technical transport infrastructures (e.g. copper / fiber networks, mobile networks, software for network operation, e.g. communication protocols as “rules”)
- ▶ Forms of access (end devices, web browsers, search engines) and application programs (apps)
- ▶ Content (e.g. in the World Wide Web), data and services

The immense growth of the internet is all due to this “layering”, as the three levels can develop relatively independently from each other. Different players (stakeholders) from the government, businesses and society play important roles in each of the three levels and are largely responsible for determining the structures and properties of the internet. From a technological point of view, the internet consists of a variety of hardware

and software subsystems (routers, transmission systems, servers, cloud computers, end devices, operating systems, online platforms, etc.), on which the applications are based and content is offered.

The technological further development continues, uninterrupted, driven by users’ requirements and the economic interests of the manufacturers. One example of this are mobile networks with their continuous new system generations (3G, 4G, 5G...). Today, this variety of products predominantly comes from companies that are not based in Europe but in Asia and the USA. Only in the basic infrastructure system sector there are two global market players in the EU (Ericsson and Nokia). This means a significant dependence on third parties and a lack of technological and digital sovereignty so “the ability of a state or society to implement political and social priorities without being hindered by an insufficient or lack of control over technology. Such technological sovereignty must be distinguished from self-sufficiency on the one hand and from outside control on the other.” (VDE2020). It is an undisputed fact that complex infrastructure systems can only be set up cost-effectively and operated efficiently through global division of labor and global supply chains. As such, it is all the more important to focus on the risk of dependencies.

Apart from regaining a certain technological, and especially digital, sovereignty (Bey2018) in research and product development, the expansion of the technical infrastructure must be considerably intensified in the future. This concerns both the area-wide expansion of fiber and mobile networks, as well as computer and server systems and the associated software, especially in public administrations and businesses. It is doubtful whether the noble goal of the coalition agreement to provide every household in Germany with a “gigabit connection” by 2025 can still be achieved. **Other industrial countries are significantly ahead of us here.**

As a general rule, the expansion of the infrastructure is decided upon by private companies. The investors and operators of the networks, platforms, servers, etc., primarily want to offer such systems and applications for economic reasons that allow them a reasonable return on investment. However, it has been shown in the past that “the market” does not regulate everything. Here, the state plays a key role in the sense of general interest, similar to the supply of water and electricity. **So far the state has been quite involved:** Access to the infrastructures is mostly regulated by law and (more or less) monitored by state authorities. The valuable frequency spectrum for the mobile network is government-owned. Usage rights are granted for a limited time and are linked to certain expansion conditions.

## What is clear:

The expansion of networks and provision of systems and resources for applications and content, as well as their development undoubtedly cost a lot of money. Ultimately, the users either pay directly or indirectly for the used services and content – whether as a paying customer of an internet service provider (ISP), or in the form of a radio and TV license fee or as a tax-payer or – more often than not – with their personal data. Today, a large part of the costs of the applications and content is covered by advertising revenues. There is nothing fundamentally wrong with that. However, in the meantime, powerful oligopolies developed.

Just think of companies like Google, Amazon and Facebook, but also Asian companies, which make useful applications, such as social networks, available to the community via their platforms and, due to the enormous number of users, occupy an incredibly powerful position, not only economically but also socio-politically. Here fundamental principles of the market economy are at stake, in which competition is encouraged and which should take place in an orderly manner in accordance with state rules. A special kind of power factor arises when the personal data of users can be accessed and used without their consent. State interference in the freedom to use the internet is increasing at an alarming rate e.g. through censorship and filtering a gateway points, not only in China. ▶

# The influence of Germany and Europe is dwindling steadily, be it in internet technologies, platforms or in apps and content.

Content is also increasingly being provided by so-called “content providers”, such as the media industry. The players that dominate here have a significant influence on the users, their purchasing behavior and social and political decisions. Here too, often imperceptibly, the users’ civil liberties are at risk. As such, in the future an even greater emphasis must be placed on guaranteeing so-called network neutrality, and in particular on the equal treatment of transfers in the internet and the non-discriminatory access when using data networks.

For many years now there have been established methods in place which prevent, or at least limit, violations of market economy rules and disadvantages to the detriment of market participants (customers) and society. One of these methods is “regulation”. They have been used with varying degrees of success in the telecommunications sector, but also in lots of other markets, such as the post market for example. This is already not simple at a national level and is even more difficult at an international level. This is where political and economic aspects come into play. **As such, we need to ask:** Who actually “rules” the internet (FES 2019)? There is a wide range of different “stakeholders” in the different levels of the internet and therefore there is no single answer to this question. **Only one thing is obvious:** The influence of Germany and Europe

is dwindling steadily, be it in internet technologies, platforms or in apps and content. After all, there are also hopeful signs of European strength – if everyone involved agrees. A good example is the EU General Data Protection Regulation which is respected worldwide (cf. the article “Privacy and Big Data” in this brochure). The partial successes in Brussels in the proceedings against Microsoft and Google for violations of antitrust law also give reason for optimism.

If, in the future, the internet is to

- ▶ take a positive development in the sense of European values again and thus remain (or become again) open and free and
- ▶ not degenerate and become a commercially-dominated, non-transparent and partially undemocratic network, joint international efforts to create a global regulation are required (internet governance).

The Internet Governance Forum (IGF) is of central importance in these efforts. The IGF was established in 2006 by the United Nations (UN) and emerged from the UN World Summit on Information Society (WSIS). The aim of this was to overcome this digital divide. In the meantime, the IGF has become the central international forum on the future of internet governance and digital policy. The basic approach

of the IGF is to encourage different actors from different regions of the world to bring their own perspectives, discuss with each other and thus advance the decision-making process in other bodies, such as the UN, the Internet Society (ISOC), the Internet Engineering Task Force (IETF), the Organization for the Internet Corporation for Assigned Names and Numbers (ICANN), the European Union or the International Telecommunication Union (ITU), (FES2019). No wonder that there are still major global disputes about exactly how to implement this. This is where national governments and parliaments are also called up. So far, however, there has often been a lack of understanding of the connections. What is needed is a competent and effective body that can monitor the network infrastructure at all levels and ensure an adequate economic and political regulation.

The internet is the backbone of the information society and, with its abundance of applications, an essential prerequisite for the post-pandemic development of the economy and society. There is no doubt that there are considerable dangers to the positive further development of the internet. Now there are plenty of good opportunities to set the course for a global, efficient, open, sustainable and, above all, trustworthy communication and information infrastructure – a complete new beginning! ─



**Professor Dr.-Ing. Jörg Eberspächer**

Co-spokesperson of the TUM Senior Excellence Faculty; Co-founder and member of the Center for Digital Technology and Management (CDTM), Munich; Fraunhofer Medal (2015); Professor for Communication Networks, TUM



**Professor Dr. Dr. h.c. Manfred Broy**

TUM Senior Excellence Faculty; Leibniz Prize (1994); Konrad Zuse Medal (2007); Founding President and, until 2019, Scientific Director of the Center Digitization Bavaria; Professor for Software & Systems Engineering, TUM

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# Internet of Things

## as the Basis for New Intelligent Products

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The “Internet of Things” (IoT, also Cyber Physical Systems (CPS)) is easy to explain: After people and organizations were previously active on the internet and connected to one another via the internet, with IoT, artefacts (“things” such as components, machines, systems, etc.) can become independent actors on the internet.

IoT can support the individualization of market services and also a decentralization of added value.

### How did we get there?

Over the past few decades, classic physical products, particularly in the area of mechanical engineering (production machines, vehicles, plants, etc.), are increasingly being equipped with sensors and actuators in order to support or carry out control and regulation tasks. It is also becoming increasingly more common for these products to have control units built into them and these products have also increased in number and in the degree of networking. The terms mechatronics, and more recently adaptronics have become established. Computer performance has increased and has become more “intelligent” as approaches of artificial intelligence (AI) and contact options to the environment have been integrated. This has enabled the classic regulatory functionality to be implemented along with the ability to adapt to changing boundary conditions such as wear and tear or environmental variables.

You can find a wide variety of **examples** of this in household devices, production plants or vehicles and many other products.

With the advent of technology enhancement and the possibility of contact with the machine environment, the idea came up a few decades ago to use this for **remote work** such as maintenance by software updates. Examples of this include the transfer of updated software for the control or the querying of status data. The transfer paths are usually predefined or explicitly agreed upon between the players (usually manufacturers and customers or operators). The effort needed for the necessary infrastructure was high and costly. Satellite-supported connections and ISDN lines were used. More recently, additional radio connections, such as those used for vehicles or in agricultural technology, have been added.

### What does the IoT change and what is needed for this?

The **technology** needed for this is inexpensive and powerful electronic hardware (sensors, memories, computers, wireless, ...), the infrastructure of the internet with a massively extended option of address assignment (IP addresses), as well as a significant increase in bandwidths. These technologies are becoming increasingly available.

With the increasing number of technical artefacts that deliver and exchange data, more questions now arise about the recording, storage and analysis of the data, as well as the conclusions made based on the analysis results. Here hardware and current software developments come together, but there are still issues relating to the security of data and connections as well as legal issues that need to be clarified. As the internet is a system that is driven and used globally, there is still a need for action in the latter areas. Important and increasingly available components include means of data storage in clouds, as well as methods from the areas of Big Data / data analytics and artificial intelligence (AI).

The possibilities offered by IoT can have direct effects on business models, as the relationship between manufacturers, retailers, customers and operators can change considerably. Examples of already existing, about to be implemented as well as visionary applications illustrate this. ►

## Usage potential of IoT

Artefacts “know” their **identity** with parentage, history and status, for example, the forerunner product, design parameters, manufacturing process and result, the current wear situation and environmental conditions. This means that artefacts can provide information about their entire life cycle, for example during the manufacturing process, in case of service or during recycling. A tracing of the history of the artefacts is also given in very detailed form.

IoT can support the **individualization** of market services and also a **decentralization** of added value. As a result, economic potentials can also be realized by reducing the use of resources, since use and consumption data can be identified.

**Business models** on a “pay per use” basis are supported and can be improved or expanded. But also the legal relationships between manufacturers, customers, users, etc., changes as questions of responsibility and liability, as well as access rights to the artefacts, have to be redefined and agreed upon. Examples of this are needs-oriented maintenance or operator models that guarantee certain services and can in some cases correspond to the “pay per use” model. Sharing systems (car-sharing, bike-sharing, etc.) are more well-known examples, but they have also been used in an industrial context for a while.

Valuable knowledge can be gained for the conception, design and manufacturing of **successor products**, as extensive application and usage data can be obtained and evaluated. However, this certainly did not exhaust the potential for use. The subsequent **areas of application** give concrete form to this topic, however they are only examples given the multitude of possibilities.

For several years now, one of the central subjects in research and practice in production technology has been “**Industry 4.0**”. This covers the entire value-added network, including the development, manufacturing, service and logistics, and should help to increase productivity, flexibility and quality, as well as helping to generate additional knowledge in this area. Within the context of Industry 4.0, the IoT approach is supplemented by “digital twins” (up-to-date digital image of the objects concerned, such as components, assemblies or product machines, for example), augmented reality,

Big Data and data analytics, as well as AI. The basic digitalization approaches in manufacturing processes (i.e. 3D printing), as well as the use of robots in production and logistics all support the endeavors of Industry 4.0.

Another complex subject area is **energy supply**, which is experiencing massive decentralization with regards to the generation of electricity. IoT technologies can help in this area by providing better and forward-looking knowledge on the generation side (wind power, solar power, biogas, etc.) and the user side (industry, public sector, private homes), as well as by having an appropriate and adequate influence on these sources and sinks, in connection with the available networks in each case.

The “intelligent” city of the future is referred to with the term “**Smart City**”. The networking of the transport systems, information about the number of passengers using public transport, current traffic and parking situations and reliable proposals based on this are just some examples of how IoT technologies could be used in the area of mobility.

The use of IoT in healthcare provision, the agri-food industry and **in many other areas** offers many benefits.

In general, IoT can help to increase the **resilience** of our systems and to make the economy more **sustainable**. However, to the detriment of resilience, the IoT also harbors new dangers that must be countered (the security of the systems, data security, misuse). With regards to the sustainability, while there is a high potential in terms of resource savings, the additional investment and energy required, particularly the energy used by the data centers required to operate the cloud, is another disadvantage of IoT.

In any case, the challenge is to use **data** more intensively in Europe and Germany as a basis for business models and to support our own infrastructures and companies. In the future, IoT will be a powerful data supplier, however it will require “intelligent” evaluations with data analytics/AI. This will require a regulation that does not prevent innovation, but does prevent market domination and therefore ensures the “digital sovereignty”.

**It is therefore important to continuously assess and evaluate all benefits and costs. In any case, an agile, creative and forward-looking behavior is required, in order to create incremental as well as more disruptive “innovations”. ┘**

IoT technologies hold considerable potential for major **crisis** situations, like **pandemics** for example. The immediate recording of test result, the storage and privacy-respecting access to them allows for the analysis of individual results and the overall development. If a patient is treated at home, monitoring devices can transfer information about the condition of the patient as well as the condition of the devices to the relevant health center. Some technical devices that interact directly with ill patients can work largely autonomously, as they can exchange data with (technical) surrounding environment if necessary. As such, the use of the internet is no longer “only” restricted to holding video conferences as sensors and analytics can also be distributed and used on-site and at home. This means that services such as telemedicine, for example, can be supported by on-site analytics and sensors.

**Prerequisites** may relate to the infrastructure (data network, data centers), the security measures for networks and data, the adapted legal framework (data protection, data usage rights, labor laws, telemedicine laws, etc.), the training and further training (IT, data management, creativity, understanding of systems, etc.) and the further development or recreation of business models. All institutions and the entire population must be involved here, as without a future-oriented discourse on the design of these usage options and the newly balanced legal and ethical framework, a wide variety of options remain open.



**Professor Dr.-Ing. Udo Lindemann**  
TUM Senior Excellence Faculty;  
VDI Ring of Honor (1986);  
Former Chair of the Senate,  
TUM; Member of the Bavarian  
Economy Future Foundation;  
Professor for Product  
Development, TUM



**Professor Dr. Helmut Krcmar**  
IBM Faculty Award (2016);  
Founding Dean of the TUM  
Campus Heilbronn;  
Professor for Computer  
Science in Economics, TUM

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# Digitalization as a Normative Force of the Factual

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The coronavirus crisis has also been a challenge for the law: How can you shape preventative health care, economic and political framework conditions and, more generally, the way people treat one another during a pandemic? One might think that now is the hour of justice, the purpose of the law is, after all, to resolve conflicts and even handle crises, or at least make a significant contribution to the handling of crises. But is it right if people can no longer exercise their basic human rights? Is the current compulsion in digitalization a normative force of the factual?

┌ In this situation the exercise of civil liberties is “life-threatening” and their restriction is justified.

## A health and economic crisis – a challenge for the law

**Firstly:** The law “applies” even in emergencies, like pandemics, and is not simply overridden. Even if it may put people’s health at risk, for example guaranteeing the right for people to gather in their hundreds in a small space, or if an at-risk patient with a pre-existing condition must obey court summons and act as a witness in court proceedings or must be present as a member of the jury, laws or obligations do not simply lose their validity overnight. **It can, however, be restricted or suspended with special regulations:** The law takes into account the fact that such emergencies may occur and provides instruments that allow us to combat the inherent danger. For example, in Section 28 of the *Infektionsschutzgesetz* [German Infection Protection Act]: “If... a suspected contagion ... is found, the competent authority shall take the necessary protective measures ...; in particular, these measure may oblige people to not leave the place where they are located, or only leave it under certain conditions, or ... to not go to public spaces, or only to do so under certain conditions.” Such protective measures in the form of contact and movement restrictions, supplemented with the obligation to wear face masks in certain places, have been put in place in accordance with the infection situation since the World Health Organization (WHO) determined the presence of a pandemic on the 11<sup>th</sup> of March 2020.

## Clash of fundamental rights: Not the end, but the test of the rule of law

It goes without saying that such restrictions on movement and contact infringe on citizen’s fundamental rights, for example in the general freedom of movement (Art. 11 GG [Basic Law for the Federal Republic of Germany]), the right to freedom of assembly (Art. 8 GG), the freedom of religion (Art. 4 GG), but also the freedom of profession (Art. 12 GG). Those who did not recognize or do not want to recognize the danger posed by the virus and the specific risks of a pandemic, see the restrictions of freedom that have been introduced and see the “state of law in danger” or see the virus as “the final nail in democracy’s coffin”.

In doing so, they overlook the clash of fundamental rights that is inherent to the pandemic. **The state has a duty to protect the life and health of the population** (Art. 2, Para. 2 GG) **and must find a (reasonable) balance between the colliding fundamental rights.** Close contact between many people during gatherings, visits to places of worship, in restaurants, at cultural or sporting events or in shops is unavoidable and leads to an uncontrollable, rapid spread of the virus. This can overwhelm healthcare system and result in many deaths. In this situation, the exercise of civil liberties is “life-threatening” and their restriction is justified. ►

### Fundamental freedom also includes insight into necessity

The numerous decisions made by the German Federal Constitutional Court, the Bavarian Constitutional Court and other courts, have shown that this weighing up initially favored the provision of healthcare, although this was somewhat relativized over time. Even the fact that we are able to call the courts at any time to check the legitimacy of the restrictions on fundamental rights shows the functionality of the constitutional state. The fact that this is sometimes questioned even by renowned scientists is perhaps due to the fact that many people are currently experiencing (survival) conditions that they have never experienced before in their lives, which makes it difficult for them to classify the measures subjectively. This, however, does not affect the necessity of the protective measures and the constitutionality of right restrictions during a pandemic. As Matthias Friehe correctly explains: "Having the impression that only authoritarian states could manage a healthcare crisis of this scale would be a fatal long-term consequence of the coronavirus pandemic. That is why the enormous challenges of making the best possible decisions under the given circumstances must not be viewed as being a crisis of the constitutional state. Strict restrictions on civil liberties, which are democratically legitimate and are strictly oriented towards the necessary and appropriate measures needed to combat the epidemic have nothing in common with the conduct of authoritarian states. Part of the freedom of a free society is understanding the necessity."

### Not too little rule of law, but not enough digitalization

While constitutional law and law to prevent threats do provide answers to the challenges of a pandemic, they also show deficits in dealing with global crises resulting from the long neglected digitalization of administrative processes and services. An example of this is the lack of digitalization of the reporting processes of the over 400 public health authorities in Germany, as well as a lack of a corresponding network with the Robert Koch Institute, but also the generally delayed construction of the telematics infrastructure. After a 15-year long political dispute about the establishment of electronic health insurance cards in Germany, with data protection concerns raised in some places, the first law on the protection of electronic patient data in the telematics infrastructure was passed in 2020 (Patientendaten-Schutz-Gesetz) and has provided the necessary digitalization boost in medical practices, hospitals, pharmacies, laboratories and for health insurance providers. But it is not only in the healthcare sector that the processes are often outdated and insufficient. **The pandemic has also**

**highlighted past mistakes in many areas of government administration:** Whether it be in schools, which seem to be far removed from digital education, or in public authorities, which have been unable to adequately carry out their administrative tasks during the pandemic as they depend on the presence of civil servants and citizens in person which is impossible during this period of strict contact restrictions. **However, the pandemic does not protect against illegal activity:** For example, a draft bill to exclude the public from court proceedings during the pandemic was planned, even though a "digital jury" would be possible, as Anne Paschke described in detail in 2018. It seems almost cynical how mercilessly the pandemic has revealed the lack of digitalization in all areas of life: There is a lack of equipment, hardware and software, networking and automation and, here and there, perhaps even a lack of willingness to change. The only rudimentary aspect missing, is the legal basis. While the last legal loopholes in healthcare, for example, are now being closed, there have been several eGovernment Acts for the general administration in existence for many years now which allow for electronic communication and the management of electronic files and digital business processes without media disruption. They simply need to be applied. Data protection law, particularly the GDPR, does not hinder digitalization, as shown in the Bavarian Industry Association study "*Digitale Bildung. Lösungsvorschläge zum Datenschutz im Schulverhältnis*" [Digital Education. Proposed Solutions for Data Protection in Schools] from 2019. Instead, it is important that such processes are designed in accordance with data protection regulations, while also considering value creation and sustainability. **This is also the greatest challenge, as it requires an interdisciplinary approach:** Programmers must work hand in hand with lawyers, data economists and social scientists to come up with valuable, legally compliant and ethically sound products and services that combine technical progress with economic success and a high acceptance among users. The project ContactTUM shows how this can work. For this project, scientists from various different disciplines at the Technical University of Munich worked together to develop a concept for a data protection-compliant, user-friendly coronavirus warning app.

### Create closeness despite distance

Digitization is the natural answer to the challenges of a society which has to live at distance indefinitely. It creates a normative force of the factual, but should soon be a factual component of all standards. The associated challenges, such as data protection, data security or authenticity, can be mastered. The newly-established TUM Center for Digital Public Services contributes to this as a research center for the design of the "digital administration". ┘

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Part of the freedom of a free society is understanding the necessity.

Matthias Friehe



**Professor Dr. Dirk Heckmann**

Judge at the Bavarian Constitutional Court and Member of the Data Ethics Committee of the Federal Government; Center for Digital Public Services, TUM; Professor for Law and Security in Digitization, TUM

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# Privacy in the Age of Big Data

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**The protection of privacy is a central right, at least in the Western hemisphere (“My home is my castle”). The right to privacy is one of our rights to freedom and is an important foundation for the free development and expansion of a person’s personality. A society, that can no longer guarantee citizens’ sphere of freedom, cannot maintain the social diversity, out of which an open and free discourse can emerge (LEO 2018).**

**In the course of digitalization, almost all areas of our lives present new challenges for state and society, which have been massively intensified due to the dramatic changes brought about by the coronavirus crisis.**

One key characteristic of digitalization is the central importance of digital, i.e. computer-compatible, data. The amount of data generated and processed is constantly increasing. Sources of data include sensors (such as cameras, fitness trackers, smart-phones), computer programs and, above all, the user themselves if they knowingly or unknowingly leave data traces when shopping or using modern navigation devices, for example. Often this data is aggregated or anonymous. At the same time, applications often offer particular advantages that are tailored to the individual user, but this requires the disclosure of personal data.

The data is analyzed with “intelligent” mathematical methods (“artificial intelligence”, algorithms), linked if needed and then used in applications. This means that relationships that often go beyond the perception and judgement of the individual can be identified. Thus, decision making is easier and persons responsible for making decisions are better prepared.

With the growing variety of useful digital applications and the increasing quantities of private data that are (or can be) evaluated, there is a higher risk of peoples’ privacy being infringed. Sharing large parts of private lives and activities can increase the possibilities of social control and can, under certain circumstances, lead to subtle or open discrimination. In addition, such risks exist because it is now easier for private and state players to monitor people (LEO 2018). You can already see some shocking examples of this today in China, for example, with their elaborate “Social Scoring System” (Wikipedia 2020), which has perhaps helped to limit the spread of the pandemic in China. Even the control of individual or social behavior that is not perceptible or only perceptible to a limited extent, including manipulation, is a particular danger in the “internet economy”.

It poses a threat to the central pillars of privacy protection. On the one hand, users are becoming increasingly careless with their personal data, particularly with the use of free applications (with private data being used as payment) and on the other hand, private and commercial institutions, as well as governments, are becoming increasingly interested in the data of users and citizens. Data ownership is a question of power!

However, the protection of the rights and privacy of users should not be seen as an obstacle to economic development and a curtailment of the possibilities of digitalization. Rather the implementation of user rights can – alongside the protec-

tion of fundamental rights as a value in itself – create a long-term locational advantage, because it enables users to trust both private providers and state institutions. Such trust is a prerequisite for sustainability and the long-term acceptance of digitalization (LEO 2018).

With regards to the protection of privacy, there has recently been a worrying paradigm shift, especially in the wake of the almost desperate search for measures to fight against the pandemic. Given the possibility of being able to better study how diseases spread through the analysis of data and the ability to develop measures to protect the health of millions of people, the fundamental task of protecting peoples’ privacy risks taking a back seat. This is even more the case when people are being increasingly careless with their own data, even before the coronavirus pandemic, in particular when it comes to social media and eCommerce.

**The question is:** To what extent can the existing legal regulations continue to maintain peoples’ privacy? In addition to protecting the individual against state authorities, there must also be adequate measures to protect people against the companies that (want to) use their data. The application of the law is made much more difficult as new technologies often breakdown boundaries. This means that the digital technologies and their infrastructure, the business models used and the services provided with digitized technology are not limited to a single region but are usually available transnationally or globally. As such, the law is faced with significant challenges (LEO 2018).

From an economic point of view, the digital transformation also encourages the building of the global positions of power of major companies such as Amazon, Facebook, etc. They occupy important market segments, which can lead to the suppression of competition and also, directly or indirectly, to the endangerment of the rights of freedom of individuals.

There is also a considerable lack of transparency in the use of digital technologies and with the handling of the corresponding business models. What data is used by whom, for how long and for what, and is it also passed on to foreign companies? This reduces the users’ trust in the security and legality of the “systems”. The first step was made towards a Europe-wide uniform establishment of data protection standards with the new EU General Data Protection Regulations (GDPR). ►

# Data ownership is a question of power!

The illustrated problems and challenges are not new, but they have come to light during the coronavirus pandemic and it has become clear that several identified fields of action must be urgently addressed post-COVID.

## System security and protection of privacy as relevant economic factors

System security and protection of privacy must be recognized as relevant economic factors and must not be neglected simply because they were not viewed as important in times of emergency and crisis. Security properties must be preventively built into systems and applications, something that has been propagandized as “Security by Design” for many years now (often in vain).

## Actually use technology

Today, it is essential to comprehensively use existing technology in practical systems to protect data from being attacked or misused. Discussions about the design of “coronavirus apps” have allowed the well-known problems and alternative solutions to be publicly discussed, and that is a good thing! Interdisciplinary research efforts are also required here so that technological, legal and ethical perspectives can be included and different science-based scenarios can be developed.

## Transnational governance

The legal challenges listed above require a range of measures, such as the creation of a “transnational governance” in the IT sector with the involvement of and cooperation with the

various different actors (politicians, companies, users). This is likely to be the biggest problem here as cultural differences (e.g. between Europe and Asia) and different legal frameworks play a major role. The mentioned risks of oligopolization must be countered by a global regulation of (partial) markets that is as uniform as possible.

## Strengthening the public discourse about the importance of privacy

After all, strengthening the social discourse about the importance of privacy and an understanding of the ethical standards in Big Data are now of crucial importance. Eventually, there should be an educational offensive to promote digital maturity for all age groups (LEO 2018).

## Maintaining sovereignty over your own data

This can also make people more aware that data economy is actually worthwhile and that there are disadvantages if you, as a user, give up “sovereignty of your own data” in favor of supposed or actual useful “services”. For example, every user must decide, according to the situation, where and when they want or should share their location and / or specific health information for health reasons. As such, greater transparency with regards to the use of data is urgently needed. In view of the rapid medical-technological progress, these aspects will become even more important in the future. For technical reasons, the requirement for a “digital eraser” does not seem realistic because once data is online, it is often used further and the “secondary data” that is created can often not be traced back to the original source. Data linking is a key success factor for the use of AI and Big Data processes!

## Control of algorithms used

There is also a demand for better control over the algorithms used in the digital systems. While this does clash with the understandable commercial interests of some providers, this is precisely why it is an important subject, as is the ongoing issue of the extent to which individual personal data is required in applications at all or whether in many cases anonymized data is not sufficient to achieve the intended purpose. Since the coronavirus crisis this has also been discussed in public more than before.

The coronavirus crisis has made the potential of digitalization and the use of Big Data visible, as if under a burning glass, but it has also made the risks of an uncontrolled use and the danger of a massive infringement of privacy clear. The outlined options for action make it possible to use modern technology sensibly while protecting individuals’ right to privacy and therefore strengthening our democratic society. ┘



**Professor Dr.-Ing. Jörg Eberspächer**  
Co-spokesperson of the TUM Senior Excellence Faculty; Co-founder and member of the Center for Digital Technology and Management (CDTM), Munich; Fraunhofer Medal (2015); Professor for Communication Networks, TUM

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# Technological Sovereignty

**Lockdown: Production has been restricted or brought to a complete stop; borders are closed; supply chains have been interrupted. A scenario that no-one could have imagined at the start of the year 2020 has now suddenly become a reality.**

This situation had an immediate impact on us and showed how drastically the failure of individual elements affects the close interlinking of the value chains in our economy and how heavily our lives depend on uninterrupted international collaborations.<sup>1</sup> The recent discussions about the distribution of the vaccines against the coronavirus have once again made it clear that access to key resources and technologies is not available to everyone at all times. It is therefore imperative to identify areas in which sovereign action is required for services of general public interest and for our economy.

## Sovereignty and “technological sovereignty”

The term “sovereignty” refers to the independence of a state from the influence of other states but also to the right of a state to act freely at its own discretion. Main characteristics of sovereignty include the ability and the factual opportunity to act independently and autonomously. Sovereignty is differentiated from autarchy on the one hand, and outside control on the other. As such, “technological sovereignty” means being able to act independently and autonomously with regards to technology.

Given the essential importance of all types of technology in our lives, and the close international networking and dependencies, the question arises to what extent is “technological sovereignty” needed and subsequently with which measures should this be achieved and to what extent.

**Here are two current examples of this:**

- ▶ The COVID pandemic has shown, that many countries did not have sufficient quantities of basic medical resources available. Due to a lack of in-country production capacities, we were largely left dependent on insufficient deliveries from the Far East, meaning that we were unable to confidently supply our medical sector with an adequate number of protective masks, for example. One of the aims of technological sovereignty is to make sure that we maintain a certain production capacity either nationally or within the EU.
- ▶ Our communication networks have mostly successfully dealt with the increased traffic, e.g. due to working from home, home schooling, increased video conferences, etc. Clearly, the telecommunications sector in Germany has been able to meet the challenges in terms of network planning and operation. A further aim of technological sovereignty is maintaining this ability, as well as the ability to develop the required technology in the EU.

As our lives are highly dependent on technology, we must comprehensively deal with the question of technological sovereignty. A long-term, forward-looking, overarching strategic and political positioning that is aligned with societal well-being is required. The Information Technology Society in the VDE (VDE ITG) presented a position paper on “Technological Sovereignty”<sup>2</sup> at the VDE Tec Summit at the End of February 2020 and in it, outlined a method for systematically identifying relevant fields of technology and for finding which type of sovereign action is required in each case.

## Dimensions of “technological sovereignty”

**In order to make technological sovereignty tangible, several aspects must be put in relation to one another:**

- ▶ The first aspect (dimension) concerns the technology itself, split into fields of technology. These should be as concrete as possible, while being abstract at the same time so that the assignments can be long-term. The term “field of technology” refers to larger technical systems which carry out various different core functions. The technology used for these core functions can change relatively quickly. For example, core ICT tasks include transporting, preparing, storing and processing information. The technology used to transport information is changing constantly (e.g. 3G ▶ 4G ▶ 5G). With this approach, fields of technology can be identified in all different sectors, such as the energy sector or in healthcare, pharmaceuticals, software, biotechnology, etc.
- ▶ The second dimension is the industries of our economy, whose companies are dependent on sovereign access to certain technologies in order to generate their added value. If a field of technology is essential to a range of different industries then a high degree of sovereignty should be available with regards to this technology. The importance of the industries can be seen through key figures, such as their share of the GDP. Along with the industries, you could also include government players, e.g. the departments responsible for domestic security.
- ▶ The third dimension covers the requirements for sovereignty along a general value chain. Is this about the building up of knowledge through training, about research and product development, about production capacities, about the operation of technical products, or “just” about their use by the end user? This allows for concrete, specific requirements for “technological sovereignty” for technologies to be recorded and evaluated. ▶

In principle, education, knowledge and at least research to some degree is needed in order to be able to determine which technologies could become relevant. To achieve a competitive advantage, it may be necessary to have sovereign control of the product development and/or production, depending on the technology.

## Requirements for technological sovereignty

In order to have sovereign control of technologies because of their economic, social and political relevance there are – in the coordinate system illustrated above – two key questions that need to be answered: How relevant is a field of technology or a technology for our society? Which specific characteristics of technological sovereignty should we possess for the most relevant fields of technology or technologies?

### Five criteria are proposed to help determine the relevance of fields of technology.

(1) The economic benefit covers the aggregated economic performance of the industries for which the technology field is relevant, weighted as a percentage with the leverage effect of a technology field for an industry (e.g. ICT in automation technology).

(2) The future viability of a technology includes the capacity for innovation which forms the basis for the future competitiveness. The more applications in which a technology drives innovation forward, the more relevant it is (e.g. AI).

(3) The coronavirus pandemic has revealed that technology's importance for the services of general public interest must be an essential criterion. The "against" demonstrations have shown that this also requires social acceptance.

(4) Cyber security is just one aspect of "security". How relevant is a technology field to the implementation of our domestic and foreign policy? This also includes the security of supply and resilience of infrastructure.

(5) Finally, in view of the ongoing fight to tackle climate change, the sustainability of a field of technology should also always be considered.

Which specific characteristics of "sovereign action" do we need with regards to the technologies that have been prioritized according to relevance? A manufacturing company has completely different requirements in terms of sovereign action when compared to a network operator or end user, or even the government with its institutions and its responsibility for social cohesion. It is therefore advisable to structure the requirements for "sovereign action" along the value chain: (1) knowledge sovereignty, (2) research sovereignty, (3) infrastructure

sovereignty, (4) data sovereignty, (5) transparency sovereignty, (6) development sovereignty, (7) production sovereignty, (8) platform sovereignty, (9) operational sovereignty. To make requirements comparable, it makes sense to define degrees of sovereignty which range from self-sufficiency to complete dependence on third parties.

## Application of the methodology

If you consistently apply the outlined methodology with the three dimensions, the evaluation – the relevance – of the technologies, and the determination of the required degree of sovereignty, the result is a framework that allows for a qualified assessment of technologies and the necessary degree of sovereignty – not as an exact algorithm, but as a basis for a structured discussion among experts and that can be used to come up with recommendations.



**Dr.-Ing. Klaus Illgner**  
Member of the Board of the Information Technology Society (ITG) in the VDE; CTO K|Lens GmbH



**Sigurd Schuster**  
Member of the Board of the Information Technology Society (ITG) in the VDE; Senior Representative Ecosystem Relations, Nokia; Independent Management Consultant

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## Post-COVID Insights

As a result of the COVID pandemic, we have to think in terms of (complex) systems as only bringing together specific knowledge from various different areas (domains) gives us a comprehensive picture of the really relevant requirements for sovereign action. The increasingly important interdisciplinary interaction beyond the boundaries of fields of technology can only be successful if there is sufficient sovereignty in all fields of technology involved.

The COVID pandemic and its effects have made it clear that we need a forward-looking, systematic gathering of requirements for an ability to act as sovereign. For this purpose, it is sensible to use the outlined methodology to identify relevant fields of technology across all industries and fields of application and to record the requirements for sovereign action along a value chain for the fields of technology.

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05

# HABITATS, RURRALITY, URBANITY & MOBILITY



# Does the Countryside Now Have a Future Again?

Where has the confidence gone? “Das Land hat Zukunft. Neue Perspektiven für die ländlichen Räume” [“The countryside has a future. New perspectives for rural areas”] – such was the title of the anthology published by Alois Glück and Holger Magel in 1990. Following from the Campaign for Rural Areas of the Council of Europe in 1988, there was a sense of elation everywhere. The reunification of Germany in 1990 gave a further boost to rural development and rural areas as well as political and financial attention although not always in the desired, and above all else, sustainable ecological or spatial degree of coverage or quality.

After 30 years of consistent efforts and a variety of structural policies, it is regrettably evident that the sense of optimism for rural areas and the belief in a future for the countryside have both dwindled considerably. The rural exodus has become a Europe-wide phenomenon which is continuing, even in prosperous Germany. Farmers are becoming fewer in number, as is agricultural land, which is also being put to intense use and is becoming increasingly polluted, and is less useful and fertile due to climate change. Towns and cities are considered “in”, and the age of urbanism is being celebrated! New city dwellers only consider the countryside to be a place for weekend recreation, or use it as a peri-urban place in which to live and sleep. Despite almost desperate and thoroughly commendable efforts by politicians, the former agricultural heartland of Bavaria also appears to be losing its rural character and its independent rural vitality. Booming cities such as Munich act like vacuum cleaners, changing their rural surroundings into conglomerate areas (also known as conurbations), and permanently depriving the more distant rural areas of their workforce, especially young people, and in doing so, their most important resource for the future. Meanwhile, those who can (not) afford it stay in the countryside, and join the daily commuter madness.

Is the resulting game of hare and hedgehog – as soon as rural areas have gained some ground, cities pull away again due to the unchecked expansion of new high-tech companies and the creative industries, drawing in the rural workforce – a law of nature? Or is it actually the result of the current “institutional economic regime” which, whether strictly or excessively, follows the “logic of the economy, the markets and the accumulation of capital” (Hartmut Rosa)? Is this the result of decades of vain appeals to the brick walls of sector-based policies, lobbying and narrow-minded economic thinking? Not to mention the defensive responses, such as: “But what do you want? Prosperity has increased. The environment may have been negatively affected, and that is something that needs to be addressed; but it is generally a sacrifice worth making. We are not paid for a long-term approach to thinking and investment.”

## After the coronavirus – Is everything different now?

Several voices are now arguing for a change of direction. ZEIT columnist Uwe Jean Heuser talks about “giving the recovery efforts a direction”, to which the world of business and we add: making life as a whole more green and more digital. Not out of a sense of emotion, out of a love for nature or the high minded desire to save the world, but simply because of the facts, such as they are described here several times – because of science, reason and sustainability! The coronavirus pandemic has not brought new insights into the state of the world, society or the urban rural relations – it has simply opened the eyes and the awareness of society to how unstable and rapidly endangered our “globalized” economic model and lifestyles are. It has also provided a very decisive insight, as highlighted by Hartmut Rosa in his essay “Wir können die Welt verändern” [“We can change the world”]. Namely, the restoration of the primacy of politics

and therefore collective self-efficacy. For Rosa, this is the key new development of the current crisis. Those who have become accustomed to a longstanding sense of political and civic powerlessness can now see that something is happening which had always been considered impossible (Armin Nassehi, quoted in Rosa). It is now necessary for all of us, especially the world of politics – supported by experts – which has gained an unprecedented degree of importance in the coronavirus pandemic, to do the right thing for a “reboot” and/or rebuilding of Europe. That does not mean getting everything back up to speed as quickly as possible (and at the same time – as requested by trade associations and chambers of industry and commerce – to throw climate goals and other priorities such as reducing land use out of the window), but to reinvent a “stabilization mode”. And to use the new power of politics and the support of society to bring about a fundamental paradigm shift! In “ARD extra” on 22.05.2020, President of the Bundestag Wolfgang Schäuble made a point of mentioning the three challenges of the future after or in spite of the coronavirus pandemic: climate change, loss of biodiversity and the dramatic increase in land use. Mastering these challenges together with the many tasks caused by the coronavirus is now necessary; as Hannah Arendt once said (quoted in Rosa) “to leave well-worn paths behind, to finish with the current responses and chains of response, and to bring about something genuinely new as creative and active players.”

## A new future for the countryside?

Bringing about something genuinely new, or finally doing something, and realizing the long-available creative ideas for strengthening rural areas that have been ignored due to the prevailing approach and the “institutionalized dynamics of growth” which have existed up to now. The coronavirus crisis has highlighted the weaknesses of the globalized economy and the necessity of regional cycles, the considerable importance of decentralized health care, and the value of rural living in comparison with the more heat- and disease-prone, and now disease-ridden, big cities. Those who have been living in the countryside during this period, rather than a big city with its coronavirus super-spreader beer festivals, have been able to appreciate the advantages of rural life once again. Niall Ferguson, for example, reflected on this in his remarkable article in the commentary section of NZZ on 18.5.2020 “Das Dorf ist in, Metropolen sind out” [“The village is in, big cities are out”], and Katharina Bracher in her article entitled “Kommt jetzt die große Stadtfucht? Warum über unserem Sehnsuchtsort (Anmerkung: gemeint ist die Stadt) bald die Sonne untergehen könnte” [“Has the great urban exodus begun? Why the sun could soon set on (note: the cities) where we really want to be.”]. Does that mean that the countryside has a new future? If only it weren’t for its deficits which we are all too familiar, such as skilled jobs that are within easy reach, public transport and mobility chains which are appropriate for all generations and accessible to all areas, reliable broadband supply and digitalization, local amenities and educational services, and finally, continued loss of landscape, agricultural diversity and ecological stability! ►

The list of shortcomings is well known in the worlds of politics and science and in society as a whole. Depending on personal perspective and the statistics, the current situation is viewed positively or negatively. There appears to be no objective or universally-accepted standard that is able to cover all aspects of human life in an unbiased and neutral way. Thus, the intention of the federal government to subject all government actions and/or financial support programs to an equivalence check in the future sounds interesting. However, Horst Seehofer, Minister for Spatial Planning, has not mentioned which criteria should be used to determine the impact on the equivalence of living conditions. Unfortunately, the responsible commission has failed to define the constitutional equivalent living conditions more accurately, let alone operationalize it. In the future, it will therefore be impossible to judge by consensus whether the much-vaunted balance between town and country exists in Germany, and how rural areas can be given a better future through a necessary change of direction in spatial planning, agricultural, economic, infrastructure, social and educational policies.

### Science, sustainability, reason – it is high time for research into equivalence in Bavaria ...

... to achieve a better future by changing direction to something genuinely new. But what kind of new? To make a change, methodological principles regarding measuring, analysis and evaluation are required. To adapt Hölderlin's much-quoted saying, a method has long been available: It is the model of spatial justice developed by Magel / Miosga in the context of their participation in the enquiry commission on "Equivalent Living Conditions throughout Bavaria", with its four dimensions of justice (opportunity, distribution, procedural and generational justice) as the ethical and (technical) political basis of the goals of equivalence. This was unanimously adopted by the commission and is used as a basis for the further discussions. It could also help to address and resolve rural deficits and needs for action in a more individual and specific way – on the basis of discussions with the ideas in the respective region – rather than offering the frequently-criticized generalized support packages. It could also contribute to shedding light on the discussions surrounding development steps that involve land use. The task is to now further refine and develop the model on a more scientific basis.

Unfortunately, the government of the federal state has not yet awarded a respective research project, although this has been recommended by the commission. Now is the perfect opportunity for us to do everything we can to create a new and sustainable future for the rural areas that have been rediscovered as a result of the coronavirus pandemic – with the right approach to analysis and oversight! Having rediscovered its authority in the era of the coronavirus, this is another area in which the world of politics should take action. ─



**Professor Dr.-Ing. Holger Magel**

TUM Senior Excellence Faculty; Head of the Bavarian Authority for Rural Development (1995–1997); Honorary President of the Bavarian Academy for Rural Areas; Professor for Land Management TUM



**Professor Dr. Manfred Miosga**

Professor for Urban and Regional Development, University of Bayreuth

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# The village is in, big cities are out!

# Land Use Management

**Despite, or because of, the harsh restrictions that were introduced in response to the coronavirus pandemic in March 2020, we had one reassuring experience: Although everyday items such as toilet paper suddenly found themselves in short supply, food did not. Was, and is, our current agricultural sector – as the basis for our food supply – therefore equipped against pandemics and the resulting emergency situations?**

At first glance, this seems to be the case, as obviously there were sufficient stocks, the necessary supplies have been sufficient, and even hoarding has failed to significantly affect the availability and subsequent delivery.

In this respect, the current German (and also European) systems of agricultural production should be viewed in a positive light. Achieving high yields with the use of the natural site conditions is and remains a guarantor for a secure food supply. Existing regional delivery chains supply domestic markets quickly, reliably and with a limited impact on the environment. Fresh vegetables grown in the vicinity of major cities supplement the basic food supply. The extensive or full-scale avoidance of the use of chemical pesticides has increased the quality of the produce.

Despite these positives, however, this assessment must not overlook the obvious weaknesses and disadvantages of our agricultural production systems. Uniformly large fields, reduced crop rotations, a decline in the diversity of biotopes and species with the degradation of the cultivated landscape, high rates of nitrate pollution in the groundwater, mass livestock farming solely according to labor-economic, industrial-looking aspects, as well as the unscrupulous use of off-farm means of production rightly call the sustainability of agricultural production into question. Agriculture must meet economic, social, ecological and cultural requirements, whereby – in crisis situations in particular – food production and the economic viability of farms as enterprises take priority.

**From the economic perspective**, agriculture requires minimum sizes of farms, fields and livestock in order to reduce unproductive periods of preparation and non-productive time. In both livestock farming and – in particular – arable farming, a trend has emerged for the greatest possible degree of uniformity (homogeneity), which has become even stronger in modern, mechanized agriculture. This homogenization is ultimately inexpedient and even disadvantageous, as it fails to take location- and weather-related variability and, in the case of livestock, individual variability into account. In arable farming, therefore, the only possible solution is “precision farming”, which was developed by the lead author at TUM School of Life Sciences in Weihenstephan, and must become the farming method of the future. The same applies to livestock farming, with the feeding and rearing of individual animals or groups of livestock in the form of “precision livestock farming”. Both methods provide the basis for the effective use of individual capacities and, in arable farming and the use of meadows and pastures, create opportunities to use the land which becomes exempt from agricultural use for other purposes. Mineral fertilization must focus more strongly on site-specific and timely supply of nitrogen fertilizers in particular. The continuous monitoring of crops using aerial photographs from drones and/or satellites allows for small-scale developments to be tracked. In connection with precise knowledge of the location, weather conditions, sensors on the fertilizer unit and refined algorithms, including the use of artificial intelligence, this enables the use of mineral fertilizers which is largely adapted to requirements and loss-free at the same time.

The use of organic fertilizers is far more difficult, where liquid manure with strongly varying active agents and the requirement for emission-free and crop-appropriate application technology pose challenges. In the longer term, it will be inevitable to replace liquid by solid organic fertilizers which are directly fed into the root areas of the plants.

In crop protection, it is necessary for one-sided and purely prophylactic applications of chemical agents to be overcome. Resistance breeding, with its constantly evolving molecular capabilities, can restrict the use of insecticides and fungicides to exceptional situations. The use of herbicides can be almost completely eliminated by mechanical and new physical measures, such as the use of lasers, also in combination with satellite control.

Field robotics is therefore becoming the lead technology in crop protection. This can apply the necessary measures on a strictly limited, prompt and local basis. It also opens up completely new possibilities for sowing and harvesting special crops and is therefore able to greatly reduce the considerable manual seasonal workload.

Land management is **socially-sustainable** when agricultural produce is made available to the consumers on a reliable basis at affordable prices, largely without losses, and at high and consistent quality.

The greatest challenge, therefore, is the prevention of food losses. In particular, it is up to society to drastically reduce the current practice of throwing away around 25–30% of all food that is purchased – using digital options as well. If this were the case, agriculture would not have to produce ever increasing quantities of food, and the land not needed for their production could be used for other socially-beneficial requirements.

A comparably serious problem is that areas with best soils are increasingly being built upon with constructions for commercial and logistics purposes, which could often be built in regions with less fertile soil, where they would also create much-needed jobs. Finally, action must also be taken to prevent that soil as the basis of agricultural production is more and more abused as object of economic speculation. In this context, socially-sustainable land use requires socially-accepted rules for a balance to be achieved between producers, retailers and consumers, as otherwise producers and consumers will lose out.

**Ecologically**, the requirements outlined above will lead to changes in agricultural structures and forms of cultivation. All agriculture is based on the application of biological and ecological knowledge, but also on the unavoidable interventions into the natural environment and the soil, which must be both mitigated and balanced. In arable farming, the consistent basis for achieving this is multiple crop rotation. With such an approach, the development and spread of specific pests and weeds ►

**┌ Agriculture must meet economic, social, ecological and cultural requirements, whereby – in crisis situations in particular – food production and the economic viability of farms as enterprises take priority.**

can be prevented through minimum annual intervals between the individual crops and by adapting the sizes of fields. Perennial land cover and the retention of crop residues in the fields allow for the maintaining and enrichment of humus which secures the crop yields.

The soil must be protected fully against erosion. In largely flat and frequently cleared areas of arable farming, protection against wind erosion with the use of windbreak hedges is a top priority. The lighter and sandier the soil, the closer the distances between these breaks must be. Yield-reducing shading can be prevented by aligning the hedges to the direction of the compass and adjusting their height. Hedges furthermore serve as biotopes and refuges for rural flora and fauna, especially when they form a network across the fields. Thinking ahead, regional agroforestry systems can be developed on this basis.

As the slope of cultivated land increases, water erosion must also be prevented. On steep slopes, permanent grass cover with the necessary livestock farming is preferable. In between – and this applies to very large areas of land worldwide – the transition to “contour farming” is indispensable in arable farming. This can be achieved rapidly, adapted and, if necessary, modified by means of “Transborder Farming”, with the available experience, knowledge and tools of the departments for rural development.

Apart from the damage caused by water, which can be devastating and is often unavoidable due to erosion and flooding, water is set to become an increasingly scarce factor in land management, partly due to climate change. From the ecological perspective, the intensive research and breeding of drought-resistant crop species and varieties therefore is required, including cultivation in mixed cultures. Waterconserving techniques, and methods of irrigation with modified forms of cultivation in flat beds or with dams should also be developed.

**In terms of culture**, it is agriculture that has created and shaped the rural landscape. On the one hand, this has led to completely new biotopes for numerous animal and plant species spreading in cropfields, pastures and meadows and, on the other hand, it has created a variety of rural structures that have an aesthetic effect and serve as places of recreation, leisure and enjoyment for the urban population.

The modernization of agriculture, associated with the huge decline of the number of farms, has neglected the cultural and environmental values of the countryside, which now require a revival with new objectives. A concept for this, known as “differentiated land use”, has been developed and perfected by the second author since 1972, but it has not yet been possible for it to be implemented in agricultural policy. With a new social contract on agriculture, for which Weihenstephan offers the best conditions, it can once again turn its attention to its wide-ranging cultural relevance and values, and prevent irreversible damage to the landscape. ┘



**Professor Dr. Herrmann Auernhammer**  
TUM Senior Excellence Faculty; Winner of the German Environmental Award (2001) of The German Environmental Foundation (DBU); Professor for Technology in Crop Cultivation and Landscape Conservation, TUM



**Professor Dr. Dr. h.c. Wolfgang Haber**  
Winner of the German Environmental Award (1993) of The German Environmental Foundation (DBU); President of the International Association for Ecology (1990-1996). TUM Professor of Landscape Ecology (1966-1994)

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# Cities and Mobility

## Whether in the cities or conurbations of highly industrialized nations, or the rapidly-growing urban agglomerations in developing and threshold countries – to a great extent the quality of urban life depends on the quality of the existing mobility systems.

The reverse also applies, as is evidently the case at present: When life in the city dies, the available mobility also withers away – the harsh rules of the market economy, with the game of supply and demand, take effect. If there were no “system relevance” or basic supply chains and disposal chains, emergency services and necessary passenger transport to be maintained as a matter of course, the mobility systems would come to a complete standstill.

Accordingly, research in different countries consistently reveals that the pandemic has had a similar impact on mobility behavior and transport systems. Individual mobility is being reduced to fulfilling the minimal requirements, and is essentially taking place on foot and by bicycle, and if necessary by car, while distances and areas of travel have been significantly reduced, and public transport is only being used as a last resort. The supply and disposal chains, which usually function well under conditions of normally foreseeable demand, are increasingly reaching capacity limits and organizational hurdles, even though the infrastructure has been relieved considerably of other traffic. The otherwise pulsating “city with its system of mobility” as one of its key supply networks has suddenly ground to a halt, and is behaving completely differently.

It is not yet possible to forecast the extent to which these changes will revert to the previous situation during the gradual lifting of the lockdown measures or whether the effects will be long-lasting. It is feared, for instance, that the gradual return to the private car as the priority means of transport which can currently be seen to be taking place could stabilize, and therefore run counter to the efforts of cities to increase the use of public transport and reduce private transport. It is certainly to be expected that the huge change from physical to digital mobility forced by the pandemic measures will continue to a certain extent, or will significantly accelerate a trend which has anyway been present for some time. The very positive climate impact of the new transport trends are also clear, even if the absolute values are not certain in terms of the share accounted for by transport. Are there any experiences from this unexpected, disruptive phase that can be used for future developments in the area of mobility and provide useful information to the responsible organizations? Certainly! Despite all the worries and problems, the pandemic has also created opportunities: The opportunity for each individual to readjust their personal “mobility compass”, and for society to rethink and redesign mobility in towns and cities in a holistic way. This also includes gaining experiences from the behavior of the multimodal urban

passenger and freight transport system under extremely different conditions, and to subject it to critical questioning. The questions to be asked are: What is really necessary? What is desirable? What is superfluous? What can be resolved differently? The fundamental question, which is not at all new, but which must be asked more urgently than ever before, is: What kind of mobility is the shared goal of an urban society, and what kind of transport system is required to achieve it? I believe it is important to discuss this question on an intensive and holistic basis in society right now; under no circumstances should we wait until the post-pandemic situation has settled down again at some point, when the awareness for the drastically changed situation has diminished.

## Some example-based considerations and highlights:

Citizens have been forced to adapt to a different, reduced and new form of mobility in their city with almost no time to adjust. With drastically reduced public transport services and the prohibition of unnecessary travel, the achievability of key tasks in everyday life appears in a new light; proximity and local mobility instead of long-distance mobility are in demand, and neighborhood services are regaining importance again. The awareness for higher quality urban living in terms of a city with short distances in which it is pleasant to live could increase.

There is no doubt that the environmental impact of the reduced traffic has also been recognized and valued – the peace, with the twittering of birds instead of traffic noise, was possibly more dramatic than the reduction in the noiseless, invisible emissions. Regrettably, these impressions will fade away quickly. Noise levels are rising again as the restrictions are being lifted, and people are accepting it.

It is to be expected that the advantages of digital mobility (with internet shopping and working from home as the mainstays) will gain general recognition and therefore be used by the majority due to the acceptance forced by the long duration of the lockdown and the increasing support (state subsidies, new IT solutions, etc.). Although it has long been thought that “teleworking”, as it was formerly known, reduces transport use, this has never occurred. I suspect that this time, following a possible transition phase, the situation could be similar, and rebound effects could offset the fall in demand again – if it is not possible to restructure the supply side in the transport system in time, i.e. to reorganize it quickly according to the new situation.

During the course of the digitalization of mobility, large parts of the logistics system have been reorganizing for some time, and are increasingly focusing on small-scale distribution with new solutions (see last mile delivery stations). The restrictions caused by the pandemic have pushed existing systems to their limits, which would have collapsed had the usual levels of road

traffic remained the same, which was not the case. This shows that there is an urgent need to rethink urban transport logistics as a whole and, as far as at all possible, to reorganize them. An organizational and physical separation of the various private and public services according to their urgency or systemic relevance is an appropriate model for achieving independence and therefore greater stability with critical system loads; this approach is already occasionally considered when planning the cities of the future.

Certain technological developments should, or rather must, be given a boost by the extreme exceptional situation caused by the coronavirus. In this respect, special consideration should be given to information technology networking in the direction of the “Smart City”. In particular, the variety of urban mobility systems with private and public operators, which has been increasing in recent years, not only offers a highly varied and flexible range of services, but also huge risks, including self-blocking in extreme situations, such as the present one. Here, the “central brain”, which is fully networked online (even if it is often viewed with skepticism by the citizen) is without doubt a great advantage. It goes without saying that the automation of the transport system is another technology that can bring advantages, by making transport largely independent of the human factor. It should also help to increase the availability of the transport system (for passengers and goods).

It remains to be hoped, and expected, that the exceptional experiences people are being forced to endure right now will ultimately be used to identify areas of weakness and initiate improvements. In my opinion, there is a good chance that the present crisis may accelerate upcoming decisions in transport policy, and support a critical questioning or rethinking of current transport and mobility concepts for towns and cities. ┘



**Professor Dr.-Ing. Fritz Busch**  
TUM Senior Excellence Faculty;  
Professor of Transport Technology,  
TUM

# Corona Crisis

## What Engineers and Virologists Have in Common

At the beginning of the pandemic, there was a considerable amount of uncertainty surrounding the health threat we as a society were facing, and the steps that needed to be taken to contain the pandemic. It was also obvious, however, that quick and consistent action was necessary in order to flatten the infection curve. An entire country trusted the assessment of a professional group which is normally rarely in the limelight: virologists. Together, they showed what science can achieve. The situation was analyzed, and highly specific measures to contain the pandemic were developed and recommended. Based on this assessment, both social life and much economic activity almost completely ground to a halt. During this time, we have all experienced how quickly and decisively a society, and above all else its politicians can respond when it matters.

Let us now look at another problem that is also time-critical and that we can only solve as a society: the climate crisis. While the climate crisis and its effects as such may appear abstract, CO<sub>2</sub> emissions in the area of transport and the resulting requirement for a revolution in mobility are an urgent problem. Although we have known since the 1980s that burning fossil fuels would pose a serious danger, the problem was ignored, and even covered up, for decades.<sup>1</sup> In this respect, it is only in relatively recent times that there has been a debate about ways of reducing emissions in the area of transport. A “market incentive program for electromobility” has only existed throughout Germany since 2016. It has been designed to do things such as encourage the expansion of a public charging infrastructure for electric vehicles. However, the speed at which the measures are adopted and implemented is failing to do justice to the critical nature of the climate crisis.<sup>2</sup>

Several years ago, William D. Nordhaus, an economist and Nobel Prize winner, demonstrated that CO<sub>2</sub> pricing was an effective measure for reducing global emissions.<sup>3</sup> As far as traffic is concerned, limits on emissions are an incentive for the automotive industry to forge ahead with technological developments in their vehicles.<sup>4</sup> As a key technology, electric drive trains in motor vehicles have the potential to reduce CO<sub>2</sub> effectively in private automotive transport.<sup>5</sup> Therefore, it is obviously

The crisis has shown how quickly we can find solutions for our individual mobility. To maintain this momentum, we now need quick and decisive solutions for the entire mobility sector.

the case that there is no lack of experts or scientifically sound and justified measures. With the flattening of the infection curve in Germany, however, and the duration of the restrictions to public life, the findings of the virologists are increasingly being publicly questioned, and even denied. The engineering scientists who are thinking ahead of the mobility revolution are at a similar point. Each alternative is discussed in great detail. These discussions are important and a key part of the scientific work. Nevertheless, only by consistently implementing the restrictions at the start of the pandemic have we now reached a point at which we can discuss long-term goals and measures for the way out of the crisis – because we took quick and consistent action in the beginning. The coronavirus pandemic has therefore shown us how effectively the worlds of science and politics can work together and the importance of the time component in taking action when managing crises.

The pandemic has also taught us the relevance of mobility for an effectively-functioning society and economy. Truck drivers are systemically relevant, and the companies whose logistics have allowed us to go on buying the things we need have emerged as winners from the crisis. In individual transport, an age-old method of mobility has gained in popularity. The bicycle has, at least temporarily, replaced public transport as a means of transport in towns and cities, and the response of the local politicians has been quick and decisive. Pop-up cycle lanes in cities have been set up on roads virtually overnight, providing added safety and space for cyclists. The crisis has shown how quickly we can find solutions for our individual mobility. To maintain this momentum, we now need quick and decisive solutions for the entire mobility sector. To overcome the climate crisis, the focus should be on investing in sustainable technologies and their infrastructure. In particular, when the state is the investor, the principle of sustainability should apply, and long-term, and possibly disruptive, solutions should be preferred over short-term profits.

In this respect, what has the crisis taught us for the transport revolution? It is necessary for us to gear cities and mobility services to the needs of the road user and to only support future technologies. Even if the engineers, equivalent to the virologists at the beginning of the corona crisis, are unable to foresee all the effects of the mobility revolution, policymakers must make prompt and decisive decisions on the transport revolution and adjust them on an iterative basis. The German measures for the management of the coronavirus have proven to be successful and ground breaking.<sup>6</sup> It is now important to take a pioneering role in the mobility revolution, and adopt a “flatten the curve” concept for CO<sub>2</sub> emissions as well. Only if we act quickly and decisively now, can we afford the luxury of questioning the details of implementation in the future. ─



**Professor Dr.-Ing. Markus Lienkamp**  
Head of the Institute of Automotive Technology, TUM



**Matthias Bröner M. Sc.**  
Assistant at the Institute of Automotive Technology,  
Research Area for Vehicle Concepts, TUM



**Sebastian Wolff M. Sc.**  
Assistant at the Institute of Automotive Technology,  
Group Leader of the Research Field for  
Vehicle Concepts, TUM

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# On Performance Form in Architecture, Landscape Architecture and Design



The members of the jury of the “International Prize for Sustainable Architecture”, which includes landscape architecture and the design of building products and is now in its 13th year, are changed every time with half of them being replaced. They are from different places, all over the world.

#### But one thing comes up time and again:

There has long been consensus on the causes of global environmental crises and the need to take action to prevent them in the area of construction. It is the sector where a considerable amount of resources in the form of materials and energy are consumed in the creation and operation of buildings, and where a huge amount of rubble and waste is generated. There is also agreement that, given the key importance of the topic, contributions are necessary which, in addition to their functional suitability, fulfil high aesthetic standards. In this respect, increasing numbers of representatives from the “useful arts” feel responsible for aligning their professional contribution with sustainability criteria. Ever since the 4th European Conference on “Solar Energy in Architecture and Urban Planning” in 1996 with well over 1,000 participants, the motto “think globally, act locally” has spread like a verbal wildfire. But what do these words mean?

On the one hand, that the possibilities and consequences for people and the things that happen on our planet should be seen as a whole. On the other hand, however, that actions of all kind in the areas of planning and production should, in principle, take special account of wise budgeting and local particularities. In this context, a wide range of options remain open. These do not relate to individual preferences or arbitrariness, but in the case of architecture, to adequate forms of expression. In terms of their specific realization and from a semantic perspective, buildings and their constituent parts are required

to contribute to the current culture of building as examples of sustainable development. And not just through measurable performance data concerning energy consumption, material recycling and auxiliary technical systems. But also, and especially, through the quality of their design. Wherever architecture of this kind is realized, it becomes a role model – not as a template for copies, but as a pattern for contents and methods in a successful design process. The development of significant “performance form” in the context of self-explanatory design and meaningful communication is essential. Buildings are long-term products which create identity. The more they stay adaptable and usable in the long term, the more they can be considered to be sustainable.

The general ambition is therefore plain to see. At the same time, a huge cultural difference is clear at the international level. This results from societal forms, economic conditions, the climate, materials, infrastructure and religion in a huge and inspiring wealth of architectural contributions that correspond in completely different ways to the local particularities, and which therefore in no way lead to schematization or standardization. In many places, the trend towards a modern regionalism of a new kind can be felt in the form of “bioclimatic architecture”. This is about far more than just functionality. It makes reference to life (Greek: “bios”), and assumes that human activities cause changes that should have the right kind of impact on the ecological balance, the consequences of which require continuous monitoring. This is no easy undertaking – and refers to stakeholders, those affected, materials, food, energy, technology, as well as lifecycles and closed loop recycling management. It also includes the “performance form” referred to above, the creative expression of which makes the special attributes that take effect both visible and understandable.

“Life is the result of the infinitely complex.”

Teilhard de Chardin

Needs change due to crisis situations, such as the current one. The complete halt to the everyday life to which people are accustomed allows them to return to the essentials. Priorities and values are rethought, and simplicity and frugality suddenly become a matter of course. While insecurity and fear of the unknown, often cause rigidity and make us inflexible, in times of crisis, we are forced to think “differently” in many areas to prevent us from stagnating, and to adapt to the new requirements. A rethink is called upon to be able to see the flexibility of which we are newly aware as an approach to solving the problems that have arisen, and therefore as a potential source of innovation. This catharsis creates opportunities for development, in which evolution and progress can take place. This creates the opportunity to comprehend that optimizations cannot continue to be oriented to increased rates of consumption, but to sufficiency in terms of the social consensus. This also includes “being tolerant of mistakes”, with a sense of proportion!

It is not the strongest of the species that survive, nor the most intelligent, but the ones most responsive to change.

Charles Darwin

Our habitat is gaining in importance. Suddenly, it isn't just our private home, and must become multifunctional and fulfil a wide range of requirements. Living and working, school, education, culture, sport and leisure – space is being redefined at the international level.

There is also a clear need to reach out to the natural environment, which the virtual world can only achieve to a limited extent. Interacting with living nature is a need that is already being fulfilled in many European “eco-quarters”. But how are things in built-up towns and cities? At present, the “green in the city” with its many and varied forms, such as green roofs, ►

Our habitat is gaining in importance. Suddenly, it isn't just our private home, and must become multifunctional and fulfil a wide range of requirements. Living and working, school, education, culture, sport and leisure – space is being redefined at the international level.

green facades, courtyards and “pocket parks” are gaining in importance, when the interaction of humans with the environment in their living space is severely restricted. It is necessary to strengthen the connections between living space and the outside world; semi-private spaces, staggered transitions and the flexibility of privacy also require “human” architectural planning, i.e. architectural planning which is open to a wide range of interpretations.

The close connections between buildings and open space, which are mutually dependent in the city, must be made even more effective by linking traditional architecture with landscape architecture. This means according to the criteria of space, functionality, ecology, chains of supply and disposal, transport and mobility in general, and ultimately all the processes of daily life which have to be managed and taken responsibility for. These planning dimensions can barely be overestimated as an overall design achievement in terms of the necessities of life and the potentials for development. Only a close cooperation between the disciplines in this task offers the opportunity, even under clearly limited economic conditions, as is to be expected, to nevertheless achieve a convincing degree of quality in construction and space, in the interests of regaining the necessary balance in the reality of our future lives.

However, the requirements regarding the design of man-made environments are not to provide solutions, but descriptions of needs. In this way, answers are not only reactivated, but ideas are turned into solutions – creative, systemic and innovative. Germany has always been a leading light in the logical, systematic description of structures. Of course, results of this kind are initially less “tangible”, less calculable and more experimental than results that have already been achieved, and they require courage as well as the volition to accept a new kind of seriousness. The construction of housing, in particular, is embedded in standards, norms and regulations in our part of the world, which currently barely allow for basic models of building

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We can never solve problems by using the same kind of thinking we used when we created them.

Albert Einstein, Berlin, Bronze plate in the „Street of Remembrance“

types – apart than those of the usual type. New perspectives and other strategies are required, as at present, for example, it isn't just necessary to build “more”, housing, but “affordable” housing!

Open questions must be seen as an opportunity for what may initially appear irreverent answers, which present new approaches as possible options. Structural systems with newly organized, disintegrated subsystems (supporting structures, shells, interior fittings, building services engineering) need to be developed, and spatial figurations need to be composed which remain suitable for unknown and changing users and uses over the long term. The differentiated longevity of the components often differs by a factor of 5 to 10. Sustainability – or “architecture durable” as the French say – can be achieved through looking at systems in a different way. It must be possible to develop visions for the future. Even in the early stages, these must make it clear that they are reinterpreting and redefining tasks through attempts to achieve scientific and creative solutions. Assembly/disassembly/reassembly must be the principle that replaces new build/demolition/new build wherever possible (well over 50% of all waste is from the construction sector). The mission to preserve creation – also through self-recognition as one of its elements – requires thinking in processes and cycles with generous system boundaries.

High demands on structural systems as a concept: A high degree of neutrality for different interpretations of use, changes and renewals without destruction, basic requirements for the common good, but also the freedom to develop individual solutions with interpretability for the individual. These must be considered in advance in the form of scenarios. And they must be examined, communicated and evaluated in models and only then, with the accompanying strategies, gradually brought into reality and demonstrated – in clear contrast to the current, everyday approach of designing, planning and building, with its frequently overly-defined processes and a

widespread lack of periods of targeted research, development, testing and application which are completely self-evident in other technical and scientific disciplines.

In this respect, the perspective should be as follows: simplicity, clarity and an approach which is self-explanatory for everyone. That which is easy to understand and manage does not have to be motorized or automated. That which is complicated, difficult to understand, costly to maintain, prone to failure, requires a lot of maintenance, is difficult to replace, becomes dangerous in cases of failure and leads to dependence on third parties – whether it is an indispensable service or a matter of status that has become a compulsion – should be replaced with durable technology with a clear design.

Components with a complex, responsive performance image as a meaningful object, which constantly conveys its handling, fulfils its purpose, works reliably, is simple and beautiful, and that one may even become fond of – as the form of its performance is a creative expression of its essence. ┘



**Professor Dr. (Univ. Rom) Dr. h.c. Thomas Herzog**  
TUM Senior Excellence Faculty;  
European Award for Architecture and Technology (2006);  
International Architecture Award, Chicago Athenaeum (2007);  
Global Award for Sustainable Architecture of Cité de l'Architecture Paris (2009); Professor of Design, Construction and Buildings Technology, TUM



**Dipl. Ing. (TUM), M. Sc. Lavinia Herzog**  
Architect and Landscape architect;  
PhD candidate at "La Sapienza" University of Rome

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# ECO NOMY



# Return on Investment and Growth

## of Production and Income

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**Return on investment is a key indicator in business administration. A common and important decision for each company to make is how to invest. Thus, millions are constantly invested in companies and machinery, especially in highly developed economies. The maxim is: Investments are to be utilized and yield profits for a long time. Of course, many investments along with their return on investment come with some uncertainty. When orders decline or in times of economic crises, such as the COVID crisis, investments cannot be undone. Such situations then produce “sunk costs”, i.e., costs that cannot be recovered.**

The decision on whether a particular capital investment will pay off is based on complex mathematical methods of calculation. They compare anticipated cash flows from the investment with the costs of the investment. Projections on uncertainties which might affect the development of cash flows can be included in calculations to only a very limited extent. **The following principle applies:** The more successful the investments, the more positive the effect on economic growth and thus on the gross domestic product. This indicator can be used to derive the gross national income (GNI).

#### **What is unsatisfactory from the perspective of sustainable development:**

- ▶ The gross domestic product or economic growth say nothing about environmental consequences.
- ▶ The gross national income says nothing about intra- and intergenerational distribution of income.

Therefore, neither of both indicators meets the requirements of sustainable development. Investments can have a positive or negative effect on the environment, which illustrates the interrelation with environmental sustainability. This is why Germany

also began introducing environmentally friendly technologies already in the 1980s. Starting in the 1990s, companies intensified the introduction of environmentally friendly technologies and Germany became one of the leading exporters of environmental technologies. While, up to 1990, business associations in particular were dominated by the belief that environmentally sound production would lead to negative return on investment, compromising a company's competitiveness, today's broad consensus is that such production improves both the economic development and competitiveness of companies. Considering the current situation and opportunities for environmental progress in the production of goods and services, there still is large potential for environmentally friendly investments in Germany, in particular with small and medium-sized enterprises.

This, of course, has an impact on the assessment of growth with respect to environmental sustainability. In this context, the concept of “Green Growth” has reached increasing popularity in recent years. At the beginning, Green Growth only meant the growth of the “eco industry” (European Commission 2010). Today, an economy based on Green Growth focusses on the efficiency of resources and energy. It is to combine economic systems and **“green growth strategies”** and measures (Prognos 2014, p. 3) ▶

## The OECD defines Green Growth as follows:

Green growth means promoting economic growth while reducing pollution and greenhouse gas emissions, minimizing waste and inefficient use of natural resources, and maintaining biodiversity.

Green Growth means improving health prospects for populations and strengthening energy security through less dependence on imported fossil fuels.

It also means making investment in the environment a driver for economic growth [...].

OECD 2012

The return on investment may benefit from implementing the criteria indicated in the definition, such as reducing emissions in the context of an emissions trading scheme or making efficient use of scarce resources. Production growth will therefore not be compromised. In the context of sustainable development, only such measures will move towards “**Green Economy**” which are capable of being financed by governmental actions, such as a “**Green Economic Stimulus Package**”, after the COVID crisis.

The only question remaining is income growth. Growth (GDP) may rise, while disparities of income increase at the same time, as criticized by the OECD in several reports: “More inequality despite growth?” (OECD 2008) and “More inequality despite growth?” (OECD 2011). The OECD already demanded that countries like Germany reduce disparities of income in the interest of sustainable development. This could very well have a positive effect on growth. In this respect, the concept of “**Inclusive Growth**” should be mentioned, demanding that the entire population should share the benefits of growth. This concept gained increased attention thanks to the growth report of the “Commission on Growth and Development: The Growth Report – Strategies for Sustainable Growth and Inclusive Development, World Bank 2008”.

The OECD’s basic stance in the matter is that economic growth should provide opportunities for all segments of the population and increased wealth should be distributed fairly among society by both monetary and non-monetary means. The Agenda 2030 calls for: No-one should be left behind. Thus, Inclusive Growth aims at bringing together economic growth and the reduction of inequality. The reasoning for return on investment is often that it avoids or reduces the disintegration of societies. But: Disintegration can already be seen in some European countries and also results in more unstable economies. This concept was partly broadened to include the dimension of ecology and evolved to “**Inclusive Green Growth**”.

## Conclusion

Return on investment and growth of production and income can also be realized with a broader approach in the context of sustainable development. ┘



**Professor Dr. Michael von Hauff**  
Chairman of the Institute for Earth System Preservation (IESP); Professor of Economic Policy, International Economic Relations and Sustainability, TU Kaiserslautern

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# Back to the (Sustainable) Future

## Opportunity and Necessity for Sustainable Economic Concepts

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### Starting point

#### Intensified sustainability efforts prior to SARS-CoV-2

Until recently, one could look to the future with a certain degree of optimism. After a long process and some - partially symbolic - measures (e.g., Sustainable Development Goals, Paris Agreement and follow-up conferences), topics such as sustainability and climate action could finally be found at the top of the political and social agenda. Large parts of society have recognized climate action and sustainability as the major challenges of our time and groups such as Fridays for Future were vociferous in demanding alternative solutions. Having decided the coal phase-out and adopted the Climate Change Act, Germany seemed to be on the right track. At the European level, the “Green Deal” and the “Circular Economy Action Plan” are initiatives to a sustainable transformation of our society and economy. At the same time, these topics were picked up by companies / the industry as they either recognized new opportunities or wanted to respond to customer requirements or (foreseeable) regulatory costs. Approaches as that of Bioeconomy, Circular or Green Economy and Green Growth showed the potential of becoming the central guiding principle of the new decade. For now, the SARS-CoV-2 pandemic has pushed this agenda into the background, as it currently dominates politics and brought both the economic and social life to a halt.

### The reset as a crossroads

#### Future or past

As abruptly as this stop was for society and the economy, returning to a new normal will be a longer process. However, the reset could create potential for growth through intelligent and prospective investment schemes at the German and European level, promote the transformation towards a more sustainable and climate-friendly economy, and also act as a catalyst. Possible key concepts are Bioeconomy and Circular Economy. Bioeconomy strives not only for an economy based on renewable resources which is independent of fossil resources as far as possible, but also to increase economy's biologization. Circular Economy tries to establish business models in which products and materials are used in cycles or at least cascades, the use of resources is minimized and the time of utilization is prolonged. A combination of these approaches with key technologies, such as digitalization and paired with entrepreneurial innovation, could advance green and sustainable growth, and enable a sustainable economy and life within planetary boundaries.

The first reflexes and reactions at the beginning of the SARS-CoV-2 pandemic also showed how fast previous achievements can be forgotten. Unilateralism of individual countries, calls for incentives to purchase outdated technology, and requests for the suspension and delay of strict (environmental) standards show that the SARS-CoV-2 pandemic can quickly turn a promising decade into a lost one. From a scientific point of view and considering urgent sustainability issues such as the loss of biodiversity and climate change, it is evident that there is no time for this.

At this crossroads, a plea for continuing on the path taken towards a future-proof sustainable economy and society and not wasting the opportunities for sustainability transitions seems necessary.

### What does this mean for the reset?

We believe that the following aspects are crucial for a future-proof course of action. These should be seen in combination with the many other necessary individual measures:

#### Balancing globality and regionality

Even prior to SARS-CoV-2, there was a rise in protectionism and unilateralism, combined with an increasing number of calls for a reduction of international integration. One of the goals of the Bioeconomy is to reinforce regional cycles and drive the defossilisation of the economy by using local biological resources from forestry and agriculture. However, looking at potential regions for this purpose, such as the Danube Region, shows that this should not be based on national borders. In terms of resource security, it would not seem wise to limit the provision of sufficient biogenic resources for the development of Bioeconomy concepts to country borders. Although focusing on local resources might mitigate some of the systemic risks involved in the integration in global markets, not only procurement costs but also other risks will increase considerably at the same time. In the future, climate change will threaten yields from forestry and agriculture more and more often, even in Germany. In this case, a Bioeconomy able to rely on global flows of goods will be more resilient.

#### From value chains to value cycles

Strategies for establishing a Circular Economy aim at transforming previously linear value chains from the (raw material) source up to the sink (disposal) into nearly closed cycles. This implies reducing or prolonging the material turnover, in particular the time of utilization, as much as possible. In addition to transforming physical material and energy flows, it also involves changing business models. ►

Therefore, further impetus for sustainable growth and employment should be provided. Unlike many times before, these should attach special importance to avoiding dual exploitation of countries of the Global South. These countries mostly generate very low added value when providing their limited resources, but are often used as a sink for waste such as scrap from electric and electronic equipment or plastics. The creation and integration of global and regional economic cycles can not only contribute to resource preservation, but also result in the reduction of environmental effects and strengthened resilience as well as in an impetus for development and fairness.

### Consideration of SMEs, start-ups and new players

While the largest companies, in particular, announce their need for political support and incentives to purchase their final products during economic crises clearly, loudly and “with one voice”, the performance and, most of all, strength of newly founded companies (start-ups) and small and medium-sized enterprises (SME) should not be neglected. Although they are often suppliers for the largest companies, they would also benefit from other incentives than buyer’s premiums on final products. Intelligent and prospective investment incentives which are not only aimed at established products, but also promote a sustainable, and systemically intelligent infrastructure, new production processes or product designs, for example, may be more expedient in this respect. One example are programs such as the U.S. Advanced Research Projects Agency – Energy (ARPA-E) which emerged from the investment scheme of last decade’s financial crisis. It provides financial, technological and managerial support to progressive and technology-oriented SMEs or young start-ups working on novel and high-risk technologies for a sustainable energy sector. The program’s focus on new, high-risk technologies and novel business models enhances the creative and partly also destructive potential of entrepreneurial innovations. Such technologies, innovations and business models will likely be the ones supporting a sustainable transformation towards more sustainable economic concepts such as the Bioeconomy or Circular Economy. This requires a systemic approach, that takes into account all players, is not designed to maintain the status quo, but rather on strategic development, or even a partial restart.



**Professor Dr. Claudia Doblinger**  
Professor of Innovation and Technology Management,  
Campus Straubing for Biotechnology and Sustainability,  
TUM



**Professor Dr. Magnus Fröhling**  
Professor of Circular Economy, Campus Straubing  
for Biotechnology and Sustainability, TUM



**Professor Dr. Sebastian J. Goerg**  
Professor of Economics, Campus Straubing for  
Biotechnology and Sustainability, TUM

## What does this imply?

It is our firm belief that the current situation will provide the opportunity for sustainable change which should be taken advantage of – and that a return to old patterns and established behaviors (as often desired during crises) – must be avoided. The measures taken should be primarily oriented towards the future and towards sustainability and their effects should be considered on a systemic level. This enables the best possible use of limited resources and reduces negative effects on other areas, including rebound effects. In addition, all levels, i.e., local, regional, national and global, should be taken into account simultaneously to not jump from one extreme to another. Instead, for the sake of sustainability and resilience, it can be attempted to combine the advantages of these approaches.

We should keep in mind that a sustainable and wealthy Germany would be unthinkable without Europe. The above approaches demonstrate how such a crisis can be used as an opportunity on both a global and regional basis. ┘

# Boundaryless Organisation and Transaction Costs

## Experience from the Corona Crisis

### Division of labor and transaction costs

We are used to imagine companies as self-contained, integral entities. Physically, they are housed in office buildings and factories in which their members operate and which hold the required materials, machinery and other resources. This is the place of production, development and sales. The physical structures of business locations and the legal labor and corporate relations among market partners generally define the **boundaries of a firm**. Of course, a firm crosses these boundaries constantly by operating on markets, i.e., by procuring materials, selling products or services, raising or investing capital, for example.

However, these border crossings correspond to a clear notion of inside and outside, of belonging and not belonging, of interfaces between firm and markets. Large parts of society no longer conform to this corporate model. The introduction of information and communication technologies in companies and markets changed the ways in which transactions of goods and services are organized: **Modular, agile companies, networks and cooperation, electronic markets, platform concepts and virtual organizations are the new reality.**

The **economic principle is still based on the division of labor and the specialization within companies, among companies** and on markets distributed all over the world. Division of labor and specialization require coordination and harmonization which involves a lot of effort. **Contracts form the foundation of all transactions based on the division**

**of labor:** exchange processes or purchases on markets, the provision of services within the company or cooperation among companies. The conclusion of transactions in different economic arrangements can be characterized as a network of contracts which, however, may incur high costs, the so-called transaction costs. Arnold Picot denotes these **transaction costs as the costs of the initiation, negotiation, settlement, adaptation and control of contracts**. They are the costs of information and communication between the parties involved in a transaction (Picot et al. 2015).

Depending on the type of economic transaction, there are various forms of organization between markets and companies to manage the transaction process, however, the amount of transaction costs, i.e., the costs of information and communication (coordination), may differ. This is the **efficiency criterion** of an advantageous economic activity of companies and markets. From there, Ronald Coase, the author of the theory of transaction costs (Nobel Laureate in Economic Sciences of 1991), arrived at the following question: Which form of organization is the most efficient for a given economic task (transaction)?

**The efficiency criterion is the sum of transaction costs and deadweight losses. This is the key question for long-term corporate management (Coase 1937).**

┌ Goods and services of high strategic importance relate to the “lifeblood” of a society and a company's chances of survival.

### IT and the dissolution of company boundaries

The introduction of digital technologies in companies and markets dramatically changed transaction costs. The costs of the initiation, negotiation, settlement, adaptation and control of contracts dramatically decreased. Today, the coordination and harmonization of added value based on the division of labor occur in spatially (partly globally) distributed value chains across company boundaries. **The technical integration of companies and markets dissolved the classical boundaries of the firm – both towards the inside and towards the outside.** Industrial production with high vertical integration is replaced by decentralized, modular structures in cooperation with corporate partners, suppliers and market partners. Globalized division of labor and integration provide access to new markets and opportunities for using advantages of location (specificities of location, costs of labor, costs of transportation, customer proximity). This development is closely linked to changes in competition, technology and moral concepts.

Decreasing transaction costs, new forms of organization of integrated value creation and tapping into new markets pave roads to success for many industries. **This comes at the price of global dependencies and uncertainties.** With high stability of procurement and sales markets and dynamic competition, this international connectedness proves to be economically advantageous. However, in times of uncertainty and opportunistic behavior, it can be disastrous for both companies and society. Currently, we see this phenomenon in the COVID crisis. ►

## The explosion of transaction costs in the COVID crisis

The basis of all economic transactions is trust. Experience with partners when exchanging services, common value systems, soundness when exchanging information are of paramount importance for the performance of contracts. **If trust is superseded by opportunistic behavior, transaction costs can explode.** This is aggravated by deadweight losses due to external effects. Opportunistic behavior refers to the behavior of a contractual partner to condone negative consequences for the other contractual partner.

Oliver Williamson (Nobel Laureate in Economic Sciences of 2009) developed a meaningful reference framework for the theory of the firm, the so-called Organizational Failure Framework. He explains the development of transaction costs as a function of economic and social environmental conditions (Williamson 1975).

In the context of the Organizational Failure Framework, the key influences are the **environmental factors of “specificity”, “strategic importance” and “uncertainty”** for value-added transactions, on the one hand, and the behavioral assumptions of **“opportunism” and “bounded rationality”** of players, on the other hand. These factors relate to the interdependencies among contractual partners if there is reason to believe that a contractual partner may not be able or want to fulfill their obligations (with opportunistic behavior). The more pronounced the factors described above, the higher the transaction costs.

As an environmental factor, **uncertainty** is expressed by the number and extent of unforeseeable events as seen in the months of the COVID crisis. In an uncertain environment, the performance of contracts is considerably compromised by frequent changes in deadlines, prices, conditions and quantities. Breaches or modifications of contracts result in increased transaction costs. One example is the high level of dependence on active agents from East Asia within the pharmaceutical industry.

The **degree of specificity** may relate to the location, to production facilities, to the expertise of employees or to manufacturing methods and equipment. The higher the loss of value due to the failure to perform (e.g., production stop upon non-delivery), the higher the transaction costs from enforcing contracts. The mechanical engineering sector had to face this experience with

suppliers from countries particularly affected by the pandemic. However, the amount of transaction costs also relies on the **strategic importance of the service rendered**, i.e., its contribution to the competitive position of the final product. This is the predicament of the automotive industry, for example. Here, strategically important parts of the value chain were no longer delivered, leading to a total production stop. If parts of the value chain are of specific and strategic importance, non-performance of contracts can be vital for competitiveness.

Examples are contracts on the delivery of protective suits for health services. Failure to comply with contracts on the part of contractual partners in markets making it hard or even impossible to verify and enforce compliance may result in high losses for the company and also high social costs to be borne by the society as a whole. In the course of the past months, this experience was particularly felt in the healthcare sector. The cultural or institutional framework conditions have a considerable influence on the probability of opportunistic behavior within a given system as shown by the experience made during the COVID crisis.

Apart from these influences, there are two more relevant factors, the transaction frequency and transaction atmosphere, not considered in this article.

## Management perspectives and conclusions

In the COVID crisis, particular attention has been on science, especially medicine. Political decisions are based on current research findings in virology, epidemiology and immunology, which can change rapidly. This behavior is consistent and plausible for decisions in case of uncertainty. Politicians have learned that this decision-making strategy is successful and – with good communication to the population – enjoys high social acceptance.

**What can management learn from theory for long-term management decisions?** The theory of the firm and organizational science, in particular, are empirically sound and very well understood. Long-term corporate decisions, such as value-added partnerships, siting for production and development, make-or-buy decisions or business cooperations, will continue to be decisions made with uncertainty: scarcity of resources, climate disasters, financial crises. Technological leaps and new pandemics will tend to increase the level of uncertainty in the future. The **theory of the firm can be used to derive decision-making recommendations** which are based on transaction costs and external effects, i.e., deadweight losses for society, and are therefore directed at sustainability for companies and the society. **This particularly affects four areas of decision-making: ►**

┌ Building relationships of trust is an investment which pays off in the long run, it reduces uncertainty and decreases transaction costs.

### Economic and legal framework

In the future, the digitalized economy will continue to utilize the advantages of global division of labor and specialization as they are of benefit to all value-added partners involved. The boundless firm will be the value-added model of the future in many business sectors. However, value-added partnerships require economic-legal framework conditions **under which property rights (rights of disposal) can be enforced without leading to an explosion of transaction costs or high social damage.** This particular relates to siting, the organization of value creation and business cooperations with goods and services of high specificity and high strategic importance.

### Goods and services of high specificity ...

are, for example, those of high reliance on location. A high specificity of physical capital requires investments in machinery and technology and high specificity of human resources relates to employee qualifications. If such parts of the value chain are outsourced, transaction costs and external effects could evolve uncontrollably.

### Goods and services of high strategic importance ...

relate to the **“lifeblood”** of a society and the chances of survival of a company. In the COVID crisis, we saw numerous examples within the healthcare and pharmaceutical sectors. Dependencies on few partners at locations where contractual rights cannot be enforced at all or only to an insufficient extent entice cooperation partners to adopt an opportunistic behavior in times of crisis. The consequences are uncontrollable price developments and high deadweight losses for society. **Generally speaking: The more specific and strategic an economic service, the more efficient an in-house or domestic solution for rendering the service.** The pharmaceutical and healthcare sectors rely on solutions with value-added partners involving economic-legal framework conditions under which rights of disposal (e.g., delivery times, quality standards, prices) can actually be enforced.

### Spatial decentralization and culture of trust

The COVID crisis also provided new experience for the division of labor and coordination in distributed corporate structures, in particular for working from home. It requires appropriate technical infrastructure and new methods of coordination, **above all specific qualifications and attitudes of employees and executives.**

In general, spatial decentralization expands the scope of action for all players. At the same time, expanded scopes of action also require suitable tools of coordination and of direct and indirect control and management. The related increased transaction costs, i.e., costs of coordination and control, should not overcompensate the attainable enhancements in efficiency. Methods of indirect, result-driven control and **building trust decrease transaction costs.** Therefore, companies having a very strong culture of trust tend to have more social capital than those with rather opportunistic cultures. **Of course, this also applies to cross-border value-added partnerships:** Building relationships of trust is an investment which pays off in the long run, it reduces uncertainty and decreases transaction costs. └



**Professor Dr. Dr. h.c. Ralf Reichwald**  
TUM Senior Excellence Faculty; Honorary Senator of the TU Freiberg; Professor of Business Administration – Leipzig Graduate School of Management (HHL); Professor of Business Administration – Information, Organization and Management, TUM

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# Sustainability and Consumption

## in Light of the Corona Crisis

The media coverage and discussion in Germany of 2019 suggested that the protection of natural resources and issues of sustainability would be central areas of social activities. Among the examples are the successful “Save the Bees” petition in Bavaria, the high support of Fridays for Future demonstrations demanding enhanced efforts in climate action, social demands for a reduction in plastic packaging or various activities to minimize losses in biodiversity and the extinction of species. However, these priorities in public discussion – and the political activities partly sparked by them – still fail to reflect the real consumption of large parts of German consumers of which only a small proportion and often only specific niche markets are marked by “sustainable consumption”.

### Consumer behavior and sustainability during the COVID pandemic

By this, Phipps et al. (2013) understand “consumption that simultaneously optimizes the environmental, social, and economic consequences of acquisition, use and disposition in order to meet the needs of both current and future generations”. As an example, one indication for mostly non-sustainable consumption could be seen in the fact that the per-capita emission of 7.3t of CO<sub>2</sub> equivalents (of a total of 11.3t) of climate-related gases produced by a resident in Germany is a result of private consumption and nutrition (UBA 2017). Obstacles to the expansion of a more sustainable consumption are, amongst others, often the still limited range of corresponding products/services, their higher prices, the low recognizability of corresponding products, low consumer awareness or information deficits, but also path dependencies and structural deficits in value chains (Federal Government 2019).

However, even consumers interested in sustainability and open for these topics have a hard time translating existing positive sustainability attitudes into corresponding consumer and everyday habits due to psychological behavior patterns, such as the attitude-behavior gap, rebound effects, moral licensing (Bauer and Menrad 2020), as well as routine behaviors and dominant lifestyles.

With the growing spread of the COVID-19 virus in Europe since the middle of February 2020, media coverage suddenly changed and environmental and sustainability topics – virtually omnipresent before – were almost completely replaced by news on the COVID pandemic. This intense media presence, the lack of experience with a pandemic threatening one's own health and profoundly changing everyone's everyday life within a very short time, and the shutdown activities in almost every area of social and economic life initiated by policy-makers had massive impacts on consumer behavior in Germany. In addition to a significant increase in online purchases, basic convenience goods, in particular, were in high demand in Germany during the COVID pandemic from the end of February 2020 with often more than double the volumes than in the corresponding weeks of 2019 (table). However, it was not toilet paper which was the most hoarded product in Germany during this time; instead, consumers not only stocked up on disinfectants, but predominantly on staple foods in significantly larger amounts compared to the previous year. By contrast, typical convenience products such as frozen food only saw relatively little extra demand. The purchase of beverages did not increase much compared to previous years (except for the Easter week), even though a beer at the bar was out of the question due to the closed restaurants. ►

Group of goods	CW 7/20	CW 9/20	CW 11/20	CW 13/20	CW 15/20
Disinfection products	53.1%	466.8%	243.5%	154.9%	116.1%
Bread mixes	7.8%	392.3%	334.6%	34.0%	80.3%
Flour	5.6%	148.8%	200.9%	63.8%	26.6%
Rice	12.7%	164.6%	179.0%	34.1%	4.4%
Pasta	5.6%	108.4%	170.1%	17.1%	-0.2%
Toilet paper	1.9%	46.3%	118.3%	n.a.	-20.0%
Canned sausages	-6.0%	45.6%	111.9%	n.a.	-7.3%
Cereals/muesli	0.7%	29.4%	67.6%	8.7%	6.8%
Frozen food	-1.8%	22.0%	42.5%	9.7%	15.3%
Cheese (self-service)	0.6%	14.9%	29.9%	1.3%	17.5%
Beer/shandies	-3.0%	-9.5%	9.4%	-9.4%	33.3%
Mineral water	-17.9%	4.4%	17.9%	-15.1%	-1.0%

**Table** Change in the sales volumes of selected groups of goods in Germany during the 2020 COVID pandemic (compared to sales volumes in corresponding weeks in 2019)

**Reference** Nielsen SE (Lebensmitteleinzelhandel, Drogeriemärkte ohne Aldi, Lidl, Norma) (LZ 2020a,b,c)

In addition to the purchasing behavior, it is also worth noting how consumers' assessment of sustainability aspects has changed during the COVID pandemic. Corresponding insights are offered by two surveys representative of Germany which were conducted in our field in January 2020 and at the end of April 2020, i.e., before and during the COVID pandemic. They show significantly lower approval ratings on some statements of Green Consumer Value (Haws et al. 2014), on the ecological and economic dimension of a sustainability scale of Ziesemer et al. (2016), and on perceived behavioral control, while the social dimension of sustainability received more approval. This means that environmental aspects are generally associated with less importance in the COVID situation (also because they have become harder to implement) and consumers are much less enthusiastic about alternative forms of consumption (such as sharing models, "use rather than own"), while social aspects of sustainability (in particular, employee rights, non-discrimination, fair pay) enjoy a higher level of approval. However, the rating of some "COVID statements" from April 2020 shown in the figure also illustrates the severe uncertainty among the surveyed German consumers, which led to generally tentative and hesitant consumer behavior. Nevertheless, almost 80% of respondents expect policy-makers not to lose sight of climate action, and almost 60% indicate their approval of "sustainable consumption" also during the COVID pandemic (fig.). The surveyed environmental and sustainability scales only had strong explanatory power for these two "COVID statements" related to sustainability aspects, whereas they contributed relatively little to the explanation of the variance of survey data found with the other questions concerning the impacts of the COVID pandemic on the respondents' own situation or general propensity to buy (fig.).

### Sustainable consumption after the COVID pandemic

The COVID pandemic will rather impede than accelerate the path to more sustainable consumption, especially if it leads to a heavy decline in consumer income and the consumer uncertainty already existing is substantiated by negative economic facts. Then, consumers will likely opt for known products when buying food and non-durable consumer products and be less interested in more expensive innovative and more sustainable products, partly also for budget reasons, but also since their behavior is often determined by habits, heuristics or social standards, for example. Additionally, the COVID pandemic further amplified existing trends towards an increase in online purchases, especially with non-food products, and could also prove to be a "door opener" for online purchasing of food. This would not only have severe impacts on many business models of brick-and-mortar retailers and the economic life in many city centers, but would also increase environmental issues in conurbations, unless much more environmentally sound solutions are found for delivery on the so-called "last mile". Social sustainability would also be affected negatively by increased online purchases, for example, when it comes to work in parcel delivery and logistics centers.

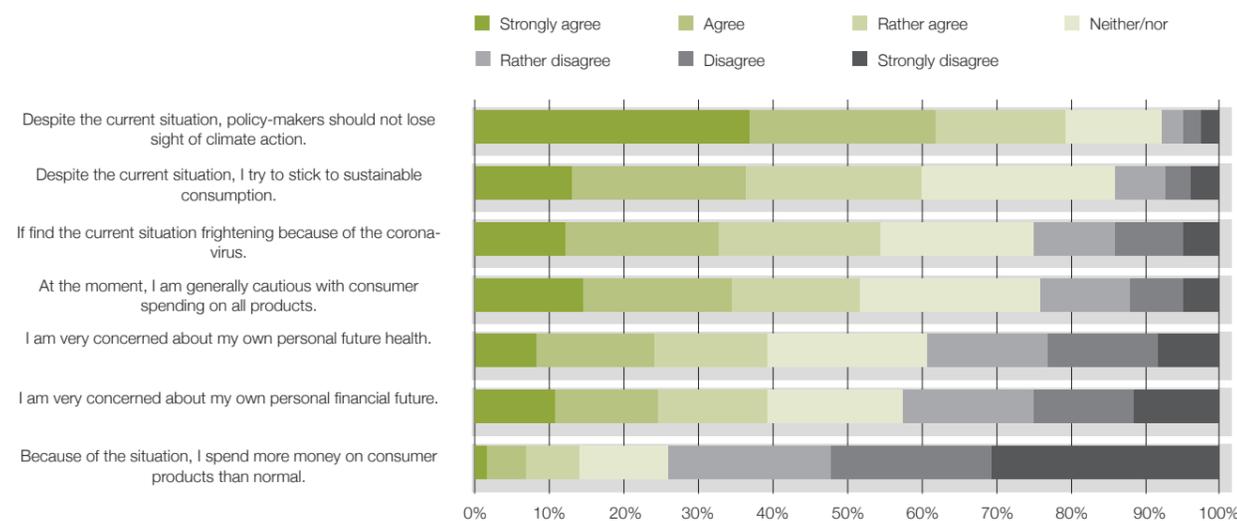


Figure Consumers' assessment of "COVID statements" from April 2020 (n = 937)

On the other hand, the programs announced by the Federal Government of Germany and the European Commission to revive economy and private consumption are to help mitigate the negative effects of the COVID pandemic. They would be a "game changer" in many economic sectors and areas of consumption if the high promised funds were consistently oriented towards improving the environmental situation and sustainability. Such funding programs should create incentives for sustainable action and make use of existing knowledge with goals such as:

- ▶ Promoting a mobility not predominantly based on motor vehicles with the inclusion of alternative drives and service/social innovations
- ▶ Shifting diet from high consumption of animal products to plant-based alternatives and establishment of corresponding value chains in Germany
- ▶ Significantly increasing self-production of renewable energy in private households in combination with energy storage and electromobility
- ▶ Replacing heating systems with an age of more than 20 years by state-of-the art systems based on renewable energy
- ▶ Creating incentive schemes for (energy) renovation of buildings by tenants
- ▶ Developing and implementing digital, user-friendly information and communication systems to provide sustainable products/services for private consumers
- ▶ Establishing efficient recycling systems for secondary raw materials in Germany and supporting consumers using them with digital options
- ▶ Making knock-on effects of a boom in online sales transparent and working on more sustainable solutions.

With the predominant focus on capital and long-lived consumer goods, such programs would not only have a direct reducing effect on the utilization of natural goods, but also exhibit a long-term effect throughout the lifecycle and useful life of the procured more sustainable and environmentally sound products. ─



**Professor Dr. Klaus Menrad**  
Professor of Marketing and Management of Biogenic Resources, Campus Straubing for Biotechnology and Sustainability, TUM

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# Opportunities for Sustainable Tech Start-Ups in Germany

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Already in the years before the COVID crisis, most OECD countries were only able to achieve slow employment growth and low increases in productivity, start-ups and young firms taking a central role as drivers of innovation and growth. Averaged across all OECD countries, they were accountable for around 20% of employees and about half of all new jobs. With their disruptive new products, services and business models, innovative start-ups with a focus on digitalization and technology made an important contribution. The outstanding growth dynamics of these start-ups, which make up about 4% of all young companies, created between 22% (in the Netherlands) and 53% (in France) of all new jobs in OECD countries.

Playing a pioneering role throughout Germany as an entrepreneurial university and being the cradle for about 80 start-ups a year, TUM has become a particularly important source for innovative companies.

Germany, too, produced rapidly growing companies such as FlixBus and Zalando and developed a visible start-up scene in recent years. Berlin and Munich became established as especially successful clusters of business creation. The German capital gave rise to a particularly high number of successful business-to-customer internet companies, usually from the fields of e-commerce and fintech. Outstanding examples include young companies such as Delivery Hero, Auto1, N26 and HelloFresh. A prominent incubator for many of these successful digital companies is Rocket Internet, a Berlin-based company founded in 2007.

The Munich start-up ecosystem has a stronger focus on business-to-business tech start-ups with companies such as Blickfeld, celonis, Konux, Liliium and NAVVIS. Playing a pioneering role throughout Germany as an entrepreneurial university and being the cradle for about 80 start-ups a year, the Technical University of Munich has become a particularly important source for innovative companies. The "Start-up Radar" of the Stifterverband [Donors' Association] and the Heinz Nixdorf Foundation ranked the TUM first among the big German entrepreneurial universities for the third time in a row. In 2019, start-ups from the environment of the TUM and its **UnternehmerTUM start-up center** collected more than one billion euros in start-up and growth financing. This corresponds to about 15% of the national volume of risk capital financing.

With the LMU Entrepreneurship Center and the Strascheg Center for Entrepreneurship, Ludwig-Maximilians-Universität München and Hochschule München also provide intensive support to start-up projects of students, scientists and alumni. A particularly successful program creating numerous spin-offs and already founded in 1998 together with LMU and TUM is the Center for Digital Technology and Management (CDTM). The cooperation of the three Munich universities is to be intensified in the scope of the "One Munich Strategy" to further increase the cluster's international competitiveness. One specific building block is the joint BMWi project "EXIST-Potentials" to enhance the internationalization of the Munich start-up scene.

Another important strength of the Bavarian cluster of innovation is the presence of established companies such as Allianz, Airbus, BMW, Burda, Infineon, Knorr-Bremse, Linde, Munich Re and Siemens and their links to local start-ups, and operations of leading global corporations such as Amazon, Apple, Google, Huawei, IBM and Microsoft.

In recent years, the political debate on the importance and funding of UnternehmerTUM has gained momentum. Initiatives at all levels have been initiated and reinforced to further expand start-up activities. Amongst others, together with UnternehmerTUM, Munich started construction of a new building for the innovation and business creation center – Munich Urban Colab. ►

At the beginning of 2021, the new center will become home to a creative quarter for start-ups, innovators, scientists and creative minds to work on liveable, future-proof and efficient solutions for the city of the future. In October 2019, the Bavarian state government announced that it will once again increase investments in artificial intelligence and “SuperTech” such as quantum technology, aerospace and CleanTech, within the framework of the Hightech Agenda Bavaria. In addition, SMEs are to receive special financial support in the form of a digital fund, a start-up fund and an automotive fund. With its SME strategy, the federal government also plans to further strengthen the start-up scene. When it comes to early-stage financing of innovative start-ups with instruments such as the high-tech business creation funds, EXIST and INVEST, it already sees the state in a good position. According to the Federal Ministry for Economic Affairs, optimization is required in the growth phase in which German start-up often lack sufficient funds. To this end, the venture capital market is to be expanded further by increasing the commitment of the new KfW investment subsidy, KfW Capital, to growth financing and also mobilizing more private and institutional investors such as insurance companies or foundations.

However, the COVID crisis has now led public authorities to shift their focus from these announced long-term financing measures to short-term stabilizing measures for the founder and start-up scene. For example, a critical aid program for solo freelancers and microenterprises, a special KfW program via house banks and an economic stabilization fund also supporting start-ups with a business value of more than 50 Million euros have been launched, amongst others. Moreover, a governance package totaling two billion euros was initiated, mainly aimed at stabilizing start-ups already having venture capital at their hands.

Now, the question is how Germany should position itself as a site for innovation in post-COVID times, which opportunities and strengths could be used and which role start-ups could play.

The years of growth prior to the crisis, but also the first months of the crisis, have shown that young companies make key contributions to society as solution providers and innovation drivers. This is particularly evident in the areas of digitalization and flexibilization of the industry and health sectors. The rapid provision of applications is exemplified by the KINEXON start-up with SafeZone, a data-protection compliant IoT solution for manufacturing companies to precisely adhere to distancing rules, and the app from the Shyftplan start-up, by which hospitals, nursing homes and factories can very flexibly manage and optimize their shift schedules and keep their employees informed at all times. Another dynamic start-up providing solutions for health services is Munich-based GNA Biosolutions, developing instruments and assays for ultrafast nucleic-acid-based COVID-19 testing.

What is important now is that the positive dynamics of the German start-up scene of the recent years will also not be compromised in post-COVID times, and the government’s

improvement measures already initiated will be implemented consistently. Additional momentum to strengthen the German system of innovation and digital transformation can be provided by experience from the months of the shut-down. In the situation of crisis, the necessity and urgency of digitalization have become clear in many organization. A number of companies and public institutions have introduced digital and innovative solutions with a new speed and keenness of experimentation and gathered positive experience with them in the time of crisis. This experience could provide additional momentum for a long-term innovation and digitalization strategy and its systematic implementation. As a user and customer, the government should make much more intensive use of the expertise of local start-ups and draw on their innovative products and services in the future.

This would be an important step for Germany and Europe to remain competitive in cutting-edge technologies such as artificial intelligence, cybersecurity, life sciences and robotics and maintain the country’s technological sovereignty. As stated in the article by Professor Achleitner, an even closer cooperation between established companies and start-ups will be the decisive factor of success.

Another great opportunity for German start-ups in the post-COVID phase will still be the topic of sustainability which has gained growing momentum from the time of its definition and the adoption of the international Sustainable Development Goals (SDG) in 2016. A positive contribution to reaching these goals also gains more and more importance for many founders, employees, investors and customers. As an example, a growing number of fund investors, such as the European Investment Fund, commit their venture capital funds to examine the SDG impact of their start-up investments and make sure that it is positive. This also increases the trend towards keeping an eye on ecological and social sustainability with for-profit start-ups.

Entrepreneurial universities and business creation centers also place increasing focus on sustainability. For example, “Shaping a sustainable living environment” is one mission of the Technical University of Munich. Here, the interplay between environmental, climate, energy, nutrition and resource concerns, seen as one of the biggest challenges in the history of humanity, is addressed systematically by research, education and start-up funding. In particular, the innovative potential is to be raised across multiple disciplines spanning the natural sciences, life sciences, engineering, the humanities, social sciences, economics and medicine. In addition, through the TUM-affiliated institute UnternehmerTUM, the BMW Foundation launched the start-up accelerator RESPOND, supporting founders in the scaling of their company and emphasizing the importance of corporately, ecologically and socially relevant business models. RESPOND is set up for a period of five months and is directed at start-up teams who solve complex global issues with innovative technologies and entrepreneurial endeavors. In the four attendance phases of the program, the founders participate in workshops on impact-based economy, marketing, sales, financing and responsible management.

**Very successful companies were often launched during or shortly after times of crisis. Together with UnternehmerTUM, the TUM is prepared to initiate the next generation of sustainable tech start-ups and accompany them on their path of growth. ┘**



**Professor Dr. Helmut Schönenberger**  
Vice President for Entrepreneurship, TUM;  
CEO of the TUM business creation center,  
UnternehmerTUM

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**OECD, DynEmp: Measuring job creation by start-ups and young firms,** <https://www.oecd.org/industry/dynemp.html#reports>, May 2020

# Start-Ups as Part of a Sustainably More Successful Economy

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The importance of start-ups for the innovativeness of our economy is already widely accepted. Therefore, the fact that many of them are so severely affected by the COVID crisis weighs particularly heavy. Especially more seasoned high-tech start-ups, often referred to as growth companies, are currently threatened by a significant decrease in growth, insolvency or being sold off, particular to foreign countries.

┌ The importance of digitalization has never been clearer – those ahead in this development now find themselves in a considerably better position.

The disappearance of these companies would cause great damage to the German economy in the long term: In addition to technologies, talent, expertise and innovative spirit would be lost. We would be weakened with lasting effect in the long run. Therefore, it is absolutely welcome that the federal government wants to act quickly and promises a billion-euro COVID aid package for young companies.

**But other than the federal government, what is the role of the economy itself in this situation?** This can be explained with empirical evidence from the times of the financial crisis ten years ago. A scientific study by members of TUM and KfW showed that, prior to the financial crisis, more than 85% of the almost 2,000 German tech start-ups investigated generated revenues already in the early years. However, as a consequence of the financial crisis, customers cut back significantly on their orders, making it necessary to fall back on external financing sources. But venture capital was unable to fully fill the gap caused by dwindling revenues. As a result, tech start-ups with the largest growth potential, in particular, reduced their investments and froze innovation projects.

**Now, this unsettling development seems to repeat itself in the COVID crisis.** Talks with company founders show that they often spend 95% of their time on crisis management these days. In addition to rational aspects, it is also very human to take less time for future projects while under

such pressure. It is also hard for start-ups to take up physical contact with potential partners. Opportunities of getting to know each other are lost. Less opportunities for contact are a fundamental practical problem for many start-ups having industrial customers.

As such, the COVID crisis is a kind of fast-forward experience. Processes which would probably have come anyway, now happen with greater probability and, above all, significantly faster. The importance of digitalization has never been clearer – those ahead in this development now find themselves in a considerably better position. Therefore, against the backdrop of the crisis, we must not forget the fundamental digital challenge already faced by the German economy prior to the COVID crisis. However, it must be seen much clearer.

The accelerated structural change is not only felt in the area of digitalization – but also in other fields. To only name one example, Germany can be proud of its domestic achievements in 3D printing. Yet, this technology only gained ground bit by bit in recent years. The issues with global supply chains laid bare by COVID-19 will certainly shed a new light on the underlying opportunities and trigger another growth spurt. For example, we have a variety of new technologies at our hands which are likely to create value in the “New Normal” after COVID-19. The goal must be to preserve our economic strength during the COVID- and post-COVID economy. ►

┌ If wanting to invest in the future, it makes sense for established companies to take a look at innovations of start-ups.



**Professor Dr. Dr. h.c. Ann-Kristin Achleitner**  
Member of the Executive Committee of the National Academy of Science and Engineering (acatech);  
TUM Distinguished Affiliated Professor

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**Bavarian State Chancellery, Hightech Agenda Bavaria, Government Policy Statement by the Bavarian Minister-President Dr. Markus Söder**, MdL, on 10 October 2019 to the Bavarian State Parliament

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**OECD, No Country for Young Firms? Start-up Dynamics and National Policies**, Paris 2016

**OECD, DynEmp: Measuring job creation by start-ups and young firms**, <https://www.oecd.org/industry/dynemp.htm#reports>, May 2020

It should be clear to everybody that the virus will remain with us for a long time and that other epidemics could also occur. Our society and with it our economy will undergo a sustained change due to the crisis, and it will be worthwhile for all to adapt to it early on and to not only recognize the considerable challenges but also the opportunities presented when actively and quickly tackling the necessary adjustments and developments. In the current crisis, established companies simply must not just look to the past and everyday life. Above all, they need to look ahead and invest in the future.

This can be the case for reasons of efficiency and effectiveness. Also the financial pressure on the economy by the COVID crisis can be reason for a possible cooperation and not against it.

Josef Brunner, the Executive Chairman and Founding Investor of Relay, a provider in the Industrial Internet of Things (IIoT), wrote an article in November of last year as to why there has never been a better time to found a B2B start-up in Germany. Indeed, it was a coming recession which he saw as a reason for this as he assumed that companies would dial down in-house digitalization efforts and turn to ready-to-implement solutions already more validated on the market.

What proved to be good thinking in a simple recession could be particularly true for the present COVID crisis and recession: **If there ever was a time where it made sense to cooperate with established start-ups in the eyes of the existing industry, then it is now.** Some companies even had the strength to deliberately accelerate new innovations

during this time – making use of the forced idle time and adjusting their production accordingly, for example. Looking at those start-ups helping to improve their productivity in exactly these times clearly illustrates the width of opportunities – and how many of the companies in this area come from Germany.

For some, such innovations from the start-up world can also provide an impetus which helps specifically in the COVID crisis. The website **“Start-ups against Corona – Start-up solutions for Corona problems”**, also co-supported by the TUM, and the examples shown there clearly illustrate how large and innovative the spectrum is here, as well.

We talk a lot about start-ups requiring an ecosystem. In fact, the entire economy is an ecosystem and one of the positive effects of the crisis could be that the individual parts of economy will cooperate efficiently and effectively for the benefit of all. If the economy is to become fitter and more sustainable some time after this COVID shock, comprise sound companies and comprehensive jobs, then our thinking should not be based on individual silos of different kinds of companies but on a cooperation between different parts of the economy. **This applies in general** – but becomes even more true when striving for resilience of a company’s own value chains more than before. The necessity for this was demonstrated by the current pandemic, if not earlier.

However, apart from openness and effort, such a joint approach also relies on transparency regarding the existing companies and their products and services, and on contacts already existing or able to be established.

Here, the German economic structure could be of advantage. While innovative activity is heavily concentrated in countries such as the United Kingdom and France, it is distributed nationwide in Germany. This regionality also allows another form of proximity. Therefore, it is important that this opportunity is actually used. As the leading university-based center for innovation in Europe, the UnternehmerTUM of the Technical University of Munich shows how much can be achieved when bringing people and companies together. ┘

# Information and Communication Technologies

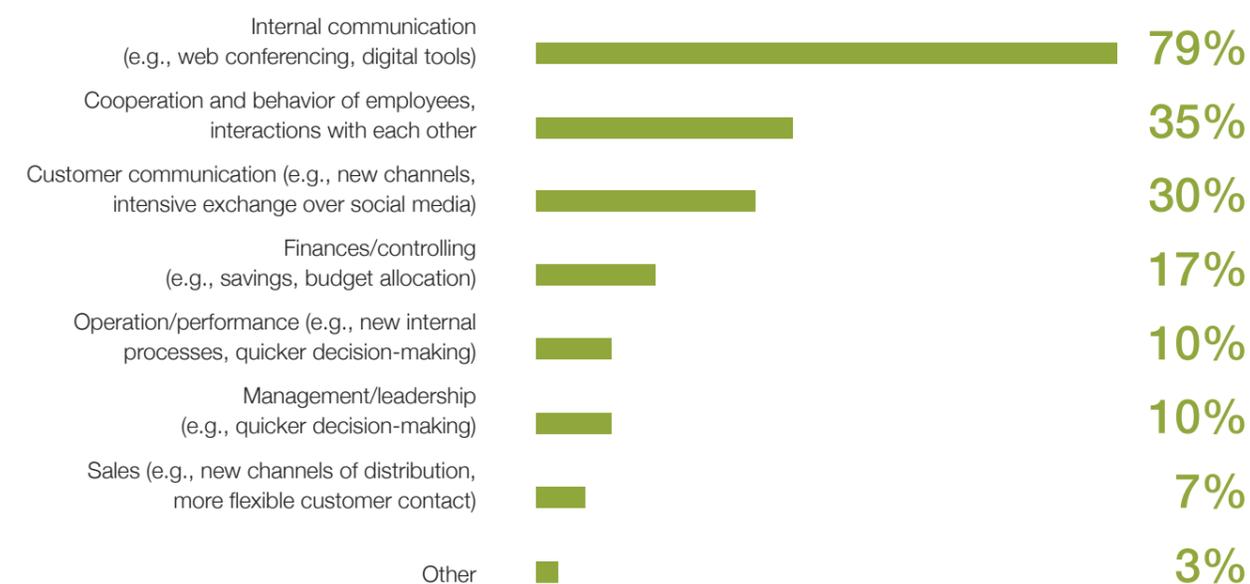
## What Are We Learning from the Crisis?

**A different normal. After more than two months into the COVID pandemic, one thing has become clear: Germany, is ready for using new information and communication technologies, when forced to.**

In April 2020, at the height of the lockdown, the MÜNCHNER KREIS conducted an expert survey among 211 digitalization and technology experts from Germany on the occasion of its eighth Future Study initiative, supported by the Bertelsmann Stiftung and TUM Campus Heilbronn gGmbH. The aim of the study was to shed light on the consequences of the COVID pandemic with respect to social, economic and technological aspects.

According to the study results, 80% of the interviewed experts acknowledged that the greatest changes in their organization caused by the COVID pandemic occurred in the area of internal communication. State-of-the-art information and communication technologies now suddenly and comprehensively shape the working life and interpersonal communication to an extent never experienced before. ►

### Where do you currently see – as a result of the COVID pandemic – the greatest changes in your organization?



Question A02: Where do you currently see – caused by the COVID pandemic – the greatest changes in your organization?  
Basis: German experts, n=211; more than one response possible (max. 2 answers)

**Figure 1** Results of the expert survey by the MÜNCHNER KREIS on the topic of COVID-induced changes (reference: MÜNCHNER KREIS (2020), Sonderstudie zu den Auswirkungen der Corona-Pandemie im Rahmen der „MÜNCHNER KREIS Zukunftsstudie VIII: Leben Arbeit Bildung“)

## The cultural dimension

At the same time, the results also show that although the use of technologies progressed significantly, changes in management behavior and work organization are still missing. This raises the question as to how our working life will look like after the end of the lockdown. There is reason to assume that, in the future, work will not be determined by a one-sided solution, neither in the form of total attendance nor as permanent work in the virtual world. Instead, it will be necessary to engage in a differentiated discussion and rebalance potential work models, i.e., how, where, when and how much we will work in the future.

## The structural dimension

In addition to balancing a new work culture, it will also be necessary to address structural obstacles on the path to new forms of work which have now become evident. This refers to the availability of sufficient bandwidth, for example. Even if the internet as such can be assumed to have sufficient load capacity, this does not apply everywhere to the same extent.

Moreover, the question remains as to how far the requirements for working from home have been met in the form of distributed access to required data with sufficient security. Structural issues also include the capability to handle the technologies – both as a user and as a provider.

## The economic dimension

In addition to structural challenges, the past months also clearly showed that the different industries were very differently prepared for the challenges of a digitalized working environment due to their diverse value chains. This is particularly due to the fact that apart from the world of digital twins, there is also a world of physical cooperation, and it is evident that in this world – despite enthusiasm about the capabilities of the internet – not every activity can be readily translated into a mobile- and medially-conveyed form. Where working together on site is indispensable, for example with personal services in healthcare, nursing or production, it is simply not possible at present to implement every activity using digital technologies, so transportation to the object of work or personal contact with persons will continue to be necessary.

## The interpersonal dimension

Similarly, the interpersonal dimension presents us with challenges when implementing digital work models. Here, we should enter a new debate on how social cohesion and empathy towards other persons can persevere in the virtual world of the future. Interpersonal contact that used to come naturally over a cup of coffee now needs to be organized using digital communication technologies and – as the pandemic has unfortunately shown us – quickly loses the charm of spontaneity and closeness.

## The global dimension

Finally, we need to keep in mind that the major challenges existing prior to the COVID pandemic have not been suspended by the COVID crisis. How can we handle climate change? How do we define an open and fair society? And, how do we tie future technologies such as AI into our lives? These questions are waiting to be answered. So it is up to us as a society to think about how we can use what we were forced to learn quickly in times of COVID to manage these major challenges.

## On the path towards a forward-looking debate

In conclusion, the COVID pandemic along with the lockdown expanded society's perception of what is possible when using digital technologies. With the lockdown, our knowledge about these digital possibilities became real; whether it was during video conferences as a consequence of a dissolving culture of attendance or as a result of using digital services to interact with governmental or private entities. Because the usefulness of information and communication technologies for work have come to be expected during COVID lockdown, further applications of these technologies will be explored.

It should be noted that the proven usefulness will not necessarily lead to the technologies being integrated into social and economic life. After all, in addition to technological requirements, adequate infrastructure and the ability to use the technologies, it is now necessary to build – or re-discover – the right meta-skills.

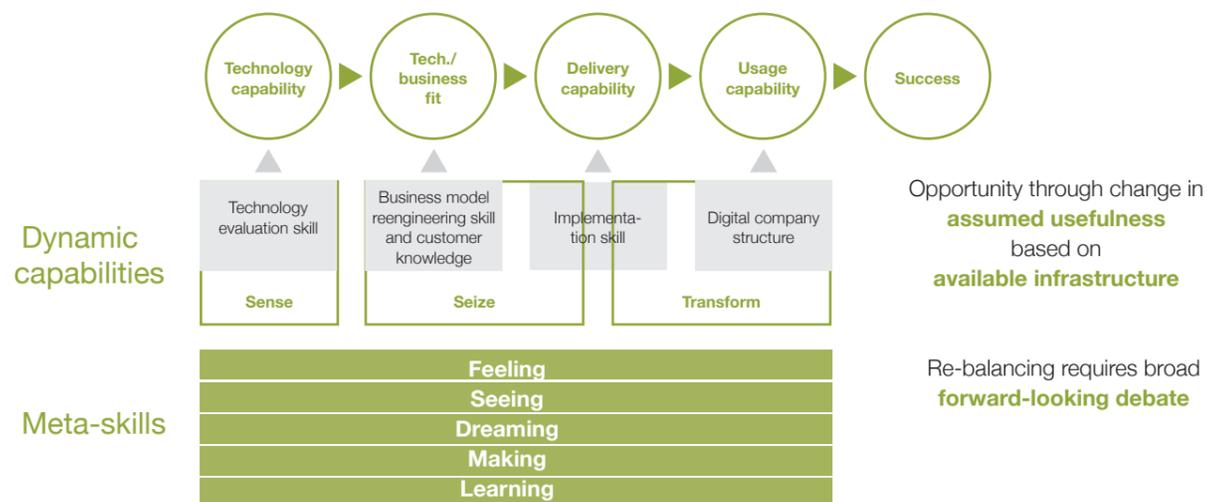


Figure 2: Meta-skills on the path towards a forward-looking debate on the use of technologies (reference: own figure)

We are all called to engage in a joint broad and forward-looking debate to come to an organizational and social consensus on which of the capabilities of electronic tools should be used in what form in the future. We now need to keep this debate going with the courage to confront and integrate change. ┘



**Professor Dr. Helmut Krcmar**  
IBM Faculty Award (2016); Founding Dean and Delegate Officer of the President of the TUM Campus Heilbronn; Professor of Information Systems, TUM

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# Public Debt

## COVID-19 and the Incentive Mechanisms of Democracy

### I.

In every crisis, sooner or later, people called on the government to step in – if there still was one. Most loudly were calls for money from all sides. **But where should the government get the required funds when tax revenue was not enough?** It had to and has to get into debt<sup>1</sup>. The old theory by John Maynard Keynes to avert an impending recession by public “deficit spending” is still applied all over the world. What the world certainly likes to forget is the second part of his theory according to which, after having successfully overcome the recession, the government should then use its tax revenue to pay back the loans taken out before. The cause for this asymmetry is rooted in the large space of political economy. And it is this space exactly which reveals a fundamental mechanism that works in every representative democracy and feeds public debt systematically. Economics has developed countless theories to explain the lasting and excessive debt in many countries. However, until today, it was not possible to identify purely economic factors in any of the countries concerned, which could be responsible for this development. By contrast, politico-economic theory offered much more successful explanations. According to it, politico-institutional factors, in particular, must be included when wanting to find an explanation for repeated new debt. **The root cause turns out to be an obvious conflict between the short-term incentives of a representative democracy and the long-term requirements of rational public finance.** This particular conflict is what shows itself in recession crises, including, in particular, the present COVID pandemic.

### II.

There is a number of politico-economic explanatory mechanisms which can be supported by both consistent theoretical models and corresponding empirical analyses. First and foremost, the big issue of securing power or gaining political power comes into play. The eternal struggle between government and opposition incites the government to secure its power by a deliberate imbalance between public spending and public revenue. Having almost unlimited access to the credit market, the government can ease budget restraints using an instrument practically inscrutable to voters as shown by all surveys available. Hence, it is preferred to increase spending – especially shortly prior to elections – but to finance it through public loans. In this way, voters enjoy public treats for which they do not have to pay as the issue of funding through public loans is put off to some time in the future. In this context, the composition of the respective government also plays a role. Especially if it consists of several parties, they are more likely to create higher budget deficits because of a prisoner’s dilemma due to the individual interests of each party. Further influences standing in the way of sustainable public finance include the respective country’s electoral system. It appears as though, in contrast to the first-past-the-post system, the system of proportional representation tends to foster high mountains of debt. Furthermore, it was observed that whenever political power is shared – such as between Bundestag and Bundesrat, between the federal government, states and municipalities, among political parties within a coalition or among parties as a consequence of power shifts over time – the tendency towards higher public deficits increases. At the bottom of this observation, there are strategic factors in the financial competition for political power. What should also be mentioned in this context are the so-called politico-economic budget cycles and inter- and intragenerational mechanisms of redistribution which are just as imperceptible as they are highly effective. All of these drivers of public debt are both obscured and intensified by the COVID crisis.

### III.

So if the incentive mechanisms of competitive democracy are the cause for ever growing mountains of debt, what can be done against it? If the trend towards debt essentially results from institutional properties of representative democracies, then a possible solution to the problem must involve institutional reform. Many proposals have been made to this end. They range from various concepts of a constitutional barrier, partial exclusion as with monetary policy, earmarking of taxes to several reforms of the budgetary process. Yet, all of these proposals suffer from a fundamental problem. The only ones being able to implement any of these reforms are those currently in office. However, they are not interested in limiting their financial room for maneuver.

This is quite understandable because who would want to bite the financial hand that feeds them? A logical step out of this dilemma, which is also easy to justify by game theory, is the idea to overcome the national credibility problem by delegating certain control over public borrowing to an independent international institution. This is called “commitment by delegation”. Those in office allow their hands to be tied from the outside so chances of re-election will not be threatened by any cut-backs on spending. Even though voters would be expected to somewhat tighten their belts, the financial responsibility would not lie with the respective officeholder but be subject to the adherence to certain requirements as found in the Treaty of Maastricht, for example. In this manner, national political bias could be corrected, provided there are effective sanctioning mechanisms, of course. Not least for reasons of political opportunism and the politically intended goal of a united Europe, numerous agreements of the Treaty of Maastricht have certainly been undermined. Despite a revision of the Treaty drawn up in the meantime, it remains to be seen whether this situation will change in the future. ►

## IV.

The COVID crisis has come as an extensive macroeconomic shock. Calls for the government or international community to step in are more than understandable. **However, every major crisis was exploited sooner or later by taking advantage of the dark window of opportunity to bring about conviction-driven decisions.** A current example are the so-called corona bonds. These European bonds elevated to the rank of a key sheet anchor would not only undermine existing treaties, but provoke totally misled financial incentives. Some countries of the European Union could get into debt with attractive conditions and in unprecedented amounts, whereas other countries – in particular Germany, of course – would be liable. In this way, any kind of fiscal discipline would be lost. The COVID crisis brought the topic of joint liability back on the political table, and that even though there are three large pots capable of fulfilling all financial desires to an adequate extent: the EU financial backstop of the European Stability Mechanism (ESM), bonds purchased by the European Central Bank and resources from the European Investment Bank (EIB Group).



**Professor Dr. Robert K. von Weizsäcker**  
Member of the German Council of Science and Humanities (1997–1999); Professor of Economics – Public Finance and Industrial Organization, TUM; Centre for Economic Policy Research, London

1. The potential possibility of financing the massive spending through purely printing money is not discussed in this article.

## In a Nutshell

**Increasing public debt is a systemic price of competitive democracies. It is also a financial price of the COVID crisis. ┘**

# The Contribution of Political Economics to International Economic Relations

after the Corona Crisis

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It is a central task of the social sciences to identify and analyze – as well as ethically evaluate – political, social and economic effects of major events such as the COVID pandemic. This should occur, as much as possible, on the basis of reliable empirical information, which for COVID, however, is only just being collected.<sup>1</sup> The primary goal of this essay is to offer some thoughts on how political science and economics might contribute to making international economic relationships stronger and more economically and politically sustainable in the time after COVID-19. In the final paragraph, the essay sketches a proposal for how to facilitate this contribution.

┌ From a tactical point of view, “Optimal Tariff Theory” is correct to the point of being supported by mathematical proof. Strategically, however, it fails as a guideline for trade policy ...

**The prospects for international economic relations after the COVID crisis are not good:** In times of economic hardship, calls for protectionism and a mercantilist trade policy become commonplace.<sup>2</sup> And in the United States, unemployment has already exceeded the level of the Great Depression of 1929 –1933. The commercial interests of internationally highly interconnected companies (which today describes many small and medium-sized enterprises in Germany) can be an antidote against protectionist temptations.<sup>3</sup> However, given that personal contacts along global supply chains directly contributed to the international spread of COVID-19,<sup>4</sup> it is likely that demands for a return to self-contained domestic production will probably increase as a result of the pandemic. The experience of overt political interference in production processes that span several countries (including through export bans of critical medical supplies, which had seemed unthinkable in Western countries for decades) will only intensify these demands.

What can political science and economics contribute – through research and teaching – to sustain international economic relations after the COVID crisis? I submit that greater attention to trade theory may help – not just by advancing the research frontier through novel theoretical and empirical contributions, but also by making trade theory an integral component of secondary and tertiary education.

**The goal is to convey a basic understanding of international economic relations to as many people as possible.** This enables them to understand why fragmenting markets by turning borders into barriers is so harmful and therefore should only be done for very good reasons, even in the context of COVID-19.<sup>5</sup> The new master's program in Business and Economics Education at the TUM School of Education holds great promise for strengthening the knowledge and understanding of international economic relations not only among the university elite but ultimately also among Germany's vocational students. Environmental sustainability should of course also be taken into account. Making environmental "externalities" visible also allows us to illustrate very nicely that societal costs (and benefits) are often poorly reflected in prices determined by market supply and demand – yet can often be corrected in market-compatible ways through well-designed regulation.<sup>6</sup>

Approaching trade and its externalities purely through the lens of economics, however, is insufficient. To address the upcoming challenges after the COVID pandemic, we need the inherently interdisciplinary perspective of International Political Economy (IPE). IPE scholars seek to understand the dynamic interactions between cross-border economic processes and inter- or transnational politics and policy – which is why the founders of modern trade theory (Adam Smith, David Ricardo, etc.) ►

consciously considered themselves **political economists**. In the 1970s, economists such as Susan Strange and Charles Kindleberger and political scientists such as Robert Gilpin, Robert Keohane and Dieter Senghaas deliberately used an IPE approach to gain a better understanding of ever more complex international economic relations.<sup>7</sup> The resulting modern IPE examines how international trade and financial flows (and other border-crossing phenomena facilitated by them, including production and consumption) are shaped by the political context (and the power to create and change those conditions). At the same time, IPE analyzes the political consequences of cross-border economic processes through which not only goods, services, and money are exchanged, but ultimately power is also distributed or redistributed.

After the COVID pandemic, it will be particularly important to take these interactions between politics, policy and economy into account, because it will not suffice to point out that protectionism and other forms of economic nationalism are inefficient. If less than 10% of the population benefits from more than 90% of profits earned from globalization, as appears to have been the case for decades in the United States,<sup>8</sup> it should not come as a surprise when political support for open markets collapses. In that sense I fear that Trump has been a symptom rather than a cause of changes regarding the role of the USA in international economic relations. Germany and Europe would be well advised to design measures supporting the economic recovery from the pandemic in such a way that it will neither have protectionist consequences, nor threaten the domestic political sustainability of international economic relations.<sup>9</sup>

In the realm of foreign economic policy, Germany and Europe face an even greater challenge. For almost 200 years,<sup>10</sup> every few decades, macro-economists of the economic nationalist persuasion have come up with the idea that it would be possible for a country with a relatively large domestic market to levy an “optimal” tariff that would be more beneficial to the country than free trade. This is possible because an economically large country’s market power enables it to impose tariffs (up to point) such that the net welfare losses occur entirely at the cost of producers from other countries. From a tactical point of view, the “Optimal Tariff Theory” is correct to the point of being supported by mathematical proof. Strategically, however, it fails as a guideline for trade policy, since the blatantly manipulated trade partners will resist, either by taking counter-measures in product segments where they themselves have a dominant market position – or by trying to shift the damage to third parties. The result is a spiral of trade-distorting measures involving economic losses for all instead of an unexpected gain for the country that put the spiral into motion. To anticipate these dynamics, however, requires policymakers to go beyond tactical calculation, and engage in politico-strategic analysis instead.

The false belief that a great, powerful nation, such as the United States, could “profitably” levy tariffs, was revived by Donald Trump and his trade policy advisor, Peter Navarro, even before the COVID crisis. The use and abuse of power prompted by such beliefs can take many forms.

**All of them have a major flaw:** Any short-term material gains that might be achieved are outweighed by much greater damage in the long run.

After the economic nationalism of the 1930s and World War II, international institutions such as the World Trade Organization were created to make governments more resistant against such temptations. Like Odysseus anticipating the deadly temptations of the Sirens, governments tried to tie their hands for their own protection. However, since the beginning of Trump’s presidency, the U.S. government (tolerated or even supported by the Republican majority in the Senate) has shown an alarming willingness to destroy those international institutions. Whenever any international institution has gotten in the way of Trump’s pursuit of usually short-sighted benefits, the administration has sought to undermine it – including institutions built over decades and often according to a U.S. masterplan.<sup>11</sup> COVID then showed that this abdication of global leadership goes far beyond the economic realm. As long as Trump and his disciples and opportunistic aspiring successors are a major political force, the United States cannot be relied upon to reliably provide long-term international leadership.

Angela Merkel’s warning that Europeans (and thus also Germans) may need to get ready to pro-actively shape their own futures will thus be even more timely after COVID: It will not suffice for Europeans to put – and keep – their own house in order (even though doing so is hard enough). Europeans (and Germans) will have ask themselves: Are they ready to sustain and indeed strengthen the international institutions that are necessary for maintaining international economic openness – jointly with and never against the United States, but, if necessary, without it. India, a democracy of more than 1.3 billion people, could in the medium term become a key partner for Europe in global governance, but India currently still appears to be too preoccupied with its internal matters. Russia currently seems neither able nor interested in doing anything other than undermining liberal democracy and Western-built institutions. And in the case of China, its increasingly autocratic domestic politics raises severe concerns about its ability and interest in being a reliable partner rather than a strongman seeking international dominance.<sup>12</sup>

Addressing these challenges requires a next generation of political leaders equipped with the skills and character to tackle the fundamental political questions of the day with a sense of the important difference between tactics and strategy. It requires policy analysts with the capacity to think “out of the box” and thus use their profound knowledge of different policy areas to expand both short-term and long-term options for policymaking on the micro- and macro-level. It also requires individuals skilled in working in teams. To (further) educate them will be the great and urgent task of research-based university-level training in the political and policy sciences. Such an effort also requires adequate framework conditions. Over decades, the leading U.S. research universities have built large interdisciplinary public policy schools such as Harvard’s John F. Kennedy School of Government and Princeton’s School of

— The result is a spiral of trade-distorting measures involving economic losses for all instead of an unexpected gain for the country that put the spiral into motion.



**Professor Dr. Tim Bütke**  
Professor and Chair for International Relations,  
Hochschule für Politik at TUM and TUM School of  
Management; Senior Fellow, Kenan Institute for Ethics,  
Duke University

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Public and International Affairs (formerly the Woodrow Wilson School). Apart from the Willy Brandt School in Erfurt, which covers only a few specialties, Germany currently has only one real public policy school: the Hertie School of Governance in Berlin, which is excellent though still small by international standards and entirely private. In 2014–2016, the Bavarian State Parliament had the foresight to reimagine the Hochschule für Politik (HfP). Relaunching the HfP at TUM, the State Parliament endowed it with dual mission of striving for excellence in research and teaching in both political science and public policy. The foundations have thus been laid for a first public School of Public Policy – at the leading German research university with a special knack for applied research. The time is ripe to build on these foundations so as to shape the future after the COVID crisis. —

07

# HEALTH & MEDICINE



# Health and Medicine

**The COVID pandemic shows that the control of infectious diseases is one of the major medical, social and political challenges. Whether the dangerous SARS-CoV-2 virus will lose its bite in the near future through vaccination and new medication remains to be seen. According to the WHO, at least 150 vaccine projects were initiated around the world within a short period of time. We certainly learned during the COVID crisis that preventive measures that significantly limit our freedoms and have drastic socio-economic consequences can effectively suppress the spread of the virus.**

A special momentum of the crisis and the lockdown was that we were made to experience the fragility of our living conditions. This caused many people to think about what could be done better in the future. Naturally, doctors mainly thought about healthcare, as it is no secret, even in the year of COVID-19, how many people suffer from chronic, physical and mental health problems. We are thinking about the possibilities for a far-reaching change and consider where the German society and politics would need to set its priorities in terms of structures and research in health and medicine. What kind of healthcare system do we want to have in the future? What kind of system can we afford? We are dealing with these questions in our article.

First of all, we assume that our healthcare system is only sustainable if it keeps a keen eye on public health, i.e. the health of the entire population, and if resources are used sensibly in the medical field.

Varied and differentiated preventive measures and high-quality treatments for the many chronically ill are of major importance for maintaining good health in societies. This can only be achieved with permanent, differentiated epidemiological research. Within this context, collecting and evaluating data by the lawful use of state-of-the-art digital technologies is essential.

## Primary tasks in the field of public health and medicine

Sickness, age and death are inevitable parts of human life. The central problem of public healthcare and medicine are the many people who suffer from somatic or mental chronic health issues (diabetes, various lung diseases, dementia, schizophrenia, etc.). Prevention and early detection are of major importance. With a manifest chronic illness, medical professionalism comes into play – targeted treatments are essential to maintain good quality of life as long as possible. With regard to the total population, acute illnesses that can be cured by medical care or even disappear by themselves are a much lesser problem than chronic illnesses.

If it is a matter of life and death, as it is with COVID-19, it means that healthcare must be focused on the essentials. The pursuit of profit, which leads to unnecessary interventions or dangerous levels of pressure after staff reductions, is incompatible with the primary targets of a sustainable healthcare system. Furthermore, excessive bureaucracy with time-consuming documentation in patient files (paper or computer) is rather counter-productive in view of the actual tasks. Medical and nursing staff should be able to fully focus on the best direct care for patients. This is usually done with responsibility and based on ethical principles such as the Hippocratic Oath.

## Digital options and robotics

Intelligent IT is by far the most important instrument for supporting work processes and making them more efficient. For example, quality management could largely be done by using this modern technology. The digital options are continuously further developed, including in terms of user-friendliness. So there is hope that IT will finally be used comprehensively in medicine and in the healthcare system.

Where IT is concerned, it should be highlighted that the humanoid robotic assistance systems in particular will be a huge topic in the future. They can make life easier for the chronically ill, especially older people, and relieve nursing staff (see “Munich School of Robotics” at the TUM). Their use is essential if the shortage of nursing staff and doctors is exacerbated in the future and can no longer be compensated even by higher salaries or personnel hired from abroad. Our society will experience huge problems in this regard. At that point, at the latest, many will ask why society and policymakers have not considered and made use of the strategic option of IT including robotics, which results in reduced workload and staff savings, a lot earlier. There is a glimmer of hope: After COVID-19 appeared, IT seems to have found more acceptance in general (see article H. Krcmar).

## Excessive medical care with a view to life expectancy

During the COVID crisis, at times significantly less patients went to hospitals and surgeries than before. Some people stayed away from medical facilities for fear of infection. For some of them who had a real acute need for action, this meant a huge disadvantage, e.g. in case of heart attack, stroke, cancer and such chronic illnesses that need regular check-ups.

However, the decline of patient numbers also needs to be seen as an indication for excessive and improper care. Let's consider two causes: **1)** A not insignificant number of people come to medical facilities and hospital outpatient departments because of non-medical needs, e.g. to escape loneliness. This raises the question to what extent doctors should provide life counseling? This question must be considered in society and politics. We need better structural solutions for the many people (both young and old) who suffer emotionally and mentally. Following Singapore's example, the promotion of multi-generation homes could be a step in the right direction. **2)** The German healthcare system generates medical services that seem rather unnecessary from other European countries' perspectives. The provision of such services was partly suspended during the crisis. Excessive medical care has been provided e.g. in the catheter and stent treatment of coronary arteries or with appendectomies and joint replacements (hip, knee). ►

# The targeted collection and evaluation of data under defined aspects provides great health benefits for society and its individual members!

What impact does increased medical care have on people's life expectancy beyond a certain point? For example, England has the least number of such interventions per 100,000 inhabitants (data provided by OECD and EU, see online); France and Italy are in a "worse" position compared to Germany as well. However, it is interesting to find in this context that even in England, with its state-controlled healthcare system (NHS), and particularly in Italy and France, both women and men have a higher statistical life expectancy (men/women: Germany: 78.7/81.1 y; Great Britain 79.5/81.3 y; France 79.6/82.6 y; Italy 81.6/83.6 J) (OECD 2017). This fact clearly shows that life expectancy is not determined by medical care alone (see Human Development Index, UNO).

Hans Rosling shows in his book "Factfulness" (Ullstein 2020) a correlation between income per capita and a higher life expectancy. The healthcare politician K. Lauterbach has repeatedly pointed out that the life expectancy of poorer people is significantly lower than the life expectancy of people in high-income groups in Germany as well (YouTube 02/ 05/ 2020, conversation between Gregor Gysi and Professor Dr. Karl Lauterbach). The level of education and specific preventive measures, where Germany seems to be lagging behind with respect to nutrition, also play a role. The question whether older people in Germany enjoy a comparably higher quality of life due to "excessive medical care" cannot be conclusively answered for lack of epidemiological research. It becomes clear that there are still major challenges in public healthcare and that solutions need to be found.

## Too many hospitals?

An important matter within the context of medical care is the number of hospitals and their viability. Consulting companies (e.g. Roland Berger, *Krankenhausstudie* [Hospital study] 2019) recommend a Germany-wide reduction by several hundred so that the remaining institutions can operate gainfully or with higher profits. Scientific academies (Leopoldina: *Zum Verhältnis von Medizin und Ökonomie im deutschen Gesundheitssystem* [On the relationship between medicine and economy in the German healthcare system] 2016) deal with the matter of excessive care as well. We as the authors of this article think that the number of hospitals must not solely be based on business-oriented considerations. With our many years of medical experience in responsible positions, we do not disregard that only a reasonable management can guarantee good healthcare provision for the population. However, the matter of hospitals should first and foremost be based on the medical needs of the urban and rural population and of an ageing society. We also think that healthcare for sick children should be given more priority. The position of the Bavarian State Ministry of Health and Care seems to be sustainable and reasonable in its basic approach: "The hospital planning aims to ensure the needs-based healthcare for the population by providing for a functionally tiered and efficiently structured network of complementing hospitals" (see also the article by H. Magel and M. Miosga). In the authors' point of view, the question what is needs-based must be reconsidered and re-established again and again on the basis of continuous epidemiological studies with consistent collection of data.

## Rare diseases and their paradigmatic significance for personalized therapy

For a long time, patients suffering from rare diseases have had little perspectives with regard to therapeutic interventions. However, following the introduction of innovative diagnostic procedures, specifically genomic analytics, progress has recently been made towards causal treatment approaches. Rare diseases play a relatively bigger role among children compared to adults, where chronic illnesses dominate. Until now more attention is given to them in the therapeutic field of work in pediatrics than in adult medicine.

One paradigmatic example of a rare disease is the spinal muscular atrophy. In the past, persons affected by this disease already died as toddlers in severe cases. Today, options are available that can significantly improve the genetic defect and the corresponding symptoms if the condition is not too advanced. The patients' life expectancy is improved as well. However, the treatment of spinal muscular atrophy with antisense oligonucleotides and/or gene therapy is so far one of the most expensive medicinal treatment methods in the history of medicine. It should be mentioned that rare diseases are not satisfactorily reflected in the current German hospital billing system (DRG).

The research of rare diseases is generally of major interest to medicine. Based on this research, it could be verified little by little that personalized therapy approaches addressing specific genetic and molecular-biology findings of the individual patient

result in real breakthroughs, breakthroughs that give hope to chronically ill adults as well. The further development of the new genome-oriented form of personalized therapy is expensive and will burden the healthcare system significantly more in the future. It should therefore be a political task and obligation to relieve the healthcare system of the payment of costs for diagnostic measures and therapies without a verifiable benefit. This would help to better secure funding for rare diseases.

## Clinical studies in oncology and the necessity of epidemiological research

Clinical studies of patients are the most important instrument the medical field has to promote new procedures and advancements. However, this type of clinical research must also be critically scrutinized. This particularly applies to the field of oncology. We have heard about revolutions in cancer therapy and major successes in research from scientists, doctors and the pharmaceutical industry for decades. Many thousands of clinical studies of patients have been and are being carried out. However, despite the numerous studies, the rate of recoveries from cancer has improved a lot less "dramatically" than is often suggested. About 45% of patients still die from their malignant tumors. Without getting into details: Clinical studies sometimes pursue issues of hardly convincing purpose; a lot of studies are cancelled early. To what extent the latter can be justified to the participating patients is an open question. At any rate, studies tie up personnel and infrastructure and could therefore be regarded as a waste of labor and funds. It remains undisputed that medical studies generally establish new diagnostic procedures and new therapies (including more gentle and/or less aggressive ones). Nonetheless, it seems urgently required to think about whether the current studies culture in the field of oncology, which has become a value in itself, needs to be reformed. The ethics commissions in medicine should take the lead in the search for a new approach for medical sustainability. The sponsoring of studies and many more issues need to be thoroughly considered and discussed.

The epidemiological data of the tumor registries speak a different language compared to the studies. The registries evaluate, depending on the stage (!) of the defined cancerous disease (e.g. lung cancer), large groups of treated patients under the aspect of survival after therapy. The following essentially results with regard to adult oncology: Patients in the early stages of cancer are being cured. In contrast, in loco-regional advanced stages, the disease can only sometimes be definitely controlled. Patients with distant metastases can still not be cured, with few exceptions. ►

In summary: The facts regarding the cure of cancerous diseases in adult oncology have not changed very much over the past decades, with few exceptions! Differentiated consideration of the various stages of the disease shows that progress has been nowhere near revolutionary.

Overall, the cure rates for breast cancer have improved by approx. 10%. This mainly results from the fact that, in more recent years, the disease has been detected and treated in healable early stages in more women (early detection!). Although the new immunological medication results in significant prolongation of life for a smaller subgroup of patients in advanced stages of the disease, it does not effect a permanent cure. We want to highlight again: Only the epidemiological data of international and national registers show what real advancements have been achieved in cure rates depending on the stage of the disease and compared to the past. Longer existing registries in Germany are e.g. the register in Saarland and the register at the Munich tumor center (founded in 1978, see online).

Epidemiological research not only aims to review the findings of clinical studies of large populations in the field of oncology and in the many other medical disciplines (e.g. internal medicine including cardiology, etc., surgery, neurology, psychiatry, pediatrics, radiology, etc.). Although epidemiological research ultimately aims for population-related scientific statements, it usually relies on personal data on the subjects' state of health, sociodemographic details, information on risk factors and oftentimes medical examination results and findings from the analysis of biological materials. On this basis, it helps to find out whether specific data correlations (e.g. genetic or molecular-biology data correlations) provide suitable approaches for targeted preventive measures or individually designated therapies. When it comes to the common type 2 diabetes, which does not provide a uniform disease pattern under epidemiological aspects, the German Center for Diabetes Research (Helmholtz Association), for example, is working on possibilities for personalized prevention and therapy.

In order to generate more efficient progress in healthcare and medicine in the future, epidemiologically oriented research must be hugely extended. In a continuous cooperation between hospitals and doctors, registries (epidemiologists), research institutions, payers, health departments, ethics commissions and the government, data must be collected and evaluated, much more than previously, in a targeted manner. This research needs to be done on the basis of networking and responsibly used IT. IT with all its possibilities including Artificial Intelligence must finally be used in the entire health-

care system under "e-governance" (see also the articles by A. Bode, M. Broy, J. Eberspächer, D. Heckmann, K. Mainzer). Corresponding structures must be established and funds must be provided for this highly complex challenge. Apart from the basic patient-related data (age, gender), the data pools will also include numerous other differentiated information. It refers to: therapy performed (e.g. therapy complications, quality of life, survival), diagnostic imaging, molecular biology and genetics of the disease, patient's life circumstances, use of in-home nursing care for the elderly, use of robots in nursing, screenings, early detection, preventive measures and much more.

The targeted collection and evaluation of data under defined aspects provides great health benefits for society and its individual members! It enables to know precisely the effects preventive and medical measures have in the general population. Scientific findings in epidemiology make sure that the healthcare policy is able to make decisions that are cost-effective and serve people in terms of a permanently functioning healthcare system. All that is found superfluous is given up. Procedures that prove useful are permanently established. Epidemiological discoveries that offer great opportunities for more progress in prevention and/or clinical medicine are further scientifically examined in terms of their potential. "If thousands of patients with diabetes, cancer or dementia made their data available, we could learn from them. Data 'can heal people'" (speech by the German Minister of Health, Jens Spahn, on 18 January 2020, DLD Innovation Conference, Munich).

### Early detection

The largest German healthcare study (National Cohort), which questions and medically examines 200,000 people regarding their life circumstances and medical histories (start in 2014, term of 20–30 years), does not primarily serve to establish better therapies. It mainly serves the development of measures and strategies for better prevention and early detection (Federal Health Gazette 63(3), March 2020).

Let us briefly explain the benefit of early detection by the example of cancerous diseases. The latest research results from Belgium and Holland confirm the benefit of computer tomography screenings of the lung. In the screened group of men and women, the cancer mortality was significantly lower than in the non-screened group (H. de Koning et al., N Engl J Med, 2020). It should be mentioned that high-risk groups of smokers were screened. The significance of this targeted early detection is that the early detection of the cancer in a

non-metastasized stage offers the great chance of definitive cure. This does not only apply to lung cancer. Early detection generally also means the highest chances of cure of colon, prostate, cervical and breast cancer (see also the article by S. Klug and M. Kiechle).

The mammography screening has reduced the number of advanced breast cancers with poor prognosis by approx. 20% (Walter Heindl, lecture at DEGRO Congress 2019, Münster). Tumor register data confirm the increasing number of early detected breast cancers. For a not insignificant part, this explains the increase of the cure rates for breast cancer in the more recent past (see above). Early detection has advantages for many other non-oncological diseases as well. It generally allows for early (including gentle) treatment to cure or to delay the onset of serious symptoms.

It goes without saying that the use of newly developed procedures of early detection should be accompanied by epidemiological research and evaluation. This is required to identify its true benefit. It should be highlighted and thoroughly emphasized in this context that with each anomaly that is detected early during screenings (imaging, laboratory, cytology, etc.), any consecutive intervention should be carefully considered in the indication stage. Here as well, anything "superfluous" and/or risky should be avoided. Early detection does not mean that further therapeutic interventions must be made immediately! The further observation of the result by following the "Wait and See" strategy may be sufficient.

### Prevention

Screenings such as the mammography serve the early detection of diseases and are thus part of the classic secondary preventive measures; they are covered by health insurance funds. Tertiary prevention has its fixed position in medicine as well: It serves to reduce possible consequences or returns of the disease and should largely be put on a level with rehabilitation.

Measures of primary prevention and health promotion have the longest-lasting effect on health, despite the success of curative medicine. A classic example for primary prevention is avoiding the risk factor of smoking in order to reduce lung cancer and other types of cancer, and also of cardiovascular and respiratory diseases. To achieve this national health target, a law for the protection of non-smokers was passed that significantly restricts smoking in public spaces. In addition to a tobacco tax increase, health promotion measures were taken by the Federal

Centre for Health Education (BZgA): With the slogan "Be smart – don't start", young people were asked not to start smoking in the first place. According to surveys made by the Robert Koch Institute, in the intervention period between 2001 and 2014, the number of "never-smokers" increased from 40.5% to 75.3%, and particularly the number of young smokers significantly fell (*Gesundheitsberichterstattung des Bundes* [Federal Government health report] 2015).

In principle, prevention thus aims to reduce the burden of disease of the individual or the entire population through various activities (RKI). In the WHO European Region, non-communicable diseases are responsible for at least 86% of all deaths and 77% of the burden of disease. The four most important non-communicable diseases are cardiovascular diseases, cancer, chronic obstructive pulmonary diseases and diabetes. One of the WHO's main targets is to reduce their occurrence by taking preventive measures.

In addition to the aforementioned measures of behavioral prevention, measures of structural prevention are known to be particularly effective; they include e.g. environment-related health protection, sustainable green urban development that stimulates physical activity, schoolyards that promote physical activity, and traffic protection.

An important complementary element to prevention is health promotion. It does not argue with the prevention of diseases, e.g. by avoiding disease-specific risks such as smoking, ►

but with the general reinforcement of the protective factors for health. The individual is to be enabled to promote and maintain his/her own health at all levels (biopsychosocial), e.g. by informing about a healthy lifestyle, by enough exercise, a healthy diet and stress reduction. Prevention in combination with health promotion is required, including for the fulfilment of the Sustainable Developmental Goals (SDG), which were defined by the United Nations in 2015 as goals for its Agenda for Sustainable Development until 2030: Ensure healthy lives and promote well being for all at all ages (SDG 3) (see also the articles by A. S. Winkler and C. Prazeres da Costa, A. S. Winkler et al., J. F. Amuasi and A. S. Winkler, S. Klug and M. Kiechle, A. J. Mahmud et al.). In Germany, long-existing flaws in prevention and health promotion were addressed, after more than 10 years of struggling, by the *Präventionsgesetz* [Prevention act], which took effect in 2016. “Although the financial resources were increased relatively strongly, they remain on a low level in absolute terms. They will still only cover a small part of the total population and/or of the risk groups,” says the BZgA 2018 about the effects this act had so far. It allegedly does not promote the cooperation of society as a whole for the lasting prevention and health promotion, but allocates a central role to the health insurance funds. For example, widely effective political decisions for important target groups have not been made so far: Few anti-obesity programs for children are paid by some funds, not by others; follow-up programs for the sustainable enhancement of motivation and behavior after successful weight loss are rare.

Worldwide recommendations deal with population-based prevention and health promotion instead of individual efforts, as this is much more successful than merely addressing specific risk groups: A comprehensive introduction of e.g. more physical education in full-day schools or more water (instead of soda) sales points in schools, which is common in many countries, has not yet been achieved in Germany. Examples from Scandinavian and other countries, such as a traffic light food labelling system for declaring the food ingredients and/or the salt content, a sugar tax or the ban of trans-fats show the many different options the government has (see also the article by H. Hauner). The question whether these German deficiencies are the reason why the average life expectancy of women and men is lower in Germany than it is in Sweden, England, etc. (see also the section about excessive care) needs to be explored in more detail.



**Professor Dr. Dr. h.c. Michael Molls**  
Spokesperson of the TUM Senior Excellence Faculty; Director of the TUM Institute for Advanced Study (IAS); Professor and former Director of the Clinic for Radiotherapy and Radiological Oncology, TUM



**Professor Dr. Renate Oberhoffer-Fritz**  
Dean of the Department of Sport and Health Sciences, TUM; Professor of Preventive Pediatrics, TUM



**Professor Dr. Ingo Borggräfe**  
Head of Pediatric Epileptology, LMU Munich

This article, which deals with sustainability in medicine and healthcare, makes the case for the focus on essentials and the removal of everything that is superfluous and useless. It draws attention to a science-based healthcare system including prevention, early detection, cure and, in particular, the best care for the chronically ill. The great importance of IT and AI for optimizing workflows in medicine and for generating progress in health-related research is highlighted. It is a pressing task of science and politics to convince the people of the many different benefits that can be achieved by means of IT. IT-supported epidemiological research is producing the data that enable a rational and sustainable management of the healthcare system. It also uncovers new innovation potentials.

The COVID crisis has, to some extent, resulted in heated discussions. The pure “deontologists” hold on to the principle of equality before the law as set out in the Basic Law for the Federal Republic of Germany (Article 3) without discussion. For us as a team of authors in the field of medicine, it is certain that this irrefutable principle, which is of fundamental importance, cannot always be fully upheld in medicine.

Our society largely accepts that the elderly must be put at a disadvantage in favor of younger people when it comes to, for example, a liver transplant, because there is a lack of donor organs. Obviously, a “mild” form of utilitarianism, as it is not uncommon in Great Britain and the Commonwealth countries, has long been existent and accepted in our society. Many people do not seem to be aware of that! We do not know whether the global societies with a total population of approx. 8 billion people (in 2050: 9.7 billion!) will be affected by even more dangerous pandemics (even more contagious, even more deadly) than COVID-19 in the future. Thus, it cannot be excluded that the people in Europe will face significantly worse ordeals than the COVID 19 year of 2020. We should think about whether we still want to be guided, even then, by strictest ethical “rigorism” in the social discourse.

Should we not discuss seriously, openly and honestly in our society whether a “mild” utilitarianism is a responsible mindset when we are hit by extreme disasters with multi-dimensional consequences with a view to the wellbeing of the people? At any rate, we as a team of authors wish to have a respectful, differentiated culture of discussion for our society, now and in the future, which seeks mutual understanding and good solutions. This seems particularly necessary when highly complex, very difficult, existence threatening issues need to be addressed. ─

# Global Health

## COVID-19 as a Catalyst

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**The COVID-19 pandemic has brought the concept of Global Health (GH) into the public focus overnight. The field of GH, which is often given little attention by many physicians and scientists in this country, has arrived in our living rooms and, due to the extent of the pandemic, forces us to realize that we are all in the same boat, also in terms of health.**

Until now, most of us have had little interest in health problems of other countries, especially those of the Global South. However, these problems are now anxiously recognized by the public at large. We are reminded of the Ebola virus outbreak 2013–2016 in West Africa, which could be contained effectively both locally and worldwide thanks to the heroic efforts of many global health actors. Thus, the Ebola virus luckily never arrived in Germany. Why did we not learn our lesson at that time? We should have intensified the dialogue with and among our partners, not only in public health, but above all on the political level, to develop sustainable prevention concepts in partnership. At the latest, these concepts should have been implemented during the current COVID-19 pandemic, the first global health emergency since the Spanish flu in 1918.

### The concept of Global Health

The concept of Global Health (GH) has been developed from the Declaration of Alma-Ata, where an international conference on primary health care was held by the World Health Organization (WHO) in 1978. It became one of the most important milestones of the 20<sup>th</sup> century in the field of public health and identified primary healthcare as key for achieving the goal of “Health for All”. The Declaration states: “An acceptable level of health for all the people of the world by the year 2000 can be attained through a fuller and better use of the world’s resources”.<sup>1</sup> In the following decades, a lot happened in the increasingly globalized world, so that in 2000, the global community, represented by the United Nations (UN), proclaimed the Millennium Development Goals (MDGs). They consisted of eight, in part narrowly defined goals; already at that time, the eighth goal called for global partnership as a central element of development. In 2015, the MDGs were succeeded by the 17 Sustainable Development Goals (SDGs), also defined by the UN, to be achieved by 2030.

The Sustainable Development Goals are broad and inclusive, as defined from a systemic perspective and can be roughly divided into a social, an ecological and an economic area, all of which are interconnected at various levels. SDG 3 specifically deals with Global Health and aims to “ensure healthy lives and promote well-being for all at all ages”. GH also wants to be understood as a human right to healthcare and calls for cooperation and collaboration across disciplines and sectors in order to enable health around the globe by engaging all relevant actors (science, economy, politics and civil society). This also includes the recognition of social inequalities, the so-called determinants of health such as poverty, lack of education or gender-specific discrimination as key factors influencing public and individual health.

### Global Health's fields of action

The COVID-19 pandemic could leave the impression that GH's range of action is mainly defined by epidemics or pandemics and that GH is primarily designed for acute global health crises. Although the fight against epidemics is an important element of GH, new and recurring infectious diseases tend to move to the background when the so-called burden of disease is considered, which, in addition to mortality and morbidity, includes risk factors related to work or environment. These calculations ensure that diseases can be compared more comprehensively. Epidemics and pandemics may wake people up, but they tend to cause less burden of disease compared to e.g. the major “killers” malaria, HIV/AIDS and tuberculosis.<sup>2</sup> However, the Spanish flu and the COVID-19 pandemic are exceptions, not just due to the significantly increased burden of disease compared to other epidemics, but also due to the significant impact on the global economy. Although infectious diseases deliver far better headlines, it must be pointed out that more than 70% of all people die from non-communicable chronic illnesses, first of all cardiovascular diseases followed by cancer and pulmonary diseases as well as diabetes (see chapter: Klug and Kiechle on cancer in Africa).<sup>2</sup>

However, GH is not only found in the classic bio-medical, to some extent narrowly defined areas, but often uses the health-care system perspective which shifts the focus away from individual illnesses and towards a horizontal, multidisciplinary one and thus considers healthcare systems in their entirety. Therefore, important overarching topics in GH are e.g. migration and climate change as global determinants of health, or the One Health concept which emphasizes on the interconnectedness between humans, animals and the environment (see chapter: Winkler, Amuasi, Wacker on One Health). Antimicrobial resistance (AMR) and many of the neglected or poverty-related tropical diseases (NTDs) can also be found in this field. Further topics in GH include nutrition (see chapter: Hauner on nutrition), digitalization, governance as well as globally acting trade and economic systems. ►

## Sustainability on a global scale

To underline SDG 3 with commitment, the heads of the governments of Germany, Norway and Ghana started the Global Action Plan (<https://www.who.int/initiatives/sdg3-global-action-plan/frequently-asked-questions>) in 2018, containing the appeal to the WHO Director-General, Dr. Tedros Adhanom Ghebreyesus, and other important stakeholders, mainly UN organizations, to reliably support the plan.<sup>3</sup> At the World Health Summit (WHS) 2018 in Berlin, ten of these twelve organizations who work in the field of global health under the leadership of the WHO accepted the challenge and assured their full support for the Global Action Plan for SDG 3. In September 2019, at the UN General Assembly, all twelve organizations who had signed the Global Action Plan launched a joint plan to better support countries in implementing SDG 3. These visions on a global scale are important and a key driving force. However, the operationalization requires the implementation at a local level by means of interdisciplinary and cross-sectoral structures that not only break down global conversation to the local level, but help shape the global discourse through local actions. One example of such a local structure at university level is the Center for Global Health (CGH) at the TUM School of Medicine.

## Sustainability at a local university level

The CGH was founded in 2017 as a response to the emerging need of politics and society (see above) by the Department for Neurology and the Institute for Medical Microbiology, Immunology and Hygiene. This initiative grew out of the long-standing research activities of the two directors in the field of immunology and chronic infectious diseases, neglected tropical diseases and non-communicable diseases, particularly in the field of global neurology and allergies, all of which SDG 3 calls for to be combated. The CGH is primarily conceived as a virtual platform to enable scientists across faculties to exchange ideas, knowledge and expertise about key research topics of global health promotion and disease prevention, always in light of the interaction of the various global determinants of health. The CGH sees itself as a nucleus for GH at the TUM. It aims to jointly design interdisciplinary and multidisciplinary research and teaching across the faculties and seeks to trigger new global health projects.<sup>4</sup> The CGH's vision is to make a significant and lasting contribution to GH and to strengthen the process of further developing Germany's Global Health Agenda. This is achieved specifically by the interdisciplinary and cross-faculty bundling of scientific expertise and resources of the TUM and rests on the following three pillars:

**Networks:** The CGH is the point of contact for actors of various sectors (science, politics, economy and civil society) and disciplines (e.g. biomedicine, social and political sciences) to network and exchange knowledge and experience in GH.

**Research:** The CGH creates a platform that promotes exchange and communication on current research topics in GH across the disciplines and actively initiates and supports projects.

**Teaching:** The CGH contributes to the education of the next GH generation by providing teaching in the GH field and by inspiring students to cooperate across the disciplines.

When health crises such as the COVID-19 pandemic occur, it is of major importance to be able to quickly resort to established science-coordinating structures to launch innovative projects and/or interconnect existing innovation. Thanks to its TUM-internal and international networks, the CGH currently initiates some multidisciplinary scientific collaborations, increases the TUM-internal cooperation and thus contributes to the global agenda in the fight against COVID-19.<sup>4</sup> The COVID-19 pandemic shows what significance GH should have in the university landscape. In the spirit of sustainability, structures promoting interdisciplinarity in research and teaching at universities and beyond must be demanded, supported and firmly established, not only to be able to quickly respond in a crisis, but also to learn from the crisis and to protect our health more sustainably in the future. Universities can and must contribute to this goal with all their expertise and innovative strength. System-oriented sustainability in healthcare is essential, because healthcare concerns us all – we have known this all along, but COVID-19 has now reminded us of it. ┘

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#### 3. Global Action Plan for Healthy Lives and Well-being for All.

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#### 4. The Center for Global Health, TUM School of Medicine.

<https://www.med.tum.de/de/center-global-health>

┌ Ensure healthy lives and promote well-being for all at all ages.



**Professor Dr. Dr. Andrea Sylvia Winkler**  
Center for Global Health, Department of Neurology, TUM; Centre for Global Health, Institute of Health and Society, University of Oslo, Norway



**Professor Dr. Clarissa Prazeres da Costa**  
Center for Global Health, Institute for Medical Microbiology, Immunology and Hygiene, TUM

# One Health – Out of Many!

An Inclusive Access  
with Future Potential

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**The One Health concept extends global strategies for the health of entire populations or population groups by multidisciplinary cooperation and communication with focus on health at the human-animal-environment interfaces.<sup>1</sup> Often human beings take center stage, neglecting the two other fields of action, i.e. animal and environmental health.**

┌ The One Health approach is holistic; thinking and acting are transformed, across the classic disciplines and sectors, into a synergistic integrative approach for the benefit of humans, animals, the environment and their common health.

The One Health approach is inherent in the targets of the Sustainable Development Goals (see chapter: Winkler and Prazeres da Costa on global health) and includes concerns of healthy and sustainable food production, animal husbandry and biodiversity at local, regional and global levels. Aspects of dynamic urbanization, the destruction of natural habitats, climate change, intensified agriculture and phenomena such as antimicrobial resistance are observed in their interdependence. The health challenges resulting from these developments force us to rethink on a broad population basis and require corresponding overarching research and cooperation.

### The One Health concept from a historical perspective

Health, including the diseases that threaten us, the medication and vaccines that promote our health, and the natural ecosystems that sustain us, have long been understood at the human-animal-environment interface. Hippocrates, the ancient Greek “Father of (Modern) Medicine”, already suggested in 400 BC to achieve public health by ensuring a clean environment. Rudolph Virchow, the famous reform physician and founder of modern pathology, called “medicine a social science” and advocated medical reform that would combat inhumane living conditions and poverty, and to promote widespread health education as well as healthy urban planning. He coined the term “zoonoses” (= diseases transferred from animals to humans) and proclaimed in 1872: “There is no scientific barrier between animal and human medicine, nor should there be; the experience made in one field must be used to develop the other.” Rudolph Virchow wrote this in an article in 1848 for “Die medicinische Reform” [“The medical reform”], a weekly publication published from 10 July 1848 to 29 June 1849.

With the differentiations, specializations and huge scientific advancements in human and veterinary medicine, the holistic view of health concerns took a back seat. Professional silos were established that distanced human and veterinary medicine from each other and separated the well-being of humans and animals from the necessary integrity of their common environment. In Germany, links with the social sciences were additionally cut, as a result of a violent policy of Volksgesundheit, which sterilized and exterminated less fit population groups and propagated hereditary health, racial purity, or the healthy body of the German Volk. It took a great deal of effort to re-establish the awareness of how inextricably intertwined the well-being of humans and animals is with an intact common environment.

This process necessitates the combined involvement of the World Health Organization, the World Organization for Animal Health and the Food and Agriculture Organization of the United Nations. The human dominance over the biosphere in the past century, supported by unprecedented technological advancements, must now be used positively for the benefit of health again. People have a huge responsibility. The understanding of One Health must urgently be recalibrated, existing knowledge must be rediscovered and permanently secured for the future through responsible science, harnessing a huge variety of expertise. ►

## From the One Health approach to a sustainable One Health concept

The One Health approach is holistic; thinking and acting are transformed, across the classic disciplines and sectors, into a synergistic integrative approaches for the benefit of humans, animals, the environment and their common health (= One Health). The One Health approach is closely connected to the Sustainable Development Goals. In an interdependent world, there is a growing consensus that targets in the healthcare sector require efficient interdisciplinary cooperation, including technical, economic and digital competence. Global health threats such as climate change, new or recurring pathogens from Ebola virus to SARS-CoV-2 and the silent epidemic of non-communicable diseases (including cardiovascular diseases, cancer, pulmonary diseases, diabetes and mental health problems) are phenomena that prove that e.g. environmental and species protection as well as poverty alleviation and access to proper education must not be neglected.

Holistic solutions must be found that go far beyond the treatment of the sick. In this context, health-related opportunities must be preventively increased for the various population groups, for animals, plants and their common environment. It is important to provide health protection and, at the same time, realize health promotion in terms of One Health as a political concept everywhere and at all times (mainstreaming the One Health approach). Moreover, this must be made with diversity in mind, i.e. with attention and reference to grown cultures, available resources and the diversity of people, meaning their differences in gender, age, origin, education, other diversity dimensions and circumstances.<sup>3</sup> This can only be achieved by taking coordinated measures in several disciplines and by cooperation across the sectors (public and private sector).

An informed and evidence-based health policy as well as corporate responsibility, investments in research and education and good governance and leadership are pointing the way. In order to realize One Health as an overall concept, cooperative, multi-lateral and committed democratic actions are required in all areas of society, in every country and on a global scale.

## Good health through conduct and conditions

A One Health approach is relevant in pretty much all areas of health. This is also supported by veterinarians, who have coined the term One Health in the past century in the field of zoonoses (60–70% of all infectious diseases are zoonoses). The exchange of germs in encounters between animals and humans plus their carriers (=vectors) from the environmental reservoir was their concern. Mainly neglected tropical diseases and emerging and re-emerging infectious diseases (epidemics) impressively demonstrate the benefit of a One Health approach, but also the more recent research on the environment as shared habitat of humans and animals.

To see the environment not only as a pool for pathogens and contaminations of all kinds, but also as a vast biorepository with immense untapped health benefits, is a growing research perspective, also with regard to well-being and quality of life studies, which includes the man-made environment (i.e. the individual and environmental factors with which the World Health Organization operationalizes health following the biopsychosocial model). Promote health, for example, by reducing heat and air pollution, building healthy cities (greening, but also energy supply and management of waste and wastewater), new agricultural concepts (methods of cultivation, pest control etc.), but also new forms of health behaviors (physical activity, nutrition, slowing down and inclusion) for the heterogeneous populations, that must be part of a plan of health for all, is as much in line with the One Health idea as the fight against the SARS-CoV-2 pandemic.



**Professor Dr. Dr. Andrea Sylvia Winkler**  
Center for Global Health, Department of Neurology, TUM; Centre for Global Health, Institute of Health and Society, University of Oslo, Norway; Co-chair of *The Lancet One Health Commission*;



**Dr. John Humphrey Amuasi**  
Global Health and Infectious Diseases Research Group, Kumasi Centre for Collaborative Research in Tropical Medicine, Kumasi, Ghana; Global Health Department, School of Public Health, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana; Co-chair of *The Lancet One Health Commission*



**Professor Dr. Elisabeth Wacker**  
Chair of the Scientific Advisory Board on the *Bericht der Bundesregierung über die Lebenslagen von Menschen mit Behinderung* [Federal Government report on the situation of persons with disabilities]; Professor of Diversity Sociology, TUM

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## Awareness: COVID-19 as an opportunity for rethinking and acting

The risks arising from wild animal markets or similar arrangements (such as factory farming) that come with the pursuit of profit or ignorance are known and also rejected for ethical reasons. If the SARS-CoV-2 pandemic actually arose from such circumstances in Wuhan/China in December 2019, this would be a (further and especially alarming) call for rethinking and rearranging our interactions using a One Health approach. The global catastrophic consequences of the COVID-19 pandemic, and the call for more knowledge are a unique situation which calls for action with renewed attention on holistic health concepts, as is offered by One Health. The interdependence of humans, animals and environment on one planet are recognized and acknowledged again. Research is responsible and the first point for providing knowledge and driving actions to generate results, using communication that can be understood. The chairpersons of “*The Lancet One Health Commission*”<sup>1</sup> call for, jointly with other experts in the field of “One Health/Planetary Health”, a coalition<sup>3</sup> of multidisciplinary and multilateralism to learn from the current pandemic, to operationalize the findings and to include them in preventive concepts. At the TUM, there is a lot of outstanding competence and the necessary attention to address this major health challenge and direct it into a health-promoting reorientation of cooperation. The conditions and the awareness for a coalition serving One Health are present in research and transfer of knowledge, and some collaboration with TUM-internal and external partners is already working well, therefore: Out of many – One Health! ─

# Dealing with Pandemics

An epidemic is a geographically limited infection, while a pandemic is classified as a transcontinental spread of such a human infectious disease. However, during a pandemic, there can also be territories that are not or not yet affected by the disease. Since 2017, pandemics have been declared by the WHO Director-General. However, the declaration of a pandemic itself does not say anything about the severity, fatality rate (lethality) or the long-term consequences of a disease.

At the start of an epidemic, the severity and mortality rate of a disease are often overestimated. On the one hand, that is because the severe cases or an accumulation of deaths, for which a common underlying cause is then found, are usually being noticed first. The causes of epidemics or pandemics are not always new – history shows us that many infectious diseases reoccur in waves.

Since the start of our common era until the 18<sup>th</sup> century, the plague, the smallpox, the “English sweating sickness” or hemorrhagic fever carried off significant parts of the population in waves. Cholera, typhus and the flu were the main epidemics in the 19<sup>th</sup> century until, at the turn of the 20<sup>th</sup> century, a plague pandemic coming from China claimed nearly twelve million human lives in 18 years. Around the time of World War I, the Spanish flu as the so far most significant pandemic claimed an estimated 25–50 million human lives in under three years.

Since then, there have not been any more of such large waves of infectious diseases, as not only the possibilities to treat bacterial infections with antibiotics, but also the prevention of infections through hygiene measures and the availability of vaccinations had been significantly improved. This meant that infectious diseases were perceived as less significant by humans, although chronic infectious diseases such as tuberculosis, hepatitis B and C, HIV infections, malaria as well as antibiotics-resistant bacteria still kill more than 5 million people each year. Nonetheless, these infectious diseases are just not as spectacular as the major pandemics of the past centuries, and people living in the highly developed Western world almost believed that they were immune to infectious diseases.

The current SARS-CoV-2 pandemic has now suddenly and painfully reminded us that we are not at all immune to new or recurring infectious diseases. Quite the contrary, our way of life increasingly promotes their spread. The fact that humans are pushing into animal habitats promotes the transfer of diseases from animals to humans, commonly known as zoonoses. Climate change and increasingly warmer winters allow insects to spread across moderate climates. They can also transfer viruses and parasites, so that these oftentimes severe, febrile diseases continue to spread. However, the most important aspect is the fact that people closely living together in the growing megacities of the planet promote the quick spread of infections that can be transferred from human to human. Furthermore, all the intense worldwide traveling and trading enables a quick spread of infections around the world. Viruses do not recognize borders and simply travel with us unnoticed.

What means do we have to deal with infectious diseases and to be better prepared for future pandemics? Our options include social distancing, hygiene, vaccinations and antiviral medication and/or antibiotics. From an economic point of view, social

distancing and the associated massive restriction of trade and production can only be a last resort that should be avoided. Thorough infection research is required – from fundamental to translational to clinical research – that widely covers the potential pathogen groups. It is important to focus on new vaccines and/or vaccination strategies that can be quickly activated and used when needed. However, it is equally important to find new antivirals and effective medication against viruses that are not as widespread yet. Not a lot of money can be made with this, which is why it needs to remain a domain of publicly funded research.

The early detection of new and/or recurring infections is certainly another essential element for preventing the spread of infections. Geographical names for these infections, such as “Spanish flu” or “Mexico flu” are misleading; they suggest the local confinement of a problem that is certainly a global one. This means that it is essential to have a close worldwide cooperation and quick communication as well as good diagnostic tools established in the event of an outbreak, and to be able to use them quickly. But it also means that high priority must still be given to communicable diseases – the ones that claim the lives of millions of people every year, which we have gotten used to, and the ones that must be eliminated as soon as they appear. The global community will only be able to address this issue together, with financial support of the rich countries and in cooperation with the not-so-privileged countries – **it is a case of “humanity first”!**



**Professor Dr. Ulrike Protzer**  
Director of the Institute of Virology at the TUM and at Helmholtz Zentrum München;  
Member of the Bavarian State Government's COVID Crisis Expert Council;  
Professor of Virology, TUM

# Psyche and Environment

## COVID-19 as an Opportunity to Reflect on the Essential

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**The COVID pandemic confronts us with a so-called “wicked problem” (according to Rittel and Webber, 1973). Our standard of knowledge regarding the problem is incomplete or contradictory, the changing requirements can only be covered to a limited extent, an endpoint is not clearly defined. Therefore, a satisfactory solution for the problem is hardly or not at all possible. The pandemic requires a macrosocial approach and effort. Psychology makes a contribution by e.g. examining the continuous interaction between the individual and its environment and demonstrates the importance to provide structure, build trust and communicate optimistic perspectives in the present situation.**

### Perception, internal and external situation and behavior

The pandemic's biological and medical dimension already has the potential for psychological uncertainty: SARS-CoV-2 is a newly identified virus. The disease is distinctly experienced by different people, categorizing older individuals, as well as those with previous illnesses into designated risk groups. The flood of media information is overwhelming and sometimes contradictory. However, it needs to be understood that not objective circumstances fully determine an individual's health and well-being. Crucial is the subjective perception of the situation. What is perceived as a threat by one person, is perceived as challenge and motivation by another. Individuals' reactions significantly depend on which information is provided and how it is communicated. If the information is perceived as insufficient, incomprehensible or even catastrophizing, fear and anxiety are instigated. This is accompanied by feelings of helplessness and reduced controllability.

### Social relations and mental health

Psychological resilience research investigates mental resilience in difficult situations. The pandemic is an existential threat for many people. Social relations are an essential protective factor for our health and well-being. The extent and quality of social relations influence morbidity and even mortality (Holt-Lunstad, Smith, & Layton, 2010). In that sense, the infection prevention measures issued by the legislator, such as “social distancing” and quarantine, is a double-edged sword involving risk. Quarantine can have various, complex and sometimes severe psychological consequences. The prevention or mitigation of such consequences must be achieved by “all means”. Regarding coping resources, we can already draw on numerous insights and experiences: Beneficial impacts can be expected from voluntariness of taken measures, availability of information, any form of support and communication, as well as a clearly-defined duration of the measures.

### Development tasks in times of COVID

How are we dealing with the experienced loss of control? Trust is essential; it reduces stress and anxiety. The sociologist Luhmann described trust as a mechanism for reducing complexity. Therefore, it is essential that citizens trust the political decision-makers. Enforcing measures under threats of punishment may lead to obedience; however, if there is no personal acceptance, necessary behavior change will not be voluntarily adopted in the long term. In contrast, providing structure and perspectives imparts hope and trust. So far, the parameters regarding the course of the infection show that solidarity and reason generally prevail in the population. This is an important signal and a chance for the future.

A preventive measure that has a huge benefit for the community is often of little benefit for the individual – and vice versa. If the individual finds the restrictions too severe and if he/she cannot recognize how they are useful, the willingness to cooperate declines. This prevention paradox, as Rose called it in 1981, is shown by the weekly successive COVID-19 Snapshot Monitoring (COSMO) study: Most recently, concerns about our own health and risk perception were declining, as was the acceptance of the measures. Similar phenomena are known in risk perception and the acceptance of vaccinations. Moreover, a general strategy does not sufficiently take those people into account who are particularly vulnerable – the lockdown during the current pandemic specifically affects people already suffering from mental illness.

### Perspective for environment-related prevention

In psychotherapy, psychological stabilization often involves going through crises. What impulses and solutions are being offered for a more stable future? With regard to environment and psyche, behavioral prevention and situational prevention must be mentioned. The latter refers to how we can change the environment and situation so that the risk of getting sick is reduced for individual people. Physical activity, especially in nature, strengthens physical and mental health and well-being. For nature to unfold its full effect, mindful and focused attention is required: hearing, seeing, feeling, smelling. Aside from strengthening the immune system, the experience of nature can also become a spiritual experience that helps to communicate meaningfulness. Experiencing a sense of awe in nature can promote helpfulness and trust via the release of hormones. Additionally, findings show that more green plants in urban environments can reduce suicide rates. ►

A pleasant side effect: Ecological awareness is increased by more outdoor activities. How do we want to live and behave in our environment in the future? Before the pandemic, expansion, pollution of land, water and air caused by our mobile lifestyle had been ever-present. During lockdown, movement analyses showed declining mobility and the start of habitat recoveries. If this development continues, it will not only ensure a sufficient basis of life for our society, but also reduce the risk of further pandemics. However, significant self-regulation is required from each individual, not in the sense of self-disciplining, but as a self-determined shaping of one's life by acceptance and conviction. A mind shift forced by COVID offers this chance. For example, increased work from home has become a potential model for the time after the pandemic. Psychologically, working from home may contribute to deceleration and stress reduction by eliminating the daily commute on busy streets or in public transport. However, supportive structures of everyday working life are changing as well. Home office must not result in a complete loss of structure.

The professional world has a shared responsibility for maintaining mental and emotional health and must fulfil its social function. The advancements of a flexible, caring and social arrangement of work that were recently achieved in many places were a dynamic step in this direction. Hope remains that these approaches are further pursued and developed. Furthermore, the pandemic pushed the field of psychotherapy to establish video-based options for the benefit of the patients. However, this can only be an addendum to personal contact between client and therapist. The pandemic has drawn attention to the issue of loneliness. Social media are only a compromise. They do not replace real social contacts with their abundance of sensory experiences, but rather have the potential to lead individuals into a greater feeling of isolation.

The various aspects of loneliness are of significant importance for solidarity within our society. Furthermore, from a socio-psychological point of view, a change in the perception of what is "external" or "foreign" has potential for future developments. In recent days, we may have experienced the virus as the major threat for all in our environment. Misery loves companion. Can this experience have a corrective effect on the prevailing xenophobia?

The sustainable handling of our environment has its origin in the individual. In addition to the matter, the living body and the psyche, a person also entails spirit. Therefore, education and culture are essential to not only gain knowledge, but also adopt value-based social interactions. Firm expectations that nurseries and schools as well as theaters, museums and other cultural institutions will eventually reopen is a ray of hope in this regard. For the individual, a holistic evolvement in his or her environment constitutes a major path to mental health and well-being.



**Professor Dr. Jürgen Beckmann**  
Professor of Sports Psychology, TUM



**Dr. Maximilian Huber**  
Psychocardiology Research Group at  
the German Heart Centre Munich

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## Conclusion

The United Nations stated in mid-May 2020: So far, too little attention has been paid to mental health during the COVID pandemic, and in general. According to the Global Burden of Disease Study, depressions will be the most common cause for years of life lost due to sickness or death until 2030. This situation will probably be exacerbated by the pandemic. What can help in times of COVID are transparent communication, health education and support of all kinds. Furthermore, prevention in harmony with nature, increased social orientation in the professional world, less loneliness in our society, the autonomous, but ethical handling of basic needs as well as education and culture will ensure a liveable future. ┘

# Nutrition

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**Nutrition is the basis of all life. It ensures the supply of all nutrients that enable life and guarantee optimum functioning. The more complex the being, the broader the need for nutrients usually is. However, the history of evolution also shows that many living beings adapt to the availability of nutrients in their environment. Finally, there is the possibility that organisms develop high flexibility to make use of a changing availability of nutrients. The latter also applies to human beings, who have learned to adapt to a changing nutrient supply, e.g. in the course of the seasons.**

┌ The overall food production is responsible for 21% to 37% of the global anthropogenic greenhouse gas emissions

This was the prerequisite that Homo sapiens was able to spread across the planet and settle in many regions and climate zones so successfully. This high “metabolic flexibility” distinguishes him from other beings and has significantly contributed to his success and his dominance in the species’ struggle for natural resources.

The human being’s success story is fascinating and has, of course, not only to do with this ability, but can also be explained by his talents to create coherent social systems and organizational structures and to develop effective technologies. However, many technical innovations, the related population growth and the rampant consumption of resources with various ecological consequences are now substantially endangering this successful model and require, as is generally agreed by all institutions dealing with this, a quick paradigm shift and political action.

The situation around nutrition involves many threats and raises many questions as well. In theory, the global production of plant food could feed at least 15 billion people. However, more than half of the grain harvest and a large part of soy produced is used to fatten livestock. 5 to 7 kg of animal feed is required to produce 1 kg of meat, which leads to high land and water consumption and high greenhouse gas emissions. The consequences further include the loss of biodiversity and environmental damage

following the extensive use of insecticides/pesticides and fertilizers with a high nitrogen load. This is added by the loss of harvests due to e.g. poor logistics and consumer wastefulness. The overall food production is responsible for 21–37% of the global anthropogenic greenhouse gas emissions (IPCC 2019).

From the medical perspective, there are two problems resulting from the unequal distribution of food: On the one hand, hunger and malnutrition are widespread. More than 800 million people suffer from hunger, and more than two billion people suffer from iron deficiency, to give but two examples. Due to the current COVID pandemic, a quick and significant deterioration of the food situation must be expected in many poor countries. On the other hand, there are currently more than 2 billion people who are overweight, one third of them being obese as a consequence of chronic overeating, mainly in richer countries. Obesity burdens nearly all organs of the body and significantly drives nearly all diseases of modern society.

Therefore, the quality and quantity of the food we eat is of major importance to human health. Today, food-related chronic diseases are the biggest challenge in our health system and cause a large part of the costs. A recent analysis made by the Global Burden of Disease consortium shows that dietary factors, divided into 15 subcategories, explained about 22% of all global deaths. In Germany, it is 18.5%. ►

The deaths are mainly caused by cardiovascular diseases, but also cancer and type 2 diabetes (GBD, 2019). Many people suspect and/or know intuitively that their weight problems are caused by the way they eat and that this promotes many illnesses and medical conditions; however, they like to ignore this connection due to the possible consequences resulting for their way of life. Eating is an emotional, personal matter, people want to retain their freedom to choose what they eat. Only this can help to understand why many people so consistently ignore the connection between their diet and their health.

However, this behavior is problematic. If people took an objective approach when balancing their interests, there could be other priorities than short-term culinary enjoyment in the end. In the long term, most people wish to stay fit and healthy and live as long as possible. This results in a permanent conflict between the need for short-term enjoyment, health and longevity. Short-term enjoyment mostly dominates, especially since it helps as a kind of reward system to better deal with everyday stress and other mental strains. Short-term pleasure is the focus of many business interests. Omnipresent seductive adverts, pressure by peer groups and a toxic food environment contribute to many people's decision against their long-term interests and their acceptance of personal damage in the form of illnesses and loss of quality of life and life expectancy. A reasonable synthesis of both and a good balance are possible, but require the individual and the social players to rethink.

This dilemma could be solved by a comprehensive systemic approach, which has already been discussed as a One Health concept for years, but has not been addressed seriously enough by political decision-makers and the public. The goal should be to create a reasonable balance between protecting the ecosystems and the freedom and lifestyle of people. This vision could have become a reality a while ago, but has so far failed due to the inertia of the population and the business interests of individuals and/or small groups. From a global perspective, the pressure to act is growing massively, as climate change becomes an enormous threat, endangering the livelihoods of many and especially poorer countries.

In recent times, the close connection between nutrition, health and life cycle assessment has been discussed and analyzed in more detail. An international commission suggested last year how the natural resources can be maintained and all people can be adequately fed at the same time in view of the ever-growing population (assumption: ten billion people in 2050). However, this vision would imply a lasting change to human nutrition, with significantly improved health as one of the benefits. Mainly plant-based food with a low share of meat and fish products (< 300 g/week) is recommended; it is expected to protect against wide-spread diseases of modern society and to improve the quality of life and life expectancy. It would furthermore make a significant contribution to biodiversity and the achievement of the climate objectives (Willett et al., 2019). Such a great success would require massive changes to our agricultural and food systems as well as to consumer behavior. It would be a broad systemic approach far beyond the medical perspective which could help humanity address many current challenges at the same time.

The topic of healthy and sustainable nutrition had gone viral before the COVID-19 pandemic struck, with many creative ideas and initiatives that were and are often pursued by young start-ups, but also by potent investors who backed e.g. vegan burgers. TUM provides a number of interesting activities as well. The interdisciplinary competence cluster of the food research "enable", for example, which is coordinated at the TUM, is working very hard to make popular fast-food healthier without sensory losses, to support consumers in their decision to purchase healthier alternatives or to teach children and young people about better nutrition via entertaining games and other formats, to mention but a few examples. New technologies and the creative enthusiasm of young people provide a lot of potential. In the end, however, we need coordinated systemic approaches followed by all stakeholders to appropriately address the described challenges and to retain a high quality of life.



**Professor Dr. Hans Hauner**

DAG Medal of the German Association for the Study of Obesity (2015); Director Else Kröner Fresenius Center for Nutritional Medicine, TUM; Professor of Nutritional Medicine, TUM

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**The current COVID-19 pandemic impressively shows what power the global community can develop when faced by such a dangerous threat. However, the global “food crisis” and climate change are at least comparable crisis scenarios. The decisive actions taken by governments and societies in the fight against COVID should encourage us to address these challenges with more courage and determination as well. ┘**

# The Food Sector

## Departure into a New Decade

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**The current COVID-19 pandemic impressively demonstrated how important the food supply is for the common good. Unrestrained panic buying shows how crisis situations push the basic needs, the fulfilment of which is taken for granted in the industrialized countries, into focus again.**

As food bottlenecks encourage political unrest and drive conflicts, a lasting supply of safe, tasty and high-quality food for the population in consideration of economic, ecological, social and cultural aspects is of key importance, particularly in times of crisis. At the same time, the consumer behavior is changing, particularly in the industrialized countries. Food is increasingly central to how people identify themselves; they are looking for healthy, sustainably produced, personalized and performance-increasing nutritional concepts. At the same time, the agricultural-food-health sector is quickly changing, which results in new scientific challenges of hitherto unknown proportions: More than 50% of the worldwide spaces that can be used for

crop cultivation are already being used for food production, and more than 30% of all produced food goes to waste. Meanwhile, consistent population growth as well as changed eating habits require an approx. 60% increase of food production to feed the 9.6 billion people who are expected to live on the planet in 2050. This situation is made worse by intense forms of animal husbandry, and our long transport routes for non-seasonal products cause emissions and greenhouse gases. In addition, the demand for energy and renewables is continuously increasing and will grow even more due to climate change.

**Ideas that will significantly change the food sector in its future development are outlined in the following.**

More than 30% of all food produced goes to waste.

### On-site production

The centralized production of food and the introduction of the products into global supply chains, which was increasing in the past, has had more and more negative impact on product freshness and on our environment in the past decades. A decentralized, "close to the consumer" food production will be the trend of the next decade. Apart from the optimization of local food chains, such as direct marketing by the farmer or the introduction of vegetable box schemes, a new form of agriculture will become more profitable in the forthcoming years in the course of ongoing urbanization: The so-called "vertical farming" is the practice of growing crops in vertically stacked layers in buildings, from where the cultivated products are then directly supplied to nearby restaurants, for example, where they are freshly cooked. Food crops may be cultivated under strictly controlled conditions in high-rises on empty urban plots or in greenhouses on unused rooftops. This has some obvious advantages: Nutrients can be controlled and optimum conditions for individual plant growth can be created, short transport routes can be taken and a related lower CO<sub>2</sub> emission and 95% less consumption of fertilizer and, most importantly, water can be achieved. Pest-related crop failures and/or the use of pesticides and herbicides do not play a part in this form of agriculture, and neither do extreme weather conditions.

The independence from environmental and weather impacts allows year-round crop growth and several harvests. It is estimated that a 30-storey high-rise greenhouse could supply almost as much food as 1,000 ha of farmland. Vertical farming uses the hydroponics technology, i.e. soilless farming. As a consequence, space-saving and hydroponic agriculture can help conserve our soils. One of the biggest challenges for vertical farming is the provision of the necessary energy, mainly

for the light required for plant growth. However, new research efforts must be made to develop lower-energy LED lights and improved sensor technology. Such vertical farming methods are a good example for how food will be increasingly produced locally and crisis-proof in the future, and how it can be supplied to the consumer via short transport routes. In order to ensure worldwide food supplies across the forthcoming decades, farming will still be required in rural areas. However, new digitalization procedures along the entire value-added chain are indispensable in the agricultural and food sector due to the increased consumer demand for sustainability and transparency in production processes and the simultaneously required efficiency enhancement.

The linking of complex data systems as well as the use of modern robotics technologies enable us to produce resource-saving food with reduced use of pesticides and herbicides in the future. While a site-specific plant production on the basis of digital data is pursued by means of new precision farming technologies, such as the regulation and control of agricultural machinery to increase crop yields, smart farming uses data for process optimization. For example, various datasets on feeding, the cow's health condition, administration of medication, weight, milk quantity and milk quality in milking systems are combined. Thanks to the digitalization of agricultural processes, the food industry is able to offer a personalized, safe and flexible range of products to the end consumer and to have them get insight into the process history via apps, to increase consumer confidence in the products. This means that value creation will become more participatory and more attention will be paid to the consumers' individual needs. ►

## Waste minimization and value enhancement of industrial side streams

It became increasingly clear in the past years that about one third of the food intended for human consumption is lost along the entire value chain, from the field to the fork. This includes both food losses and food waste in a range of approx. 1.3 billion tons per year. With cereals alone, the post-harvest losses amount to up to 30%, and with fruit and vegetables, fish and seafood, they even amount to up to 50%. This is caused by e.g. mold, pests and rot following faulty processing and storage. The quantities of food losses and wastes are overall comparable in more and in less developed countries; however, there are often different causes. While in less developed countries, the losses mostly occur during the harvest and the early processing stages, waste mainly happens at the end of the value chain, particularly at the consumer level, in the more developed countries. This means that the side streams of food products are not used optimally at the moment. Numerous foods or side streams from which food ingredients can be obtained are currently being lost unused by the value creation cycle. Collaborative approaches aiming to enhance the value of accruing side streams and residues along the entire agriculture-food-sale-consumer chain by using biotechnological procedures and to add new value in terms of a circular bio-economy will coin the future in the next decade.

## Alternative raw materials

Nowadays, more than six times the space is used worldwide as grazing land and to cultivate animal feed than for cultivating cereals, fruit and vegetables. Moreover, 3–10 kg of plant food must be fed to the animals so that 1 kg of animal protein can be produced. In the United States and in Europe alone, the per-capita consumption of meat is 97 kg and 67 kg/per year, respectively. The intensive livestock farming required for this exacerbates the fight for the limited farmland on our planet. In addition, animal gases contribute to the further increase of greenhouse gases and other pollutant emissions. To minimize meat consumption and fulfil the protein requirement of the growing global population, the consumer behavior needs to change and alternative protein sources must be found. Compared to animal proteins, the production of plant proteins leads to 5–10 times less energy and water consumption. Also, plant proteins could be obtained from domestic sources as well

as by-product streams, such as the washing water from potato starch production or the oilseed rape press cake. However, plant protein products currently still have a significant disadvantage: Their organoleptic characteristics are not comparable to those of animal products. The plant proteins oftentimes have a bitter/astringent off-taste, which needs to be masked or reduced by means of technological and/or breeding strategies in the future. By means of SENSOMICS methods, the key flavors of e.g. pea and rape protein isolates could recently be identified and methods for their targeted technological reduction could be developed.

## A personalized diet

We are already fighting a double challenge in the field of poor nutrition, which will stay with us in the future and cause massive problems. On the one hand, approx. 3.5 billion people currently suffer from malnutrition, hunger and/or nutritional deficiency symptoms (such as vitamin, iodine or iron deficiency). On the other hand, the proportion of the population in more developed countries suffering from excess weight (~2 billion people) or obesity (>500 million people) is drastically increasing. Numerous chronic illnesses such as diabetes, tooth decay or cardiovascular diseases, which have a massive impact on our healthcare system, result from the excess consumption of salt, sugar and fat. The decoding of the human genome has opened up completely new possibilities to contribute to individually adjusted foods in terms of nutrition and taste thanks to personalized diet concepts. 99.7% of our genes are identical, but people still individually differ significantly. This is due to the 0.3% of the genetic material that do not only determine our eye color, but also the way nutrients are absorbed and utilized by a person. In the future, mobile and non-invasive diagnostic technologies will enable us to collect important vital data of humans in real time and to record the physical activity from home. Rapid technological advancements ensure that the research of individual genomes becomes faster and less expensive; the same applies to the measurement of transcriptomes, proteomes, epigenomes and metabolomes. Of course, today's understanding of the critical connections is much too fragmented to influence the effect of the smallest genetic changes preventively or therapeutically. The integration of these big data and the use of the artificial intelligence potentials will make it possible in the new decade to better understand the complex interaction of genetics, metabolism, food-associated illnesses and lifestyle in terms of a system biology of nutrition and to derive individual personalized nutritional concepts. ┘

┘ With cereals alone, the post-harvest losses amount to up to 30%, and with fruit and vegetables, fish and seafood, they even amount to up to 50%.



**Dr. Oliver Frank**  
Chair of Food Chemistry and Molecular Sensor Technology, TUM



**Professor Dr. Corinna Dawid**  
Chair of Food Chemistry and Molecular Sensor Technology, TUM

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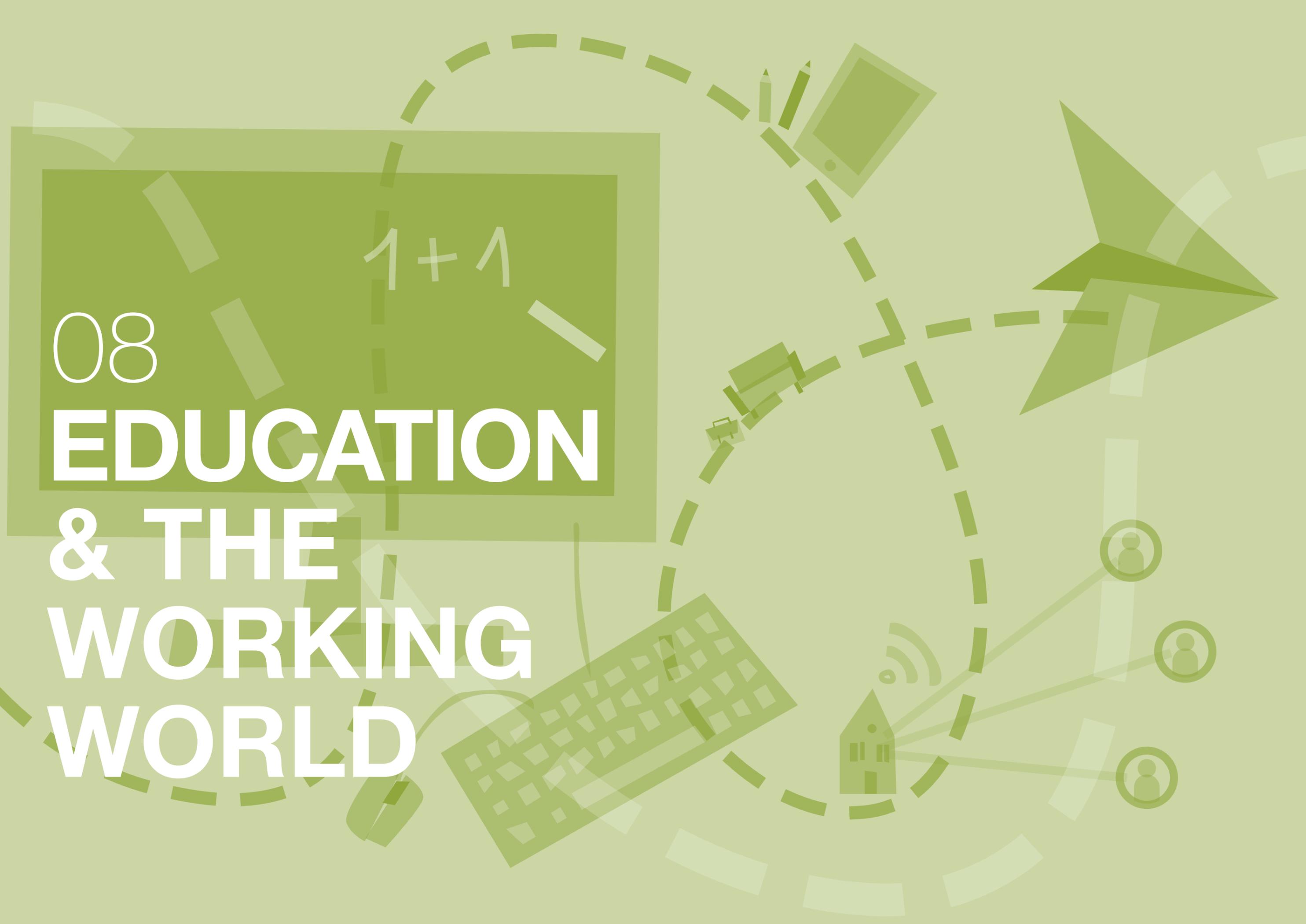
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08

**EDUCATION**

**& THE  
WORKING  
WORLD**

1+1



# Shutdown of Schools in the Corona Crisis – The Recipe for Survival is Motivation

## Illustrative Impressions from the Pupils' Perspective

**The coronavirus! Infections double in less than three days! State premiers confer their swift decision: Shut down all schools from Friday, 13 March 2020! And the pupils? The Easter break is due to start in three weeks. Extend it? Out of the question! So, heads down and hope for the best. Teaching to move online after the weekend, until Easter! That's the plan.**

Today, on 29 May 2020, the Friday before half term, most pupils are still receiving teaching online. But calls for a quick return to comprehensive classroom teaching for all can no longer be ignored. Some sound a dramatic note: "There are schools where everything is running really well, and there are schools where nothing works at all, unfortunately," is the critical verdict of Stephan Wassmuth, chair of the Federal Council of Parents.<sup>1</sup> Thomas Krüger, President of the German Children's Fund, says in an interview: "We may be dealing with a lost generation here."<sup>2</sup>

Are such dire warnings justified or a false alarm? With, as yet, no systematic evaluation of teaching away from the classroom, almost the only source of meaningful answers is the level of observation. These are subjective answers, and much depends on what school environment is being looked at. But perhaps it will still be possible to gain plausible insights as to what educational qualifications work particularly effectively in the crisis. This may affect their importance in normal times as well.

To evaluate the digital teaching situation on the ground as realistically as possible, it is worth taking the point of view of those concerned – the pupils. Niklas, 16, in year 10 at a state grammar school in Bavaria, a bright kid, athletic, active, but by no means a swot:

### How well is communication working?

"We're lucky in that our physics teacher is responsible for our school's online (learning) platform and we've already done a lot of work with it. But the first three weeks were a bit stressful, because we got our coursework via too many different online services, so that it was easy to lose track. But things started to run smoothly pretty quickly."

### How much of the content gets through? Can you give examples from different subjects?

"We have lessons in all subjects for which we get marks. In chemistry, it's working perfectly; we've almost finished the material for the year. In biology, we learn from PowerPoint slides, as we often do in normal teaching, and also with YouTube videos. Our sociology teacher had us compare the role of women in an example of a Dr Oetker advertisement from 1960 with that in times of coronavirus. That advert was very funny! Our German teacher, instead of revising a type of essay, flexibly switched to reading. I like that. Is that shirking? No, he uses written questions to test whether we've understood the text."

**"Physics lessons are perfect:** Our teacher posts a home-made video every week where he explains the material, and we always get a worksheet along with it. For art lessons, we painted three pictures. Not everyone misses PE, but I do a lot. What about the amount of time it all takes? The teachers showed us how many hours we would have had to spend in school, plus a quarter of an hour of homework for each subject. And according to that, they supplied us with material. Rather more than normal."

### How did everyone get used to the new way of working?

"We now work according to weekly plans. I like that a lot, because it means I set my own working hours. My form teacher always discusses everything with us as a form. But there are individual plans as well. For most subjects, we've got worksheets to fill in and send in, which we then get back with corrections, in some subjects also with 'nice' (encouraging?) comments. For the past few weeks, we've also been communicating with teachers by video conferencing, but not the whole form at once. It took a while to get everything organized, because of data protection conditions. Questions get answered as soon as possible, so the next day at the latest, even at weekends. I always think about whether I should ask a question about every little problem. It's often easier to do a bit more research yourself."

### The key questions: What actually gets through to pupils' heads? Are there "access keys"?

Niklas: "We're in constant contact with the teachers. Relations are very open, more than usual. If you have to send something in, you feel more responsible, you're more thorough and persistent than if you're sitting at the back of the class. With the teachers making a lot of effort, you automatically put in more effort yourself. During online teaching, I've learnt at least as much as I would have done otherwise."

Niklas is quite enthusiastic in describing his teachers' digital teaching. He is easily motivated. His classmate Anna, 15, open-minded, active and athletic, does not always find it easy. In year 7, she went through a development phase in which she lacked drive and perseverance in some subjects. With skillful coaching, her then mathematics teacher brought her back from her educational slump. His therapy was to motivate her – in many conversations in which he showed appreciation of even small advances in learning and generally signaled a personal interest in her educational progress.

### When her daily routine of online learning gets too monotonous sometimes, Anna remembers her former teacher:

"He made me think of my problem in terms of a mountain I had to climb. You have to make an effort at first; when you get to the top, it's euphoria; and then it's all downhill from there. Once during online teaching, my form teacher also helped me out of a bit of a slump by giving me personal support by email. Using personal examples, she showed me how she herself keeps going and so gave me valuable advice. She also encouraged us all to film our own motivational videos to cheer each other up. One very funny video was entitled, 'My sad life in quarantine.'" Thus, the shutdown of schools does leave room for imaginative and creative solutions to problems within the framework of the digital classroom. And there are indeed "access keys" to pupils, including to their different personalities and levels of receptivity. ►

## Conclusion:

Setting a personal example, openness, targeted motivational strategies and personal coaching where needed are the keys to successful teaching even away from the classroom. Overall, the schools likely to be most successful are those where teachers and head teachers have developed a high standard of school culture with well thought-through and practiced educational skills.

When the learning processes with online teaching are evaluated nationwide – and it is to be hoped that such an evaluation will take place as soon as possible – attention should be paid not only or primarily to performance, but also to the effects of a educationally supportive atmosphere in schools and successful key skills on the part of the teachers. It would be desirable to reduce the teachers' proportion of the pure passing on of knowledge to free up more space for teachers to bring in what is perhaps their strongest asset of educational effectiveness: motivation and coaching. What do pupils miss most in online teaching?

Niklas: "It takes a lot of time to retrieve information and to prepare and send off the materials. You don't need to do all that in school. But I like the fact that at home you can sometimes spend more time on a given topic." Thoughtfully, Niklas adds: "But I miss the questions and ideas from others."

Although pupils are often quicker and more astute than their teachers in using digital media, sometimes much time is lost in communicating for online teaching. Besides that, online teaching lacks very important "receiving arials" of normal human perception. Niklas is emphatic about how much he misses learning in the group with the inspirational and creative elements of reflection and discussion with others – in short, face-to-face teaching in the classroom.

### Special situation: A-level examinations

During the "difficult phase" of the coronavirus pandemic, the teachers' skills in moderating learning processes in group and form settings was most missed in preparing for final exams. When schools shut down on 13 March, this meant cancelling the final lessons of meticulously planned classroom teaching, personal face-to-face advice sessions, support for working and learning groups, training courses, etc. Thus, a situation of more adverse examination conditions compared to previous years was looming. But once politicians, for various serious reasons, had decided to hold A-level examinations in the usual way, ministerial staff and school teams had to ensure the organizational framework in the conditions of the coronavirus pandemic.

But ultimately, it was also thanks to the teachers and their coaching and motivational skills that an atmosphere of supportive examination conditions could be created for the 2020 A-levels.

Mia, A-level student at Anna and Niklas' grammar school: "What motivated me a lot during A-level preparations was that the teachers were no longer aloof, but took notice of you as a person and looked after you. They gave feedback to each and every one in personal conversations and emails. Many of them also offered extra support. Again and again you were asked how you were doing personally, and it wasn't always about performance."

To avoid any misunderstandings: Given the impending high demand on students' performance, this was not about creating a cuddly atmosphere removed from reality, but to offer concrete personal support and assistance. In the isolation caused by the banning of interpersonal contacts, the suggestive effect of empathy and of the teachers signaling a personal interest in the success of their pupils should not be underestimated.

Lena, A-level student: "My mathematics teacher handed out painted stones as lucky charms before the exam, painted individually for each of us. In this way she showed each of us that our individual performance is important to her and that she cares about us." In a similar way, A-level student Leonie

acknowledges the motivational effect of the stones and adds: "We also got a little personal poster with many little wishes for the future from our teacher Ms R. She also showed us that she wanted to support us right up to the last hour before the exam. The fact that the collage was personal motivated me strongly." A-level student Amelie: "This may sound unspectacular, but if you're motivated again by your course teachers the day before and they write to you that they believe in you, that pushes you onwards."

Candidates with a cooler temper perhaps perceive the little gifts as nice gestures of courtesy without a direct relevance to the exam, but a larger group evidently found them stimulating. Specifically, these suggestive signals of confidence increase students' self-esteem, leading to more effective time and workload management during the exams and thus to better examination outcomes.

Niklas, Anna, Mia, Lena, Amelie and Leonie in no way give the impression of being a "lost generation". On the contrary – they and their teachers do not moan, but "get on with it" and make the most of the challenge. Perhaps they are not representative, and perhaps their school with its educationally excellent school culture is not, either. But it cannot be argued away that there are "open doors" to pupils, including to the secret chamber of "learning with hearts and minds"; one of them is...

# the suggestive power of motivation. ↵



**Hans-Joachim Stumpf,**  
Director of Studies (retired)  
Otto von Taube grammar school,  
Gauting, TUM reference school

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## Schools in Germany in 2020:

It Needs (More than)  
the Digital Change

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Learning and teaching always involves the idea of a personal encounter. Whether it be the conversation between a teacher and a whole class or pupils talking to each other, we imagine a classroom, a school play-ground – at any rate: a meeting-place. Thus there was something disquieting about schools closing their doors, more or less all over the world, in March 2020, and there were serious doubts as to whether successful learning would be possible in such a situation. But it looks as though teachers were coping with the new method of teaching better than expected. In a May 2020 representative survey among teachers of all types of schools in Germany, more than 80% stated that they “manage well, on the whole”.

[www.vodafone-stiftung.de/umfrage-coronakrise-lehrer/](http://www.vodafone-stiftung.de/umfrage-coronakrise-lehrer/)

Learning is here seen as a constructive process which in essence is only successful with the active participation of the learner

This may in part be attributable to the significantly increased use of digital media, at least in secondary schools. Teachers state that they use email and messenger services as well as learning platforms and servers to make learning content available and to stay in touch with pupils. As recently as last year, comparative international studies had shown that digital media are relatively little used in German schools (ICILS, see Eickelmann et al., 2019; PISA, see Hofer et al., 2019). This appears to have changed, for it emerged from another survey of teachers in Germany conducted in April 2020 that the topic of “digitalization” has gained in importance in the context of schools. Across all types of schools, two thirds of teachers would like to improve their digital skills and to have recourse to better technical equipment in their schools. A little more than half of them considers it important that a shared understanding of the use of digital media in teaching is developed (*Deutsches Schulbarometer Spezial* [German school barometer special]; FORSA on behalf of Robert Bosch Stiftung and DIE ZEIT; <https://deutsches-schulportal.de/unterricht/das-deutsche-schulbarometer-spezial-corona-krise/>).

Even though the two surveys mentioned are perhaps mainly atmospheric views or plans for future action, these opinions can be interpreted as not only a surprising development, but a welcome one. It is welcome because there is clear empirical evidence showing that digital media can facilitate learning. Thus, a meta-analysis by Hillmayr et al. (2020) of a total of 92 studies conducted in the years from 2000 using the pre-post control

group design shows a significant positive effect of working with digital media in mathematics and science teaching in secondary schools. Pupils using a digital learning environment achieved better results in performance tests than those of the same age taught using a traditional textbook. Moreover, the same study shows that there is a range of beneficial factors in teaching with digital media. Good teaching, even with digital support, depends on being varied and appealing to pupils in different ways. As it turns out, the additional use of analogue materials and a time limit on working with a computer further increased pupils’ performance. Moreover, working in pairs proved more effective than working alone on a device. But it was the teacher’s competence that had the greatest impact. Where teachers had attended suitable training, this had a significant effect on pupils’ performance.

The boost to digitalization in German schools in recent months and the increase in digital media for teaching is therefore a step in the right direction. It also looks as though a longer-term development regarding their use might have been initiated. Just under half of the colleagues questioned by *Deutsches Schulbarometer Spezial* now plan to use digital media more frequently even in regular classroom teaching. But there is another figure in the aforementioned study that suggests forthcoming changes in everyday teaching: Two thirds of respondents stated that, after schools reopen, they wish to do more than before to enable their pupils to take responsibility for their own learning process. It seems as though, ►

even without the permanent personal presence of a teacher, meaningful learning was possible, pupils became proactive and were successful in this. If this intention of teachers becomes a reality, it would implement a fairly uniform finding in teaching research from different perspectives. Learning is here seen as a constructive process which in essence is only successful with the active participation of the learner. Moreover, teaching is but an offer which can only have an impact if it is actively taken up by pupils, which in turn involves taking responsibility.

If teachers do indeed count on a greater use of digital tools and pupils' own responsibility in the classroom, these two changes will make an excellent match. Digital learning opportunities, in particular, are often better suited for adjusting teaching to pupils' individual needs. There are programs that adapt to pupils' level of proficiency, offer assistance or provide individual feedback on their solutions (e.g. Reinhold et al., 2020). This provides more opportunities for learning and revising at one's own speed, or perhaps sometimes for skipping less interesting content or studying something interesting in depth. It is then possible, in particular, to better manage one's own learning and to practice interacting with learning materials independently, step by step. There is no question, however, that just providing digital media is not a panacea for good teaching. For teaching in general is not only influenced by learning materials and their quality, but made up of many factors. It depends on the personality of the teacher as well as on pupils' individual prerequisites, on the context of the classroom as well as of the subject (cf. Helmke & Schrader, 2013). The importance of the interplay of these factors was confirmed just recently by teachers responding to the aforementioned survey initiated by Vodafone. About three quarters of them judge their teaching in times of crisis as "less effective". Unfortunately, the survey does not go any deeper and explains how effectivity is to be understood. However, assuming a multi-dimensional understanding of education – an assumption shared by the curricula in probably all federal states as well as by education standards in Germany – education outcomes include not only purely academic performance, but also pupils' interestedness, motivation, or their self-image vis-à-vis a learning topic (cf. Seel & Hanke, 2015). In particular, success at school is not the same as an examination result. Rather, schooling, understood in the way outlined, imparts the ability to learn and to develop as a person through learning, and is thus the fundamental prerequisite for lifelong learning.

Schooling (not only) in Germany in 2020 – and this may be a trivial point to make – is a great challenge for all involved. But perhaps an even greater challenge is to see what changes can or must be adopted in teaching in the future. The view from these times of crisis shows that schools should not be seen as places of pure knowledge transfer, but as places of learning, experience, and the exchange with others. Without question, teachers remain the central protagonists of knowledge transfer. The general findings in the study by Hattie (2009) can also be shown in the context of learning with digital aids (Hillmayr et al., 2020). Evidently, learning requires a good, interesting and interested human role model. Thus, digital media will certainly play an important part in the classroom of the future – but not an exclusive one and, above all, not the leading part. ┘



**Professor Dr. Kristina Reiss**  
Dean of the School of Education, TUM; Chair of the Centre for International Student Assessment (ZIB); Professor of Mathematics Education (Heinz Nixdorf Endowment Chair), TUM

┘ The view from these times of crisis shows that schools should not be seen as places of pure knowledge transfer, but as places of learning, experience, and the exchange with others.

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# University Education and Social Responsibility

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The actions of societies are based on paradigms, which provide orientation and define guidelines. Paradigms in vocational training and in the transfer of knowledge have always had a strong impact on the development of value chains, the division of labor, and innovation. Over the past two centuries, they have unquestionably led to prosperity and improved living conditions. As universities, we have a responsibility for triggering the paradigm shifts ahead.

This applies to **substantive** matters for the transfer of new knowledge and new options into value chains; **structural** concerns in satisfying new requirements in skills profiles; and **communicative** issues taking account of changed societal communication structures and options. There is currently an intense process of debate along the paradigms of STEM disciplines (Science, technology, engineering, and mathematics), often closely aligned with specific observations where the subject of discussion is an obvious and often superficial need for action. A few years ago, one focus was on so-called soft skills; now, the main focus is on the skills required for ongoing digitalization.

To categorize impending transformations, it is worth looking at paradigm shifts in the past which set the course for today's world in important ways. In the technical disciplines, these undoubtedly were the deterministic views formed in the Renaissance on the basis of causal connections and of *naturam secare, naturam abstrahere*,<sup>1</sup> the abstraction of whole systems into subsystems and sub-processes. To this day, focusing on subsystems forms a crucial basis in engineering training for modelling, simulating, and solving problems. The liberating move away from an image of science still, in the early 16th century, infused with Aristotelianism, metaphysics, and holistic pretensions was painful and difficult. It required not only foresight and curiosity, but also a strong will and courage. The now axiomatic foundations of engineering, the carving up of problems, experimentation, and describing quantifiable phenomena of matter, in connection with closed mathematical-physical theories from which phenomena could be explained, but from which it was also possible to derive unknowns, led to radical abstraction and the fantastic possibilities of prediction and to technical artefacts<sup>2</sup> that fundamentally changed the world. Well into the 19th century, however, there were fierce debates about mathematization against the backdrop of practical experience which had so far been used very successfully.

For instance, the community of the day gleefully derided the great engineer Navier, who was an important exponent of the mathematization of engineering. When the state-of-the-art

Pont des Invalides in Paris was damaged – caused not by the incorrect application of a theory, but by flooding of the foundations – the opponents of mathematization took this as an opportunity to once again seriously call into question the impending and, as a result of industrialization, now unstoppable paradigm shift. In short, the **substantive** and **structural** transformation set in train in the Renaissance did not happen overnight, probably – up to a point – rightly so, as every transformation towards a world of unknowns carries the risk of dissolving viable structures and traditional ways. It took courage to stand up for a substantive and structural paradigm shift. Its opponents had strong arguments, considering, e.g., the incredible accomplishments in the construction of churches made by craftsmen working collaboratively and organized in builders' co-operatives, and without mathematization, as early as in the Middle Ages.

## What does this mean for us today?

In the technical disciplines, we must, as a matter of necessity, question to what extent we have neglected a holistic view in our educational profiles as a result of the resounding success of causal, seemingly consistent and reproducible processes that can be accurately analyzed and forecast. Might we, in teaching technical disciplines, treat the underlying stochastic processes and uncertain quantities for practitioners in such a way that the underlying uncertainties remain obscured? Do we use too many “sample solutions” in our teaching which suggest – in particular to less able students – that such type of solutions exist in “real life”? And have we perhaps failed to educate the experts for the technical solutions of the future in such a way that they can recognize and classify, possibly even master, the interfaces of artefacts with society, which are often found outside of what can more easily be causally predicted?

Perhaps our fascination with the tremendous success of what can be forecast by means of abstract models has, for decades, stopped us from examining processes in value creation that are more difficult to grasp, such as socio-economic interactions. Why was the mediation procedure around Stuttgart 21, which was really about technology, infrastructure, and ecological/socio-economic issues, not chaired by an engineer or scientist, but by a lawyer and politician? Put another way: Why did no technology expert manage to be a captivating mediator of the key linkages involved? Recent examples are varied and have attracted the intense attention of professional associations to the issue of what the training profiles of the future should look like so as to develop graduates' skills for social evaluation, for dealing with diverse reactions, but also, above all, for making reasonable trade-offs.<sup>3,4</sup>

Answers to this include the Munich Center for Technology in Society, the *Hochschule für Politik*, the TUM School of Management, our co-operation with the Munich School of Philosophy, the TUM Munich Design Institute and our new structures of professional profiles. ►

New degree programs in the technology disciplines, such as the bachelor's degree in Engineering Science taking an overarching engineering approach including a broad basic education in mathematics and science, contribute to the creation of counterparts to strongly vocationally oriented definitions of curricula, which often impair the addition of new topics to these occupational profiles. Cross-disciplinary plug-in modules for motivated students who wish to pursue studies beyond the confines of their own field are intended to produce a cohort of graduates reaching across various academic profiles. The new skills profiles of our graduates being created thus constitute both a **substantive** and a **structural** transformation.

## What about the communicative paradigm shift?

In mediaeval Europe, apart from the Byzantine cultural region, Latin was the language of teaching and of science. How much this narrowing to a language accessible only to a small elite impeded progress only became apparent when, in the Renaissance, communication in the vernacular caused a massive breakthrough. The publication of experiments and treatises by a new group of people, that is, experienced practitioners, who communicated and published in the vernacular, opened up a new horizon of experience. Leonardo da Vinci, as an artist, had only learnt Latin at an advanced age; his ingenious ideas would not have found an adequate platform without the vernacular. Furthermore, the revolution brought about by printing made it possible to disseminate newly formed ideas widely. Thus, it was increasingly possible to work out patterns from collected and documented empirical findings and to construct theories.

It is permissible to reflect the tightly compressed events of our own time in these historical developments. As regards the “vernacular”, the commitment to English as the language of science once again creates a significantly wider and now global platform for exchange. Only a few years ago, debates around this **communicative** paradigm shift – including to English-language master's courses at the TUM – were almost militant, but have lost much of their vehemence, as the younger generation have now, without a fuss and quite naturally, found a way of reconciling internationalism and cosmopolitanism with a sense of home and their personal linguistic location. Thus, for instance, a few years ago, the TUM: Junge Akademie completely switched to English, without any debate at all. German students now emphatically demand English-language master's courses to enhance their international standing.

In the current coronavirus crisis, given the need to use digital channels, we now see, as if in time-lapse, a further, far-reaching communicative paradigm shift. This has disruptively displaced the at times sluggish foundational debate on digitalization in teaching of just a few months ago. The 2020 summer semester is a unique experiment forced upon us from outside and taken up by lecturers in an enormous feat and with the utmost consideration of their students. Its formats and soon its effects will show the opportunities of the communicative paradigm shift

occurring through digitalization. In an impressive dynamic, as early as the first week of teaching at the TUM, more than 5,000 teaching videos were viewed by more than 27,000 students in 325,000 views, 9,000 video conferences were held with students, and 4,500 lecturers and more than 36,000 TUM students were about on the various digital platforms.

By now it is becoming apparent that the interplay of videos replacing lectures, where students can work according to their own performance and speed of learning, and of using the time gained for an exchange between lecturers and students via discussion formats, group work, and supplementary explanations opens up new freedoms in designing teaching. The result will be that the university remains a lively meeting-place. New discussion formats via video conferencing offer the possibility of forming ad-hoc working groups for individual tasks in a way that was not available before, and of students participating from around the world, where only the time difference between New Zealand and Peru may be an issue, and thus of a new dimension of internationalism and the exchange with partner institutions. With good reason, students' responses to first surveys on the accomplishments of digital teaching in times of coronavirus are topped by “rewind if you didn't understand something”, “more time for chats with profs”, and “new forming of teams”.

These experiences will significantly accelerate the process of **substantive, structural, and communicative** transformation. They will simplify cross-disciplinary learning elements needed for our project groups and holistic teaching formats. They will potentially change international mobility, since experience “abroad” will also be possible by digital participation in other universities' modules. And they will better prepare students for teamwork in international and interdisciplinary groups. Moreover, digital formats may potentially revolutionize access to education worldwide.

These experiences will also promote the development of blended learning, combining digital and face-to-face teaching, in a sustained manner. In designing face-to-face teaching, new ways of lecturer–student interaction, team working, and discussion formats will kick off important processes. The TUM maintains a close contact with its teaching staff, students, and academic deans on this. It has been using the steep learning curve of the first weeks to quickly gather and process best practice in teaching for the coming winter semester 2020 and the time after the coronavirus pandemic. But above all, these experiences make us aware of the value of physical presence, which we miss and which spurs on students and lecturers alike.

The experience of the summer semester 2020 also shows that the university is again getting closer to Humboldt's educational ideal, which had again and again been debated and questioned by our very large lecture audiences, especially in bachelor's degree courses. For the new teaching formats of exchange and of the replacement of knowledge transfer in lectures with discursive and group-oriented teaching promote an **“uninterrupted, but unforced and unintentional interaction constantly renewing itself”**.<sup>5</sup>

This is a great opportunity for the TUM, both its teachers and its students, who in recent weeks have experienced an enormous transformation process and have achieved great things. ┘

Let us seize it.



**Professor Dr.-Ing. Gerhard Müller**  
Former President of the Conference of Departments of Civil Engineering and Geodesy; Acting Vice-President of Learning and Teaching, TUM; Professor of Structural Mechanics, TUM

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# Opportunities and Challenges of Digital Teaching from the Student Perspective

**In 2015, the United Nations published its 17 Sustainable Development Goals, one of which is quality education (United Nations, 2015). This includes, in particular, ensuring equal access to education across all sectors of society, as well as lifelong learning of technological and vocational skills. This goal further includes using the potential of digital media, from which many areas have already benefited. But in education, it has not yet been exploited to the full (e.g., Handke, 2019).**

In the wake of nationwide measures as a result of COVID-19, the role of digital media in education changed fundamentally. Face-to-face teaching had to be stopped, although it had been proven of value for many decades. At the same time,

new multi-media teaching concepts were put to the test. This article examines both the opportunities for the future and the challenges posed by the rapid switch from the point of view of some students of the Technical University of Munich.

## Opportunities

It has been largely accepted for some time that different persons show very different learning behaviors. Nevertheless, universities across all discipline areas cling to the lecture format which takes no account of individual differences. This method of teaching is based on a gradient of knowledge and experience between the lecturers and their students. In a lecture, teachers can control the transfer of knowledge to learners by deciding on content and setting priorities. Since this format is not designed for extensive interaction, the number of participants has little impact on the quality of the presentation. For students, a lecture is often demanding, since they are frequently presented with unknown content at speed over which they have no influence. With complex topics in particular, this can be a challenge.

In digital teaching, lectures can be designed in a way that is more responsive to students' needs. Thus, the recording of lectures, for instance, brings several benefits at once. The oral presentation is saved together with the lecture slides and can be reviewed any number of times. For many students, this makes it easier to understand the topic discussed, because they can play back segments repeatedly or pause the playback to conduct further research on individual points.

Moreover, the lectures can be accommodated flexibly in one's daily schedule, so that students can make the best use of their own peak performance times. However, besides these ways of facilitating study, recorded lectures also pose new challenges for students. Thus, the inherent flexibility requires a great deal of self-management and discipline.

Besides simply transferring analogue teaching methods into the digital world, primarily multimedia formats are catching on more and more as a result of COVID-19. These include implementing the so-called flipped classroom concept. This is based on key content being acquired by independent study and then, in a (face-to-face) seminar, applied to specific questions and interactively discussed (cf. Kück, 2014). Students actively search for information and so work on a topic at greater depth. In addition, this method allows for a certain degree of autonomy, as the content can be dealt with at greater or lesser length and depth, depending on one's interests.

A greater focus on learners is also apparent in the changed role played by teachers. Most of the time, they only define the starting point and not the content of the research, or they offer support and advice for an individual's learning process. Doing research also stimulates making linkages between the material learned and related subject areas, thus allowing cross-linked knowledge to be created. A group seminar – which may be held as a question-and-answer session via video conferencing – ensures a correct understanding on the part of students by offering an opportunity to ask questions and discuss specific examples. Thus the focus is further shifted towards acquiring competences; alongside the transfer of knowledge, there is development of student's personal skills. In perspective, this is of key importance, in particular against the backdrop of lifelong learning.

Furthermore, by moving into the digital realm, lectures and seminars become more flexible. Rigid timings and longer gaps in lecture schedules can be avoided. There are no timetable clashes between lectures and seminars – and no moving around between different lecture theaters or even campuses. This enables all those involved to make more effective use of their time.

Short videos can produce a similar effect. These take only a selected area from the course material as their topic, and they have become a popular medium. In this way, the lecture material can focus on a salient point. This can improve access to specific lecture topics and provide more clarity regarding the course content. Moreover, students can learn at their own pace: Aspects that are difficult to understand can be reviewed and dealt with in depth, while concepts already internalized only require a small amount of time.

Another advantage presents itself to students who are easily distracted in face-to-face teaching and have difficulty concentrating on the lecturer. In the digital realm, they need only deal with distractions in their own homes instead.

## Challenges

Despite all the positive aspects of digital teaching in universities, the sudden shift to this teaching method also gives rise to various socio-economic and social problems. This particularly affects students with limited financial means or dependent on a part-time job to finance their studies. As students must rely on their own technology for digital teaching even more than in traditional university life, ► it carries more weight. But the technology equipment needed for participating in or following up on digital lectures and seminars, such as a new laptop or a quality screen, can blow the budgets of poorer students.

Add to this problems with housing conditions. In larger cities in particular, student accommodation is often small and cramped. There is not always room for a workstation that promotes learning. This results in a lack of a clear boundary between spare time and studying, which can be an additional source of stress. In addition, in times of COVID-19, students living in such cramped conditions no longer have the option of spending time outside the home, including making use of other study spaces such as libraries.

Technological challenges beyond the purchase of suitable devices are also relevant, such as a stable and sufficiently fast internet connection, which is not currently available everywhere. This is a particular problem for students who take part in lectures from a country with poorer infrastructure, but it can also affect learners in this country. While in underdeveloped regions it is the infrastructure that may be unsatisfactory, in the cities the financial aspects of a good internet connection may play a larger part. This presents a considerable ►

problem not only for seminars that can only be followed in real time. Successful teaching must address these problems. What is more, the switch in teaching as a result of COVID-19 makes social contacts more difficult, which had been a natural part of university life before. This particularly affects first-year students, who have only just left their familiar surroundings and, often after moving to a different town, are looking for like-minded people.

Contacts between students on a given course are crucial for academic success in a number of ways (e.g., Kollar et al., 2014). Thus, in many degree courses, collaborative problem-solving is of critical importance. Students working together can help each other develop solutions and motivate each other. While teamwork can also be carried out in the digital realm, group discussions may sometimes be more difficult to accomplish in that context. This may be due to the fact that haptic aids such as books or whiteboards cannot be used together with other students, or that interpersonal communication is limited as a result of spatial distance. Spontaneous discussions about the content of lectures that might normally occur on public transport or while walking across campus are also less likely to happen in the digital realm. This can ultimately lead to a reduced amount of reflection on the content of the lectures. It is even conceivable that the shift to online teaching leads students to identify less with their subject, as the regular exchange with like-minded people is more difficult. Direct contact between lecturers and students can also be impeded in the digital realm. In face-to-face teaching, it is not unusual for students to approach their lecturers directly at the end of a lecture. In digital communication, however, there are additional reasons to feel inhibited, such as that other students may hear the conversation or that the teaching session is even being recorded.

Furthermore, some teaching cannot be conducted other than face-to-face, though it is crucial to the relevant courses. This concerns, for example, practical laboratory work for science degrees such as chemistry or physics. For medical students, there is no teaching at patients' bedsides, which puts the development of both professional and interpersonal skills at risk. There is also no opportunity for students in teacher training to gain initial practical experience of their future job in schools. Last but not least, it must also be considered that in many disciplines, research in libraries continues to be indispensable even in the digital age and constitutes an important component of both teaching and research. ─

## Conclusion

This article has listed many of the opportunities of digital teaching. Besides personalizing teaching formats, the potential for greater efficiency in learning has been mapped out. On the other hand, there is a risk of social exclusion and the neglect of social contacts at university. Although individual aspects may adversely affect students' learning outcomes in the long run, the spread of digital teaching methods was accelerated as a result of the restrictions due to the pandemic. Thus, this hopefully unique situation is a genuine opportunity for transforming university life in beneficial ways. In the long term, the positive aspects of digitalization must be linked up with traditional elements of teaching, so that, in the interest of a sustainable education, teaching in universities can become even more enriching and give students the best possible preparation for their future as young researchers or as decision-makers in politics and business.

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**Saskia Hutschenreiter**  
TUM Young Academy  
2019 scholarship holder,  
Team Quintessence;  
TUM School of Management,  
undergraduate



**Dr. Matthias Lehner**  
TUM Young Academy  
Tutor in 2019 & 2020, Team  
Africast / Team Entertainment;  
Alumnus of the TUM School of  
Education



**Beate Neu**  
TUM Young Academy  
2019 scholarship holder,  
Team MucTrail;  
TUM School of Medicine



**Paul Sieber**  
TUM Young Academy  
2019 scholarship holder, Team  
EvaluaTUM; Department of Civil,  
Geo and Environmental Engi-  
neering, Master's student

# Lifelong Learning as a New Imperative

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As a result of ongoing digitalization, the requirements of professional life are constantly changing. Career paths are no longer linear as they once were, but often develop across disciplines, sectors, and national boundaries. An active working life today spans almost half a century. At the same time, the half-life of knowledge continues to decrease, and previously sought-after technical expertise is no longer decisive for professional success – instead, interdisciplinary “meta-skills” are becoming more important. This requires a willingness and the opportunity for lifelong learning.

Today, more than ever, we need generalists with the capacity to think interdisciplinary.

More than 90% of respondents to a large-scale study from the US state that they need to brush up their skills at least once a year; 44% even believe that they need to do so continuously (see also a recent review by MIT Sloan Management and Deloitte, 2018). In a survey of executives of German companies, a third of respondents think that they are insufficiently prepared for a digital world of work (Hattendorf, Heidbrink, Egorov, Peus, & Pircher-Verdorfer, 2017).

This is all the more problematic as the Covid-19 crisis has further accelerated digitalization and made all of us aware of the necessity of lifelong learning: Organizations switched to working from home practically overnight; collaborating virtually with colleagues, clients and business partners had to run smoothly right away. The restrictions as a result of the coronavirus make it necessary for many businesses to reinvent themselves and to develop new, mostly digital business models. Our working and professional world is thus changing dramatically and presents new challenges to our own employees at TUM and to business professionals and executives all across the world. Major societal challenges such as climate change

and digitalization can only be met by interdisciplinary collaboration: Today more than ever, we need generalists with the capacity to think interdisciplinary and so-called “meta-skills” (including leadership, learning, and innovation skills) and basic knowledge of technological trends (e.g. blockchain, machine learning, additive manufacturing).

**Against this backdrop, universities have a new role of great social relevance:** They are required – much more so than in the past – to become places of lifelong learning and to provide research-based and needs-oriented training programs for professionals and executives, so as to enable societal change. As a forward-looking university, TUM has therefore founded the **TUM Institute for LifeLong Learning**. The institute's mission is to promote the continuous education, research-based training of professionals and executives in both discipline-specific and interdisciplinary areas (such as management & leadership skills). In today's fast-paced world of work, executive and professional education must be informed by research findings processed in practice-relevant and didactically suitable ways so as to deliver real ►

added value (Knipfer & Peus, 2015; Peus, Sparr, Knipfer, & Schmid, 2012). Therefore, the contents and formats of our executive and professional education programs are constantly evolving on the basis of research findings. The TUM is regarded as a trailblazer in the area of developing new technologies and in natural and social sciences – this provides us with the unique opportunity to discuss the relevance of research findings for professionals with leading TUM researchers and to make immediate use of new findings. The program of the **TUM Institute for LifeLong Learning** is developed in consultation with corporates, chambers and professional associations, so that current and future needs from practice can be taken up. Successful examples include our certificate programs such as "Blockchain for Decision Makers" or "Building Information Modelling" for civil engineers and architects.

Effective research-based executive and professional education programs must also keep an eye on the learners themselves. Accordingly, the role of successful continuing education institutions involves both providing needs-based training programs and assisting with and advising on the selection of contents and formats and providing individual support for learners' personal development. Here, **Educational Technologies** (i.e., digital teaching/learning formats) harbor an enormous potential. They allow for "personalized training", that is, an individually tailored choice of goals, feedback, and suitable learning opportunities. In leadership development, for example, we have been using digital coaching for a few years now. A smartphone app allows executives to set personal goals for their day-to-day leadership (e.g., give employees more constructive/critical feedback), be reminded of these goals at specific times in their daily routine, and retrieve suitable content (e.g., in the form of short videos) "just in time" and "on demand". New technologies such as virtual reality provide an innovative opportunity for immersive learning experiences, which make it possible to experience different situations and associated emotions involved in them and to try out different behaviors without risking negative consequences for oneself or others. These digital technologies also make it possible to **intertwine learning and working more closely**. A good integration of formal training sessions (such as seminars and workshops) with informal learning in the workplace (such as rotation or mentoring) ensures that newly acquired skills are sustainably anchored in daily work practices.

Research-based training must actively take up the requirements of a new digitized world of work, but also understand digitalization as an opportunity to rethink learning (Schreiner, Knipfer, Schmid, & Münch, 2020). Using innovative training formats (such as digital coaching, virtual reality) and integrating new training content (such as digital work skills), the **TUM Institute for LifeLong Learning** effectively prepares TUM employees and professionals and executives of external organizations for managing the current and future social challenges even more effectively while acting responsibly. ─

Research-based training must actively take up the requirements of a new digitized world of work, but also understand digitalization as an opportunity to rethink learning.



**Professor Dr. Claudia Peus**  
Founding Director of the TUM Institute for Life Long Learning; Senior Vice President for Talent Management & Diversity, TUM; Professor of Research and Science Management, TUM



**Dr. Kristin Knipfer**  
Executive Director of the TUM Institute for LifeLong Learning; Senior Fellow TUM School of Management (Research Lab Leadership | Learning | Innovation)

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# Innovative Working Conditions

## Responsible Working at Universities

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The vast majority of universities in Germany are public universities, meaning their legal status, functions and organization depend on statutory provisions, and their key basic funding (however adequate or inadequate it may be) is provided by the public treasury. On the basis of this public organizational framework, universities act not only as public institutions of higher education, but also function (increasingly so in recent decades) as research and commercial enterprises within a national and international framework.

┌ The most efficient and effective way of transmitting information to and within a team remains a face-to-face conversation.

This balancing act between, on the one hand, clearly regulated (mostly national) statutory requirements and, on the other hand, a strongly dynamic (especially internationally oriented) socio-economic environment also has an impact on working conditions in universities: **Public service in all its traditional forms on the one hand, and expectations of an agile research organization with entrepreneurial freedom of action on the other.**

When working conditions at public universities are to be described or assessed, discussion is often “all over the place” and incoherently runs through topics such as “constitutionally guaranteed freedom of research and teaching, independent economic activity, employment legislation, worker participation, collective public-sector wage agreements and/or strictly regulated civil service law”, to mention just a few key terms. And then one thing is often mistaken for another. In a structure both complex and delicate, (and this is almost a truism) one-sided views are rarely useful, and mere “cherry-picking” should also be avoided.

Many jobs in a public university come with permanent contracts with all the “securities and blessings” of public service. At the same time, there is a large number of fixed-term employments and – in contrast to almost all other areas in the public sector that are based on fixed-term project funding and/or limited availability of funding – they have a significant effect on university working conditions. **Time and again, careful examination is necessary here:** What is necessary and sensible and what is not? Irrespective of the – for many employees – fundamental question “fixed-term or permanent”, the university as a public employer is a reliable and dependable partner. The coronavirus crisis has shown that nobody had to worry for a second about the continued payment of his or her salary or think about the risk of redundancy. This can and must be said without losing sight of problematic limitations and obstacles to innovation in other areas.

An important area with palpable room for improvement is the further digitalization of many work processes in universities, in particular in the field of management and administration. ►

Almost all those involved agree with this basic need and are often astonished by the sluggish pace of change. This is understandable to those acting responsibly, but here also it is worth taking a nuanced look. It is specific work processes that must be reviewed individually before a functioning and successful digitalization can be implemented, and an accepted compromise must be found about how many differentiated individual solutions a research organization – which after all is programmed for the greatest possible freedom of thought and action – can and wants to afford in exchange for the reward of “quick digital solutions”. “Quick and dirty” solutions should of course be avoided, but good solutions can and must be reached through “co-operation in a team of purchasers, customers, developers and users”. And here, **taking everyone on board requires space and time.**

One specific space has received particular attention during the coronavirus crisis: the workspace, which when working from home is obviously a space in the home. Here, the recent dramatic weeks and months of the crisis have shown us that much can be done by working from home, that much can be dealt with by telephone and video conferencing, but that by no means everything is solved in that way. **On the contrary:** Without wanting to deny the usefulness of working from home for both employees and for the university as an institution and employer, here also we must take a holistic point of view. Apart from the fact that, of course, many tasks and duties, including those of a technical nature, can only be performed at a specific workplace on site, an important principle of agile working continues to apply: The most efficient and effective way of transmitting information to and within a team remains a face-to-face conversation.

The larger and more complex an organization (and universities with their many disciplines and organizational units are very complex), the more it is important not to neglect the overall view of the system. And here, an organization with potentially very many dispersed individual workplaces must be aware that such manifold separation in space may also increase the risk of a segmentation of thinking. The many video conferences that have worked so well and sometimes involved far-flung participants have been successful in helping us through a difficult time and have also shown that many events, meetings and trips of the past can really belong in the past, but they have also shown (although that is only reluctantly admitted) that effectivity and productivity at work have also suffered in many places.

Innovative and excellent work not only depends on laptops and smartphones in perfect working order but, from the point of view of occupational psychology, is also determined by the socio-empathic skills of the persons involved. For all the understandable “social distancing”, recognizing informal problems and arguing out and settling conflicts so as to work on a team “spirit” (which is indispensable in teamwork) is often only possible face-to-face and in person. The shutdown caused by the crisis has taught us that we can, as far as is possible, bridge dispersed workplaces by means of digital formats, but it has also made us realize the following with certainty: Life in a university, academic life, is not that easy to replace.

In general, the university is and wants to be a sought-after workplace. For this reason, responsible decision-makers must make possible, create and maintain future-proof innovative working conditions. One point cannot be rated highly enough here: staff recruitment and retention, in particular in the areas of management and administration. Here, new talent is urgently needed, and that is an opportunity for people who want to make a difference with responsibility.

The justified desire for flexible working times and variable workplaces enabling, in particular, ways of reconciling family and working life, can be met all the more where clear leadership ensures that all employees can see “the big picture”. It is in dynamic processes, in particular, that agile, reliable and responsible management at all levels is of crucial importance. The university is a research organization and an educational institution, where administration must never be an end in itself. **But times of crisis also show us that, without an administration keeping an eye on and, ideally, being in control of the overall structure of the university, the freedom of research and teaching cannot be ensured in practice.** ┘

┘ The shutdown caused by the crisis has taught us that we can, as far as is possible, bridge dispersed workplaces by means of digital formats, but it has also made us realize the following with certainty: Life in a university, academic life, is not that easy to replace.



Albert Berger  
Chancellor, TUM

# Human Resources Strategy and Business Transformation

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**The German labor market transforms more and more from an employers' into an employees' market: The baby boomers will be retiring from professional life in the next few years. At the same time, the number of those starting work is smaller than that of those retiring. Anyone sufficiently qualified can therefore choose who to work for. In a society marked by liberalism and pluralization, the criteria by which employees rate a company as attractive are manifold. Applicants are able to assert their needs with increasing vigor. Any company that fails to respond to this and does not treat its staff sustainably will face grave problems in recruiting new staff and retaining them.**

Employees need an environment in which they dare to question established routines.

Responding to employees' needs has, however, become more difficult in a radically changing world. There is hardly a company whose area of business has not been massively challenged by digitalization. Many businesses now face the need to reinvent themselves. Products, distribution channels, internal procedures, entire business models are being questioned. In times of radical and ever faster change, decisions by top management alone, while otherwise maintaining existing work routines, are not enough. Each and every department needs to change its thinking and, like the company, fundamentally reorganize.

**This means that employers' expectations towards their staff have increased dramatically:** Knowledge, skills, diligence and commitment are no longer sufficient for long-term success in working life. A great willingness to learn and the ability to commit to a field of work undergoing constant change are essential requirements not only for a few highly qualified employees, but equally for staff in those large groups who started their working life in vocational training or an apprenticeship. The challenges described arise irrespective of the size of a company. Thus, the following thoughts are not just a description of the specific challenges faced by Deutsche Lufthansa. Rather, they apply more generally.

As a result of tremendous changes, continuing professional development is indispensable, and lifelong learning becomes a part of everyday working life. But employees' new knowledge

and skills are not enough to respond to a changing market. Significantly more fundamental transformations in companies are needed to further enable their employees. While the traditional organizational form of a strictly hierarchically structured company is geared towards working through and routine processes, this organizational form of work is no longer sufficient and will no longer be sufficient in the future. Rapid innovation must be able to occur even outside research and development or strategic departments. Employees need an environment in which they dare question established routines.

Innovative ideas generally do not emerge from deskwork, but from the interactive collaboration and communication between and within diverse teams. The rooms and spaces where such innovation is intended to happen should be designed to encourage this way of working. Many companies are therefore creating idea labs and other collaborative spaces which can be flexibly rearranged. Employees need freedom, not only in a spatial way, but also in a hierarchical sense. Management should no longer act as an authority issuing instructions, but offer space and protection. For innovation only comes about where there is courage to try out new things, discard them rapidly if they are not yet fully successful and try them again in a different way. That requires a sense of security and the positive transfer of responsibility to the individual, often referred to as "empowerment". Such innovative processes often end with a ►

prototype product, prototype service, or the attempt to restructure an internal working process. Innovative projects of this kind can be managed by modern working methods – not in the shape of ordering and commanding (transactional leadership), but by a central figure methodically directing and steering, also referred to as a “facilitator”, whose involvement is limited to methods, not substance. Flexible spaces, heavily cut-back management, modern working tools, agile working methods, and non-rigid forms of organization form the basis for that.

Many publications suggest that companies should be adjusted to agile working as a whole. It is true that all departments are affected by the necessity of change as described. However, there will still be phases of routine work for which the aforementioned elements of new work are not necessary. In such phases of working through, it must be possible initially to be allowed to question that routine.

Where businesses fail to give their staff the opportunity to object to the status quo and later no freedom to change it while at the same time internally communicating the need for radical change, they expect too much of their own employees. Their feeling of a lack of self-efficacy will cause their satisfaction to plummet and ultimately reduce the attractiveness of an employer. The employer will degenerate to a textbook example of a conservative-hierarchical company that may outwardly promise modernity but fail to practice it on the inside.

If, on the other hand, an employer cultivates a culture of empowerment, employees will make use of this. With all the freedoms required, there is also a need for an overarching plan: **a clear business purpose, clear goals issued by top management, and understandable overarching priorities.** Otherwise, employees will feel lost, especially so in a changing world of work, and not know how they are to make use of the empowerment given to them and of any newly acquired technical knowledge.

After each phase of innovation, a decision must be taken to make something new the routine, and this must then be implemented quickly and efficiently. The established hierarchical company structure with transactional leadership remains well suited for this. What is new is the courage needed by management to take swift decisions and then to issue clear instructions regarding which goals are deliberately not to be pursued (any longer). Otherwise, a company runs the risk of getting bogged down in light of the almost limitless opportunities offered by digitalization. As a result, companies will in future have a continuing parallelism of different requirements, phases of work, and company structures – known as ambidexterity.

Many large corporations reporting that they are reorganizing or reinventing themselves are at that stage. Besides a strategy geared towards the external market, there is also a need for a strategy of internal change. This concerns selection, training and development of personnel, organizational development, management and culture, as well as building design and other fundamental changes. A veritable mammoth task, which should be supported and managed by quantitative ana-

lyses, as is customary in any business strategy. The term HR, Human Resources, is a widely insufficient label for a department in charge of such a task. For this much more comprehensive endeavor is about how employees relate to each other through management, organization, architecture and general staff policies, thus creating a new and transparent company culture, in which disseminators at the operational and the management level are encouraged, while obstructionists must be admonished.

Taken together, all the aforementioned measures – such as being empowered and invited to develop new solutions and use digital tools, or a greatly increased degree of interaction and communication, particularly in innovation phases – will lead to employees' work being more condensed and, at least temporarily, more intense. Employers must respond to this and support their staff in allowing phases of strain to be followed by at least short phases of relaxation. The right measures for doing this will depend on the company.

**Change happens in many small steps. Added together they lead to a transformation of the company and, ideally, ultimately to continued business success. Staff who go along with and drive change must not be marginalized but deserve respect for their courage. Working differently is still often wrongly interpreted as a desire to indulge one's personal needs. This is a serious misapprehension which – especially if espoused by management – can thwart necessary efforts for transformation.**

**If a configuration satisfactory for all sides is achieved, staff will enjoy their work, be motivated and make a long-term commitment to their employer. Otherwise, they will change jobs and find a place to work where their needs and the company's expectations are in accord on a long-term basis.**

Working differently is still often wrongly interpreted as a desire to indulge one's personal needs.

The relevance of the aforementioned aspects for the commercial success of a business has also been recognized by rating agencies. Under the heading “ESG” – for “ecological”, “social” and “governance” – they assess, among other things, the sustainability of a company's treatment of its employees. Thus, the capital market is showing an increasing interest in a sustainable treatment of employees by companies. This makes sense, because when companies fail, they rarely fail on the market, but rather because of their own failings. There are many positive examples of how this can be avoided. ┘



Dr. jur. Florian Henn  
Deutsche Lufthansa AG

# Not Just a Women's Issue

## Gender Equality and the Compatibility of Family and Career Through the "Burning Lens" of COVID-19

**The coronavirus pandemic has thrown people off course, all over the world. Can or should we focus on "gender issues" in this time of existential risk? The answer is a resounding yes – if not now, when? Current circumstances make it downright imperative that we put our finger on that old sore spot that is now becoming seriously inflamed.**

The COVID-19 crisis is often referred to as a "burning lens" that has cast light on all manner of inequalities and brought them to a combustion point. The position of women in our society is no exception: the current situation shows the structures created over the past decades still to be unstable and insufficiently sustainable, and that we are still a long way from true parity. Terrible though the current crisis may be, it also offers us an opportunity for thinking anew and thinking forward.

It could initiate and accelerate transformation processes and give us the chance to set a sustainable new course. After all, parity between men and women is central to increasing the resilience of society against future crises. How are things looking for the role of women in Germany in the pandemic year of 2020, and what shortcomings does the "coronavirus lens" reveal? Let us begin by taking a quick look back, so as to be able to place where we are today.

### Looking back – Milestones on the way to equality

In 1949, Article 3(2) of the Basic Law of the Federal Republic of Germany stated unambiguously: "All people are equal before the law. Men and women have equal rights." Yet, in 1950s West Germany, women were largely seen in traditional roles. It was the so-called "Golden Age of Marriage" in which women were expected to devote themselves wholly to the task of being a wife and mother. It was only in the 1960s, in close connection with developments of student protests, that many young women rebelled against society's persistence in upholding old patriarchal structures. This triggered a fundamental transformation of society and a change in values, underpinned by women's demand for liberation from personal dependence and self-termination in both private and political terms.

Legally, progress in West Germany came in small but constant steps: In 1958, the Equal Rights Act came into force; in 1977, in marital and family law, the discriminating "housewife's marriage"<sup>1</sup> was abolished, and divorce law was reformed. Finally, in 1980, the principle of equal treatment at work was written into law. Then, in the 1990s, this was increasingly institutionalized in academia and politics, and women's liberation became a subject for newly created equal opportunity bodies and women's representatives.

Demanding equal treatment means, conversely, taking responsibility for one's own life. This logical precept was taken into account *inter alia* in the reform of maintenance law of 2008, according to which the principle of personal responsibility now applies. Since then, women have no longer been able to count on ongoing maintenance payments after divorce – not even after a long marriage with traditional gender roles. This was a major turning point clearly signaling that every person must look after their own career and livelihood. Plausible though this may sound in theory, it can have serious repercussions in practice where there is a lack of fair conditions and equal opportunities for professional development. Politicians have recognized this in the meantime, so that over the past 15 years, important equal opportunity measures have facilitated women's ability to pursue their careers. These include the legal right to public childcare, more flexible parental leave, a redefinition of the conditions for parental allowance, the introduction of paternity leave, and the right to return to full-time employment after working part time.

### The status quo in 2020 – Where are we now? The COVID-19 crisis as a "burning lens"

So have we achieved our goals, reached the end of the road?? Equality is now implemented in law, and gender relations in everyday life have improved significantly. Can young women in Germany today therefore realize their aims in life free from external constraints and to the same degree and with the same standard of living as men of the same age? In principle, yes – but only if their life plans do not include starting a family. As soon as children are involved, the answer to the question above becomes more nuanced. The "lens" of COVID-19 has sharpened our focus in recent weeks and shown very clearly that our system becomes brittle under shock and is now showing cracks. What was often ignored before has been made apparent – it is women, by and large, who bear society's burdens and who do so with little or no remuneration. Both before and during the crisis, our society has been availing itself of the apparently freely available resource of women.

This is a moment of truth, and the facts are sobering: Women, particularly mothers, are the hardest hit in all areas of the crisis. It is predominantly women in poorly paid employment in the care sector – now at last recognized as "systemically relevant" – who, under great stress and often a higher risk of infection, carry the burden for the welfare of the whole of society. With nurseries and schools closed, mothers in particular find themselves having to teach their children at home on top of their own work. All of them, but above all single mothers, are faced with the almost impossible task of juggling work and childcare. This is compounded by the fact that the frequently used emergency back-up of grandparents looking after the children is not available due to the high risk of infection. ►

It is mostly women who take on social burdens, unpaid or underpaid. Our society before and during the crisis has been helping itself to the apparently freely available resource of women.

### Traditional gender roles

At this point we must ask why women in particular are so much affected by the crisis and why they allow themselves to be pushed back into traditional gender roles. We also have to ask why protest about this is so restrained and why we all consider it normal that enormous sums are used by the state to rescue businesses, while the huge burden of childcare in the home is carried predominantly by women as a matter of course, free of charge, and to the detriment of their own opportunities. Even the highly regarded National Academy "Leopoldina" did not have an eye on this problem when, at the beginning of the crisis, it recommended closing all day nurseries for several months and teaching alternating small groups in schools. It was noted that the additional burdens would predominantly affect women and that their employment should be protected by more flexible working times. However, the question how exactly, in our social reality, the resulting gap in childcare could be reconciled with both parents in full-time employment, and what long-term consequences this would have for mothers, in particular, was not answered adequately. Then again, only two of the 26 members of the advisory board were women. Furthermore, women have little presence in the media as experts in this crisis. It would seem that it will be a long process before parity, starting from the statute book, is actually implemented in our systems.

### Gender-specific occupations

In recent years, women have caught up significantly in all areas of education and training. Sometimes girls even receive more support than boys. On average, they achieve better results at school; more women than men of a given cohort take their A-levels; and women now make up half of all first-year students in universities. Young adults are more equal than ever. But then a first great divergence appears in their career choices, where young people – despite many initiatives and apart from a growing number of exceptions – are still clearly split between typical women's jobs and typical men's jobs. In principle, this need not be a problem. Though typical women's jobs, as clearly shown by the crisis, are indispensable to society, they have traditionally received little appreciation in the form of financial remuneration. Thus the foundations are laid for a subsequent state of affairs that cannot satisfy the requirements of women taking personal responsibility and ensuring their own livelihoods.

### Children, the 1.5-earners model, and the instability of families

The decision to start a family can be another major turning point on the road to inequality. When today's average couples decide to have a baby, it often makes more sense from an economic perspective for the man, who often has a higher income, to continue working full time while his female partner with a lesser income lowers her expectations with respect to her career to take on the larger part of the unpaid family care work. This is made more difficult by the fact that gender-specific roles have still not been overcome and it is still not sufficiently socially acceptable for fathers to take longer periods of parental leave from their work, though, in principle, that would be possible, since the new conditions for parental allowance offer men the opportunity to play a greater part in child-rearing.

The situation can get worse with each additional child. While fathers work full-time almost without interruption, they are able to gain additional business and occupational experience, increase their salary further, and pursue their careers. And so the gap between their professional biographies and those of mothers continues to widen. After starting a family, most women in Germany today work part-time and often also in poorly paid "women's jobs". As a rule, families live by the state-subsidized 1.5-earners model. Add to this the increasing instability of contemporary marriages and families in connection with the search for alternative ways of life, often at the expense of women who must not infrequently master life with children as single mothers.

### Childcare and the world of work

Reconciling work and family is made more difficult still by the requirements of modern employment, with mobility and flexibility the order of the day in a globalized world and a continuing trend towards fixed-term contracts. Moreover, the expansion of continuous, flexible and, above all, high-quality childcare taking account of this development continues to lag behind. Where women nevertheless manage to juggle their family and career, in Germany this is usually only possible with the help of other women (grandmothers or those in precarious employment) – which cannot be an adequate solution to the overall problem. ►

Even today, children are a “disruption” with respect to women’s careers and the predominant reason why the proportion of women drops dramatically in later career stages.

### Junior researchers as an example of “career women”

The problems of reconciling work and family affect all social classes, though to different degrees. Even the academic world is no exception and sets no example, as female junior researchers with children (here used as an example of “career women”) also face the aforementioned problems. Especially now, in the coronavirus crisis, there is a risk that they will be held back in their research careers more than their male colleagues due to lack of childcare. In an academic system based on the continuous evaluation of outcomes (as measured e.g. by the number and quality of publications), children can have a significant adverse effect on the professional biographies of female researchers. This is one of the reasons why women who wish to have children abandon the career path to a professorship more often than men, even under normal circumstances and despite equal ability and qualifications. In many cases, they get stuck as non-professorial teaching staff or in research management on comparatively low-paid, fixed-term contracts and with no career prospects. Let us pause for a moment to think about what it means for a female researcher on a 6-year tenure track with children to step aside for six months because of a lack of childcare during the corona crisis, while her male colleague can use the time in lockdown to work on future projects, applications, publications, etc. In the race for a sought-after professorship, where the length of lists of publications is of critical importance, there will be no consideration of time spent caring for children. Comparable scenarios are likely to unfold in companies where women hold career positions.

### Women and the intergenerational contract

So even today, children are a disruption to women’s careers and the predominant reason why the proportion of women drops dramatically in later career stages.

This development is a major problem for our society both in economic and in social terms. In a country where the pension system is based on an intergenerational contract, it is unacceptable. In the light of demographic change, it should be clear to everyone that female competence and qualifications are more urgently needed than ever on the German labor market. Giving birth to children and raising and educating them well have an immediate impact on the well-being of society as a whole. Therefore it should be in everyone’s best interest, then, that women decide to have children. In return, society must create the conditions in which starting a family is not detrimental to the careers of mothers. Other countries show us how to do this. A resolute and radical policy of gender equality has enabled Scandinavian countries to systematically build a family-friendly infrastructure and realise equal participation in parenthood. The effects are noticeable: The two-earner family is the norm there.

## Conclusion

The general social conditions described here make it extremely difficult in a family with children for both parents to pursue their professional careers equally. This stands in stark contradiction to the principle of personal responsibility laid down in 2008 (see above). Frequent consequences for women are missed career opportunities, low incomes, financial dependence on their partner and, in the worst case, old-age poverty.

Is there a way out of our dilemma? There is no simple solution, no simple recipe. But it would be of crucial importance to quickly increase pay in the socially relevant jobs dominated by women, for the solution cannot be to systematically push women into typical men’s jobs just to improve their income and career situations. If fewer women work in typical women’s jobs, who will do those instead? A large army of illegally or precariously employed people, immigrants or those recruited from elsewhere will only ease the social dilemma by shifting it on to other people. Although such a model exists in many countries to varying degrees, it cannot be this country’s approach, in the year 2020, with respect to equality, parity, justice, and social balance. Not before and not after the corona crisis.

Thus, our “bucket list” regarding gender equality should out of necessity include fair and adequate pay for women. It should also include the further expansion of very high-quality and flexible childcare of a kind that genuinely meets our social requirements both in terms of children’s development and with respect to their parents’ equal professional development. The systems created must be able to withstand crises, for reconciling family and working life is not an instrument that can be switched on and off again as needed. The list must also include making full use of the opportunities of digitalization and expanding flexible work time models. In the future, we should expect not only adults but also children with the merest whiff of a cold to be required, even more strictly, to stay at home. How can this be organized, if not with flexible home working solutions?

Perhaps, in the end, “the virus” will release completely new feats of imagination, and we will creatively find opportunities to help parity become the norm in our lived experience. The crisis could be a turning point that motivates us to rethink our society in this regard. If that were to be achieved, COVID-19 would have acted as an evolutionary catalyst, and we would have taken a giant step on the long road to gender equality. ─



**Dr. rer. nat. Birgit Herbst-Gaebel**  
Microbiologist/Immunobiologist;  
Science Manager, TUM Senior Excellence Faculty

**‘ In a “housewife’s marriage”, the wife was entitled and required to manage the joint household. The husband had to agree to his wife’s employment contracts and was entitled to terminate them himself.**

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09  
AFRICA



# COVID-19

## as a Global Challenge

**In recent months, we have been reading a lot about the consequences of the COVID crisis in Europe, the Americas, and Asia. Record levels of unemployment, health care systems under strain, tens of thousands of deaths, and entire industries having ground to a halt. Industrialized nations have responded to the crisis on an unprecedented scale, supporting their economies with billions spent on stimulus packages and job protection schemes. The EU is preparing recovery packages for supporting its community post-COVID. And Africa?**

The numbers of infections and deaths reported appear comparatively low. It seems that the pandemic is progressing more slowly in Africa, and it is to be hoped that the figures will remain significantly below some estimates. With 17% of the world's population, Africa most recently had only 2% of confirmed COVID-19 cases. Even if the real numbers are higher, as some countries have comparatively low testing capacities and as, with less travel, the pandemic progresses more slowly in Africa, it does not bear thinking about what consequences the crisis will have in regions where shortages are part of everyday life. Africa is already feeling the effects: Revenue streams such as tourism have run dry. Exports of raw materials and energy – the main source of income for some African countries – now

only bring in a fraction of the normal revenue. There is a risk of famines, as fields cannot be cultivated in times of lockdowns and restrictions on contact. Strict measures designed to protect people's health have the most deleterious effects on the economically vulnerable.

In these unprecedented times, it is important for developed nations to think not only of themselves and in national categories, but to understand the crisis as a global challenge and to put their partnership with Africa on a sustainable footing. The TUM, which has been concertedly expanding its commitments in Africa in recent years and has enshrined its relations with the African continent in its successful excellence strategy, has laid

By 2035, with an estimated 1.1 billion people of working age, Africa will have the largest potential labor force in the world.

down sustainability as a basic principle of its Africa strategy. Our partnership for innovation and sustainable development with the Kwame Nkrumah University of Science and Technology (KNUST) in Ghana, West Africa, is based on a shared vision closely linking up science and technology with innovation and entrepreneurship and so building a bridge between the university and society to stimulate sustainable development. As the most successful university for entrepreneurs in Germany, the TUM is in a good position to get innovations off the ground, jointly with the KNUST, bringing about sustainable change locally in areas such as water, food, energy, urban development, mobility, and medicine. The TUM's commitment to a long-term and sustainable partnership is shown in a project by TUM professor and architect, Francis Kéré. Together with his African colleague Professor Rexford Oppong, he is planning the construction of a Co-operation Centre at a central location on the KNUST campus where activities can be pooled and our partnership can be given high visibility on a permanent basis. The TUM and the KNUST also collaborate in the area of COVID-19 research. Professor Gil Westmeyer is developing a rapid diagnostic test to be further validated with colleagues at the KNUST and then approved, so that it can be used in African "Point of care" centers in a decentralized manner.

Sustainability at the TUM, however, is not only about the topics, content and structures of its partnership with the KNUST. We also ensure the long-term success of our partnership by giving it a broad base and involving all interest groups at the KNUST, the TUM and beyond. From undergraduates and doctoral students through postdoctoral researchers and professors to administrators and alumni – they all take part in this special partnership with commitment, enthusiasm and ideas. And we keep widening our circles. In a lively exchange with manufacturing, intermediary organizations and government departments at federal and state level, we look for and find supporters who do not shy away from the challenges of Africa and recognize the potential for co-operation.

**For one thing is clear:** Sustainable co-operation can and will only work if collaboration adds value for both sides. Statistics are evidence Africa's potential in clear figures, even if our thinking today often remains marked by decades of reporting focused on famine, illness, and civil wars. By 2035, with an estimated 1.1 billion people of working age, Africa will have the largest potential labor force in the world (BMZ, 2017); by the end of the century, a predicted 13 of the 20 largest cities in the world will be in Africa (the others in Asia) – but none in the Americas, China, or Europe (WEF, 2017). Today, about half of the 20 fastest-growing economies are in Africa, including Ethiopia, Rwanda, Senegal, and Ghana (IMF, 2019). But Africa is an important partner not only in economic respects. We can learn a lot from the African perspective about important global issues of the future, marked by different social structures, climatic conditions, technological and economic circumstances. It would be reckless, therefore, if the COVID crisis led developed nations to focus increasingly on themselves. In the long run, both sides would be the losers. ┘



**Professor Dr. Juliane Winkelmann**  
Full Professor of Neurology and Neuroscience,  
Stanford University (2013–2015);  
Acting Vice-President for TUM International Alliances  
and Alumni; Professor of Neurogenetics, TUM

# A Plea pro Domo

## An African Advocates the Rule of Law

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“We have been in crisis mode for weeks. Whether in the general population, in the media, or in politics: The COVID crisis is the dominant topic. But there is a life besides the crisis, and there will be a life afterwards. That present and that future also deserve our consideration. [...] We cannot simply carry on along entrenched patterns of behavior. We need a fresh start.”<sup>1</sup>

As always in the face of such challenges, there are optimists, who think everything will get better, and pessimists, who think everything will get even worse. Here it is worth quoting and reflecting on the words of Pope Francis: “When we get out of this pandemic, we will no longer be able to do the things we used to do in the way we used to do them. No. Everything will be different. [...] From the great trials of mankind, including this pandemic, we will emerge better or worse off. These are two different things. I’m asking you: How do we want to get out? Better off – or worse off?”<sup>2</sup>

### I would like Afrika to be better o

I would like things to go better for Africa. I would like this beloved continent not to miss another opportunity. The end of colonialism, in the 1960s, was a missed opportunity. Even then, when many African elites were euphoric, as if everything was suddenly going to get better, as with a *Deus ex machina*, the French agricultural engineer, sociologist and environmentalist René Dumont (1904–2001) rang the alarm bells. In 1962, he published his best seller, *L’Afrique noire est mal partie*. In translation: ‘Things are not looking good for Africa’, or ‘Africa has got off on the wrong foot’. Dumont describes the disadvantages of the African continent, the problems with corruption, the effects of decolonialization. And he warns of merely dreaming up success. He pointed out that the problems shown had to be solved. But 20 years later, he diagnosed a worsening of the situation, publishing another book in 1982, whose pointed title *L’Afrique étranglée*<sup>3</sup>, ‘Africa Strangled’, reflected a dramatic turn for the worse.

My claim is that implementing the rule of law or *état de droit* is the *conditio sine qua non* for achieving a better future for the African continent. I am conscious that such a claim might provoke at least three lines of criticism. First: Is there such a thing as “one Africa” – can one recipe apply to all countries? Secondly: Is there such a thing as a “rule of law” that can be effective irrespective of cultural peculiarities, and how is that rule of law to be understood? Thirdly: How can the “rule of law”, if there is one, solve problems such as climate change, droughts, desertification, overexploitation of fields and pastures, poverty, lack of education, hunger, wars, rural exodus, unemployment, corruption, etc. – to name some of Africa’s acute problems today? In what follows, I will address these questions.

### There is no “one” Africa, but all of Africa needs the rule of law

The diversity of Africa makes it impossible to have or express a general opinion on Africa. There never has been, there is not and there probably never will be that “one Africa” of which we keep hearing. The destinies of different African countries are very varied. There are geographical, cultural, linguistic, and many other differences.

Africa, with its 55 countries, is heterogeneous and plural. There is North Africa and there is sub-Saharan Africa, and even sub-Saharan Africa has never been unified historically or politically. Sub-Saharan Africa is characterized by multicultural, multiethnic, and multinational societies, which are of necessity marked by the encounter of other cultures, other ethnic groups, and other nations. At the economic level, there is an Africa that is developing well and an Africa that is doing very badly. The diversity of Africa also becomes apparent when we ask what law or what legal system is practiced in Africa. “The diversity of African law, reflecting the diversity of cultures and ways of life in Africa, is impossible to summarize even in comprehensive monographs,” says Uwe Kischel, a highly regarded professor of law.<sup>4</sup> He rightly points out: “The law in sub-Saharan Africa has one fundamental common factor: its plurality. In Africa, different legal systems and legal concepts collide and must try and co-operate, or at least tolerate each other. This does not primarily concern the collision of official legal traditions based respectively on English and French law, geographically roughly corresponding to the dividing line between English-speaking and French-speaking countries. A treatment reduced to this simplified dichotomy would disregard not only the historical and current influence of Islamic law and the occasional significance of socialist legal principles, but also the pronounced ▶

problems in the practical application of all state-sanctioned law in Africa. Rather, the plurality of African law arises principally from the paramount importance of traditional African law in all countries, whether or not its existence is officially recognized.”<sup>5</sup> Despite this plurality of laws on the African continent, there is one common theme: To this day, Africans must define themselves along different identities including regional, tribal, clan, and religious identities. What is more, they are citizens of a continent with ancient traditions and at the same time citizens of the youngest countries of modern times. In this extremely difficult and complex situation, building functioning democratic states presents a major challenge. Naturally, slavery and colonialism must be mentioned here. Colonialism and slavery left behind not only economic, but also mental damage. Abolishing the structures of colonial rule in all their forms, in all areas of life, and in the minds, will take a long time. It must never be forgotten that Africans have not yet had sufficient time to process that phase in their history, which they will never and must not forget.

It is clearly not enough to write great constitutions and to pass good statutes, as was done in many African countries in the late 1990s and early 2000s. The failures of those governing, the denial of civil rights, social inequalities, economic disadvantages, discrimination, and the lack of social justice are all evidence that the objective of the rule of law has not yet been achieved. And this lack of rule of law is the mother – or, to adapt the metaphor to African, the “father”<sup>6</sup> – of all problems.

### Africa and the rule of law

The rule of law, *état de droit*, is perhaps the most important political ideal in current global discourse. Everyone, it seems, is in favor of the rule of law. The rule of law has become an important source of legitimacy for governments and states in the modern world. A government that abides by the rule of law is considered good and worthy of respect. But there is no precise definition of the rule of law,<sup>7</sup> and its implementation can vary significantly between different nations and legal traditions. But discussions about the nature of the rule of law must not mislead us. The rule of law is not abstract! It is by no means a *flatus vocis*! It contains something concrete: The principle that power must not be exercised arbitrarily, the principle of the primacy of law, the principle that the law must apply equally to all persons and offer the same protection without discrimination, or the idea that the law must be applied and complied with universally. In general, a regime can be considered to uphold the rule of law if the law moderates governments, if it promotes certain liberties, and if it creates order and predictability regarding the functioning of a country. Understood in the simplest way, the rule of law is a system that attempts to protect citizens’ rights against the arbitrary use and the abuse of state powers.

Peter Michael Huber, a judge at the German Federal Constitutional Court, is surely right in saying, “Besides federalism, the rule of law is probably the most important contribution made by German constitutional law to the development of

the modern constitutional state. Since the 19th century, it has characterized the political co-ordinate system of our country and been at the core of our constitution. It has found imitators not only in Europe.”<sup>8</sup> Respecting and guaranteeing human rights and fundamental freedoms, the essential foundations of democratic societies, are part of the rule of law as a matter of course. Universally, these rights and freedoms are the inheritance of all humankind. My thesis is: *L’Afrique est [encore] mal partie* – things are still not looking good for Africa – if again the crisis is not used for change, if Africans fail to seize the opportunity to implement and establish the rule of law. The rule of law is the major challenge in modern Africa in particular, if it is not to risk its internal cohesion in the long run. In what follows, I shall focus on the necessary activities to be carried out by Africans themselves. It is in Africa’s interest to take on the rule of law.

Africa must implement the rule of law irrespective of whether this is a requirement for receiving funds from donor countries and relevant institutions. The German minister for “economic co-operation”, Gerd Müller, warns: “My principle is: Not one euro goes into corrupt channels. That is why, in difficult countries, we do not co-operate directly with governments. [...] The corrupt must feel that we are not prepared to fund corrupt channels.” But he adds: “If we isolate a country, it is the people who suffer the consequences. The desire for democratic structures must come from inside. We strengthen civil society. [...] In many places, we are far from democracy, and we are also in competition with other donor countries. Chinese partners arrive with lots of money, and they say: Human rights, democracy, rule of law – let’s not talk about that.”

Africa must implement the rule of law, not only because in almost all countries’ constitutions, in the charter of the African Union and in the African Charter on Human and Peoples’ Rights, the African states have formally committed to the rule of law. Africa must implement the rule of law, not only because almost all African countries are committed to international treaties, beginning with the Charter of the United Nations, all the way to the UN Convention on the Rights of the Child. Rather, Africa must implement the rule of law because: The rule of law is a guarantee for a functioning democracy, and democracy will only benefit Africa. The primacy of law is a foundational notion in Western democracies. The rule of law demands that both citizens and governments abide by applicable laws. The disregard for and manipulation of national constitutions in many African countries, electoral fraud, the abuse of political power, legal and judicial perversions, etc. are damaging to the African continent. All this arises from societies that show little respect for the rule of law. But democratic practice in Africa would contribute to economic growth and to the development of states and societies. “Good governance” means that the exercise of public power does not run counter to the standards of democratic governance. The culture of dictatorship in Africa is the greatest obstacle to sustainable development. It leads to crimes going unpunished and to uncontrolled corruption. It knows no accountability. The arrogance of power facilitates the theft of public resources and tolerates the violation of fundamental human rights.

— Africa must implement the rule of law, because the rule of law is a guarantee for a functioning democracy, and democracy will only benefit Africa.

### The rule of law is a guarantee of peace

The most unfortunate trends in Africa are activities of conflict and terrorism. In many countries, there are various actors causing chaos and confusion and preventing nation states from developing peacefully so as to make people’s lives better. Unfortunately, there are still too many conflicts displacing enormous numbers of people and turning them into refugees. The examples of South Sudan, the Central African Republic, Nigeria, and Somalia show that there can be no normality in the lives of people in times of conflict. It is a well-known fact that violence, insecurity and crime are a major obstacle to sustainable development. It is no accident that the most conflict-ridden and insecure countries are also among the poorest. The root cause of insecurity and poverty is often a lack of rule of law: If the state is not able or willing to protect people or their property or their human rights, if institutions are not strong enough to settle social and political conflicts, if the law discriminates against women and offers them no support, if institutions are not strong enough to combat terrorism or organized crime or urban violence, there can be no sustainable development.

### The rule of law as a guarantee of a functioning judiciary, a functioning judiciary as a guarantee of economic development

Economic growth and the rule of law are closely intertwined. Economic actors have long been hesitant to invest in African countries because of the prevailing legal and judicial uncertainty which to this day persists to a considerable extent, despite OHADA (*Organisation pour l’harmonisation en Afrique du droit des affaires*, “Organization for the Harmonization of Corporate Law in Africa”). OHADA is an international organization of African states founded in 1993. The organization’s aim is to create a common commercial law for a common economic area. The existence of OHADA is some cause for optimism. But it cannot be ignored that, to this day, corruption plays a major part and deters investors both within and outside Africa from becoming engaged in Africa’s economic development. This lack of entrepreneurial activity cannot wholly be explained by corruption, but also by a widespread distrust in the judiciary. If judges are open to bribery, if large parts of the population such as women and poor people have no access to justice, there is widespread dissatisfaction and paralysis, and no engagement in economic development is to be expected. ►

## The rule of law as a guarantee of fundamental and human rights for all – children, women, minorities

The rule of law requires respecting fundamental rights, whose precise content varies in the different legal systems around the world. Unfortunately, in parts of Africa, there are competing legal systems within a single state. Formal and informal judicial systems – civil and common law, Islamic and Sharia law, African arbitration and justice, and Hindu law – coexist in some regions of Africa without any co-ordination. As a result, justice is left behind. This particularly applies to children, girls and women. On the fringes of the G20 summit in Hamburg in July 2017, the French President Macron described Africa's problems as "civilizational" and suggested in his remarks that the high birth rate in African countries was impeding progress. "Africa's challenge is completely different, it goes much deeper," Macron said, adding that while in countries "still having seven or eight children per woman" one might opt for financial support amounting to billions, this would "stabilize nothing". This statement caused a "shitstorm", both in Africa and outside Africa.

My point of view is as follows: If African countries, by specific political instruments, were to succeed in implementing the rights of children, as defined in various international human rights treaties, the most important being the 1989 UN Convention on the Rights of the Child,<sup>9</sup> including, if necessary, by means of state power, this would solve many problems. If every African man – and the emphasis is on men, not women – were forced by the state, if necessary, to provide an adequate standard of living, health care, social security, and education for every child he had fathered, then, believe me, any African man would do anything to avoid being the father of many children. The problem is not the high birth rate, but the irresponsibility of many African men. The responsibility of men is of the greatest importance with respect to the future and to sustainable development in Africa. But here it must also be pointed out that there is a subsidiary role for the state to play. Responsibility on the part of African men, but also on the part of African states, provides a tremendous opportunity for a generation of educated young people to grow up in Africa who will change the fate of Africa for the better.

The implementation of the rights of children would protect children – boys and particularly girls – against genital mutilation, abuse, forced marriages, child labor, etc. It must also be mentioned that many children are kidnapped to take part in wars as child soldiers. All this physically and mentally destroys African youth, the real future of the continent.



### Stéphane Hagbe Hagbe

Studied in Yaoundé, Paris, Munich;  
Bachelor of Philosophy, Master of Law;  
Laureate and major, 2013, "Diplôme  
Universitaire de Formation Doctorale en Droit,  
Gratianus"; observer of the African continent

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2. **Francis in a Spanish-language video message on the occasion of Whitsun 2020.**

3. **René Dumont, Marie-France Mottin**, *L'Afrique étranglée : Zambie, Tanzanie, Sénégal, Côte-d'Ivoire, Guinée-Bissau, Cap-Vert* (Points Politiques), Editions du Seuil, Paris, 1982

4. **Uwe Kischel**, *Rechtsvergleichung* 2015, p. 679

5. **Uwe Kischel**, *Rechtsvergleichung*, 2015, pp. 679–680

6. **Africa's problems are indeed more often caused by fathers than mothers!**

7. **The rule of law – its definition and properties, the possibility and conditions of its existence, and its significance as a political value – has long been the subject of scholarly investigations and debates.**

8. **Peter M. Huber „Der Rechtsstaat nach 70 Jahren Grundgesetz“**, in Hans Michael Heinig, Franz Schorkopf (eds), *70 Jahre Grundgesetz*, 2019, p. 207

9. **In 54 articles, the UN Convention on the Rights of the Child defines the rights of children and makes provision for their implementation. The rights of children according to the UN Convention on the Rights of the Child can be classified in three categories: development and support rights, rights to protection, and participatory rights.**

10 <https://chrismon.evangelisch.de/artikel/2019/46354/bundesentwicklungsminister-gerd-mueller-und-veye-tah-ueber-entwicklungszusammenarbeit-und#comments-list>

11. **Charles de Gaulle**

## Conclusion

In 2013, the African Union adopted its Agenda 2063, a strategic framework for the socio-economic development of the continent in the next 50 years. One of seven fundamental points is "good governance": respect for human rights, justice and the rule of law. I have shown that strengthening the rule of law is a challenge for all African nations in the face of mass displacement, food insecurity, and conflicts, corruption, etc

The governments, civil societies, all citizens of Africa, and the international community must make the rule of law a priority for the future and an important pillar for further economic growth. It is worth quoting the German development minister: "Many people in Germany wonder whether that continent has a future. I say: Yes, it has! [...] The countries of Africa are rich in natural resources: oil, gas, coltan, rare earths. [...] We have to ensure that this wealth leads to added value and that the exploitation of human beings and nature – a form of neocolonialism – is discontinued. I say discontinued, because those working in the coltan mines, in the gold mines, on the coffee plantations continue to be paid slave wages. [...] We cannot leave the African continent in poverty while we enjoy prosperity. If the differences continue to increase, there will be a crash. Africans cannot and will not accept that. We must build fair trade relations, fair supply chains, which create employment and value locally. That is what I am fighting for."<sup>10</sup> The German minister's statement is to be praised, and any African will find them promising. It also makes Africans aware: Countries do not have friends, they have interests.<sup>11</sup>

Africa can forge partnerships with Europe, the Americas, or Asia, but first Africans have to work out what they need. Africa will not be saved from outside. It must save itself from the inside. Implementing the rule of law will be essential to this. —

# Epidemics

## Experiences from Africa with Relevance for the Future

**In its first 20 years, the 21st century has already seen quite a few epidemics or pandemics, where a pandemic is an epidemic of larger proportions, across continents. Examples include the SARS-CoV-1 pandemic (severe acute respiratory syndrome-related coronavirus) in 2002/2003 (mostly in Asia), the influenza virus A/H1N1 pandemic (swine flu) in 2009/2010 (worldwide, originating from Mexico), the MERS-CoV epidemic (Middle East respiratory syndrome-related coronavirus) since 2012 (mostly in the Middle East), the Ebolavirus epidemic from 2013–2016 (mostly in West Africa), the Zika virus epidemic in 2015/2016 (mostly in South America), and now the current SARS-CoV-2 pandemic (coronavirus disease 2019 (COVID-19)), the only one to reach a truly global pandemic status. Once again, the focus is on interactions between humans, animals and the environment, demonstrating the urgency of One Health solutions at the global level (see the chapter by Winkler, Amuasi, and Wacker on One Health).**

The African situation is characterized not only by the geographical expansion of testing capacities, but also by the rapid innovative development of one-dollar diagnosis kits able to detect the novel coronavirus within 10 minutes.<sup>3</sup>

### Africa – A continent of epidemics

Very early on, there were concerns about the high vulnerability of Africa to COVID-19. Such concerns are based on a range of factors including: (1) the lack of, or the great permeability of, health warning systems (“surveillance”), (2) the weakness of existing health care systems, which would have great difficulty in coping with a sudden rush of patients, (3) the continuing dependence of African economies on mineral extraction and the extreme volatility of these economies vis-à-vis external influences, (4) already present civil unrest, which might compromise or even politicize health protection measures, and (5) the persistent encroachment of people into untouched animal habitats all over Africa.

These concerns are justified, as epidemics occur in Africa at regular intervals. In recent years, Ebola fever, Lassa fever, yellow fever, monkey pox, and the plague, to name but a few, have caused significant damage in the countries affected. Between 2013 and 2016, Ebola fever caused more than 11,000 deaths and caused great concern world-wide, particularly because of its mortality rate of 40%.<sup>1</sup> The Ebola epidemic led to investments in health care infrastructure, with 24,000 health care workers in West Africa alone receiving high-quality training in infection prevention and control. Laboratory capacities were greatly expanded, in particular in the three countries concerned (Sierra Leone, Guinea, and Liberia), with 24 laboratories, including world-class mobile laboratories, being able to test for Ebola.

The health care systems of several African countries have been on continuous stand-by for new epidemics since 2014. The Ebola epidemic received much attention in the media around the world. But there are other epidemics receiving almost no attention but causing many more deaths. Measles continues to be a major health problem in tropical Africa, registering high spikes in infections in the dry season, which can expand to become epidemics. In addition, every eight to twelve years, there are meningitis epidemics across the African meningitis belt reaching from Senegal in West Africa to Ethiopia in East Africa.

### COVID-19 in the African context

Despite extremely valuable experience from previous epidemics and the resulting structural development, COVID-19 has the potential to become a disaster for Africa, if the disease were to follow the same trend as in Asia, Europe, and the Americas. Apart from deaths caused by COVID-19 itself, an excessive strain on the already fragile health care institutions could have a significant impact on routine health care such as vaccination programs for children, prenatal care and obstetrics, the treatment of malaria, HIV/AIDS, tuberculosis and malnutrition, to name but a few examples. This in turn could lead to an increase in the overall death rate, in particular in cases of co-infection with COVID-19. In this context, chronic diseases such as cardiovascular disease and cancer, which make up the greatest burden of disease in Africa as well, are not to be neglected (see the chapter by Klug and Kiechle on cancer in Africa).

### Is there immunity in Africa?

Up to now, Africa seems to have been spared massive infections and deaths from COVID-19. The curve of infections remains flat, and it is to be hoped that this is not just the calm before the storm. The exceptionally young population of Africa (the majority of the population is under 20 years of age) could be an advantage in connection with COVID-19. Some have also argued that there may be a genetic predisposition protecting parts of African populations against COVID-19. But this hypothesis seems to be contradicted by the disproportionately high proportion of people with African origins in Europe and North America who have died of COVID-19. Others suggest that there could be immunogenic protection mechanisms as a result of tuberculosis vaccine and other vaccinations widely practiced in Africa. So far, however, there has been no scientific evidence of this. As there is scant evidence of something “special” about Africans that could explain the hitherto comparatively mild picture of COVID-19, it is worth taking a critical look at the measures taken by African governments, even if their implementation appeared to have little popularity at the outset and locally. ►

## Containing the pandemic: The national level

A number of conclusions can be drawn from the course of the COVID-19 pandemic in Africa so far. Africa has experience of epidemics and is therefore permanently on guard. Many African countries, especially in West Africa, drew on their experiences of the Ebola epidemic of 2013–2016, beginning with an early decision taken by many countries to close their borders even if they had no cases, and despite difficulties with implementation. In addition, many countries headed the call by the World Health Organization (WHO) for a “test and trace” strategy, which means testing as widely as possible and rigorously tracing the contacts of each person tested positive. Ghana, which of all African countries has conducted the second-highest number of COVID-19 tests (after South Africa), responded relatively quickly by imposing a mandatory quarantine on all travelers. Furthermore, an early lockdown made massive contact tracing and comprehensive testing possible. Nigeria trained emergency teams in all 36 of its states, which were used for tracing contacts and carrying out testing, and Kenya recently opened a quarantine center for suspected cases in Nairobi in order to implement the WHO’s “test and trace” strategy. Many other countries such as Mauritius, Somalia, and Madagascar are currently expanding their test capacities and strengthening their health care systems. With help from the WHO and other co-ordinating institutions, countries made different investments in communication and monitoring capacities, in training health care staff, focusing on so-called “community health workers”, and in diagnostic capacities. While, at the beginning of February, only two laboratories – in Senegal and South Africa – were able to test for SARS-CoV-2, by mid-March at least 40 African laboratories in 40 African countries were equipped to do so.<sup>2</sup> The African situation is characterized not only by the geographical expansion of testing capacities, but also by the rapid innovative development of one-dollar diagnosis kits able to detect the novel coronavirus within 10 minutes.<sup>3</sup> Furthermore, the financial proactiveness of certain African countries has been praised by international experts. For instance, Ghana mobilized its own emergency fund and so did not waste time waiting for international assistance.<sup>4</sup>

## Containing the pandemic: The international level

There had long been a need for a supreme public health authority, among other things for improving the monitoring, treatment, and prevention of infectious diseases. Africa Centres for Disease Control and Prevention (Africa CDC) was founded in January 2017. Africa CDC began its preparedness measures for COVID-19 as early as mid-January, developing an emergency plan and convening a conference of health ministers to develop an international strategy.

The responsibilities of this continental health institution include not only collecting COVID-19 data and monitoring the COVID-19 pandemic on the African continent, but also training health care staff in infection prevention and control as well as patient management, procuring and distributing COVID-19 tests, mapping clinical drug trials, and developing guidelines e.g. for wearing protective masks. Furthermore, Africa CDC closely collaborates with the WHO, whose leading role in the COVID-19 pandemic cannot be emphasized enough, in an Africa Task Force for the novel coronavirus established in early February.<sup>5</sup> Another important collaboration is with the African Union Commission in the Partnership to Accelerate COVID-19 Testing (PACT) meant to facilitate implementation of a common African continental strategy for COVID-19.<sup>6</sup> Africa CDC is supported financially not only by different governmental organizations from around the world, but also by the private sector and foundations such as the Bill and Melinda Gates Foundation.

## African lessons and looking ahead

More than three months have now passed since the first case of COVID-19 was registered in Africa (Egypt) in mid-February, and the COVID-19 infection curve remains flat. This success seems, at least in part, to be due to the following measures: early and consistent closing of national borders, imposing lockdowns in the countries themselves, strict quarantining of suspected cases, rigorous tracing of contacts of those infected with COVID-19, making use of structures already established in the course of previous epidemics, investing in health care personnel, ramping up laboratory capacities, and all that with strong national leadership and efficient international co-ordination by Africa CDC and the WHO. In addition, support by the international community, the private sector, and humanitarian foundations must not be underestimated. These invest both in co-ordination and infrastructure services by Africa CDC and the WHO and in innovative economic and scientific collaborations. In times like these, fair research and academic partnerships for building knowledge and efficient mutual knowledge and innovation transfer (not only into Africa, but also from Africa to the rest of the world) are of the highest importance.

However, Africa’s success is hanging by a thread. The economic repercussions of the pandemic are even now considered alarming for Africa. African economies, already highly indebted, will struggle to guarantee the security of companies crucial for the economy of a country. As the majority of Africans are employed by small and medium-sized enterprises unlikely to receive support, mass unemployment looms, which could trigger unrest and violence in African countries. Moreover, there are already signs of rising food prices, which in the absence of financial reserves could quickly lead to famine. It remains to be seen how far African countries will want to pursue the balancing act between public health and economic opening. The consequences of a weakened African economy will not be limited to that continent, but will have a global impact and concern all of us – at the latest, when the next wave of refugees is imminent. ─



**Dr. John Humphrey Amuasi**  
Global Health and Infectious Diseases Research Group, Kumasi Centre for Collaborative Research in Tropical Medicine, Kumasi, Ghana; Global Health Department, School of Public Health, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana; Co-chair of *The Lancet* One Health Commission



**Professor Dr. Dr. Andrea Sylvia Winkler**  
Center for Global Health, Department of Neurology, TUM; Centre for Global Health, Institute of Health and Society, University of Oslo, Norway; Co-chair of *The Lancet* One Health Commission

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# Cancer in Africa

## Before and After COVID-19

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**Around the world, including in Africa, the pandemic is spreading fear, causing a high death toll, and overburdening many health care systems. In Africa in particular, some health care systems were already in a precarious state even before the pandemic. A chronic lack of financial resources, modern equipment, materials, and well-trained personnel are more likely to be the normal state of affairs than an exception. As a result of social, cultural, geographic, or financial circumstances, access to health care in the population is often impossible, or only possible at a very late stage.**

When a highly infectious, rapidly spreading and potentially lethal virus such as SARS-CoV-2 hits a poorly prepared health care system – which must be assumed for most countries in sub-Saharan Africa – the collapse of that health care system is all but inevitable. Even before the pandemic, many African health care systems were already completely overburdened with other infectious diseases such as HIV/AIDS (718,800 deaths in 2016 alone), diarrhea (652,800), malaria (408,100), and tuberculosis (405,500). Overall, in 2016, more than 2.7 million people in Africa died of infectious and parasitic diseases.

### Non-communicable diseases

In recent years and decades non-communicable chronic diseases have further added to the burden of disease in Africa as well. In 2016, more than 3 million people died of a non-communicable disease. These include primarily cardiovascular diseases (more than 1.1 million deaths in 2016, of which 512,000 deaths from ischemic heart disease and 373,000 deaths from strokes), tumors (541,000), diseases of the digestive system (356,000), neurological disorders (142,000), and diabetes (168,000).

When the existing double burden on health care systems from endemic infectious and non-communicable diseases is now exacerbated by a pandemic from a novel virus, non-communicable diseases risk being overshadowed. In the light of more than 3 million deaths from non-communicable diseases in Africa in just one year (2016), this would be disastrous. Instead, more emphasis must be placed on promoting programs for cancer prevention, screening, and treatment in Africa. Existing safe vaccines against hepatitis B (for the prevention of liver cancer) and human papillomaviruses (for the prevention of cervical cancer) must be made available to all children in Africa,

where the incidence and mortality rates of specifically these two types of tumors are particularly high. Tried and tested cancer therapies including safe surgery must be accessible for all patients in Africa as well. This requires improving and expanding health care systems and establishing health insurance schemes to bear the costs of vaccinations and cancer screening and treatments.

### Primary cancer prevention

Many non-communicable diseases can be prevented effectively by comparatively simple measures of primary prevention. Up to 70% of cardiovascular diseases and up to 50% of cancers are preventable. Life-style factors such as smoking, unhealthy eating, alcohol consumption, and a lack of exercise are the main risk factors for many cancers such as lung cancer, colorectal cancer, and breast cancer, as well as for cardiovascular disease.

### Viruses and cancer

Since viruses can cause cancer as well as infectious diseases, vaccinations also form part of primary cancer prevention. A vaccine against hepatitis B has been available since the 1980s, which ultimately prevents liver cancer. In 2016, 41,800 people in Africa died of a hepatic carcinoma, of which 18,400 deaths were caused by hepatitis B, 8,000 by hepatitis C, and 12,000 by excessive consumption of alcohol.

Since 2006, a vaccine against human papillomaviruses (HPV) has been available. Cervical cancer is caused by HPV. In 2006, 59,110 women in Africa died of cervical cancer. This makes cervical cancer the most frequent cause of death from cancer in women in Africa. In 2018, the incidence of new cases was 27.6 per 100,000. ▶

## Cancer in women in Africa

The second most frequent cause of death from cancer in women in Africa is breast cancer. 54,800 women in Africa died of breast cancer in 2016. In 2018, the incidence of new cases was 37.9 per 100,000. There are effective methods for screening (secondary prevention) for both cervical cancer and breast cancer. The smear test for screening for cervical cancer has been available since the 1960s, and an HPV test for screening for HPV infections has also been available for some time. In Africa, where screening is available at all, the simpler and more cost-effective, but less reliable method of screening by visual inspection (VIA) is used most often. If an effective cervical cancer screening program were to be introduced in Africa and all children vaccinated against HPV, cervical carcinoma would in future be crossed off the list of causes of death from cancer.

For breast cancer, there is also an effective screening program. Several studies have shown that women having a mammography every two years between the ages of 40 and 69 show a 20–40% reduction in the mortality rate from breast cancer within ten years. Moreover, screening for breast cancer leads to the disease being diagnosed at an earlier stage. This increases the chance of breast-conserving and less invasive treatment. Effective screening programs for these two most frequent cancers are currently not available to African women.

## Sustainability: Building local structures

The German government has currently set up a range of Africa-related initiatives, and the Free State of Bavaria is also promoting an Africa package, among other things. In 2018, the TUM started a long-term Africa initiative with a focus on Kwame Nkrumah University of Science and Technology (KNUST) in Ghana. With support from the TUM Global Incentive Fund, the Chair of Epidemiology, the Center for Global Health and the women's hospital of the TUM, together with Ghanaian partners from the KNUST School of Public Health, held a workshop on the topic of "Women's Health and Cervical Cancer Prevention" in Ghana in February 2020. The aim of the workshop was to investigate the local situation in respect of cervical cancer prevention and treatment as well as HPV vaccination. In the medium and long term, together with further partners, research projects are to be carried out and sustainable prevention and therapy strategies are to be implemented. There will also be an exchange of students and lecturers.



**Professor Dr. Stefanie J. Klug**  
Award of the Foundation for Preventative Pediatrics (2009); Professor of Epidemiology, TUM



**Professor Dr. Marion Kiechle**  
Bavarian state minister for science and the arts (2018); Chair of the Bavarian bioethics commission; Professor of Gynecology and Obstetrics, TUM

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## Conclusion

Sooner or later, the horror of the pandemic will be over; infectious diseases are in retreat – but non-communicable diseases will continue to increase all over the world, including in Africa. In 2018, 18,1 million people worldwide were newly diagnosed with cancer. It is predicted that in 2040, there will be 27.5 million people suffering from cancer. A large proportion of them will live in less developed countries, including in Africa. It is wonderful and absolutely necessary that a lot of money has been made available worldwide within a short period of time for conducting research into and combating COVID-19. For instance, in 2020, the German government alone is making 750 million euros available for developing a SARS-CoV-2 vaccines. But it is not understandable that at least the same amount of resources is not invested in cancer prevention, screening, and treatment in Africa. ┘

# From Somalia to Germany:

## The Role of Women in Global Health

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**In the course of the COVID-19 pandemic, women such as Angela Merkel (Germany), Sanna Marin (Finland), Jacinda Ardern (New Zealand), Erna Solberg (Norway), Mette Frederiksen (Denmark), Tsai Ing-wen (Taiwan), and Katrín Jakobsdóttir (Iceland) have shown excellent leadership skills in the area of public health. Unfortunately, women in positions of leadership remain an exception; all over the world, women are not sufficiently involved in relevant decision-making processes affecting their lives.**

┌ 75 % of health care workers worldwide are women, but only 25 % of management positions are held by women.

### Discrepancy between carers and decision-makers

The health and social care sector around the world largely depends on the work of women, both in the formal and the informal sector; however, women are not sufficiently involved in decision-making processes. 75% of health care workers worldwide are women, but only 25% of management positions are held by women.<sup>1</sup> Thus, only a third of health ministers are women. Only 28% of the deans of the most distinguished departments of public health and medicine in the world are women. In Africa, about 85% of health care workers are women, but only 5% of management positions are held by women.<sup>1</sup> There are 54 countries in Africa, with different socio-political and economic systems and different interests. Some countries have made great progress regarding gender parity. For example, the Rwandan parliament consists of 60% women – the highest proportion of women in a parliament worldwide. Women often make an important contribution to health care; however, their work is often unpaid, underpaid, and insufficiently appreciated.

### Focus on Somalia

Somalia has one of the fastest-growing populations in Africa, with an average age of 17, and approximately seven births per woman. For nearly 30 years now, the country has been suffering from a civil war and recurring famines. An estimated 99% of women have suffered female genital mutilation.<sup>2</sup> According to the Global Health Security Index, the country occupies rank 194 out of 195.

As a result of patriarchal and clan-based political structures, and despite a representation of 24% in the central government's Somali parliament, women are significantly underrepresented in political processes and public office.<sup>2</sup> In 2016, the Somali government adopted a national equality policy and included "gender mainstreaming" in the National Development Plan for 2017–2020 as a cross-cutting issue. In 2016, the Somali government adopted a national equality policy and included "gender mainstreaming" in the National Development Plan for 2017–2020 as a cross-cutting issue.<sup>2</sup> To contain the spread of the COVID-19 pandemic in Somalia and thus to prevent an unprecedented overburdening of the health and social care system already operating at maximum capacity, the government set up a cross-sector COVID-19 working group. Only five of the 26 members of this group are women. Among other things, the working group also is tasked with addressing women-specific consequences of the crisis and to work out possible solutions. It is already apparent that the closure of schools increases the risk for young girls to be married off. A further catalyst for this is the fact that child marriages are seen as a way out of increasing economic hardship. Besides the closure of schools, Somalia also imposed night-time curfews, mandated social distancing, and limited religious gatherings.

These measures increase the risk of domestic violence against women. As women have more contact with health care services, especially in the area of women's and children's health, and here particularly in pre-natal care and obstetrics, they are disproportionately affected by the decline in primary health care. Moreover, there is a higher risk of infection for women per se than for men, as women are more likely to work at the frontline of municipal health care (about 70%) and, in addition, provide home-based care for sick family members. ►

In 2020, the proportion of women in the German parliament was just 31%, only 7% more than in Somalia.

## Germany in comparison

Women in Somalia face serious country-specific problems, but not only that. When looking at Germany and comparing some of the above problems, some surprising parallels appear. In 2020, the proportion of women in the German parliament was just 31%, only 7% more than in Somalia. As a result of a comparably high proportion of women among health care workers, women in Germany are also at greater risk of infection during the COVID-19 pandemic. In Germany, the proportion of women in health and social care occupations is 70%, and data from the Robert Koch Institute show that about 75% of infected medical staff are indeed female.<sup>3</sup>

Lockdown presents great challenges for women, in particular single mothers. Thus it continues to be predominantly up to women to organize child care alongside their job and domestic chores – and there is an increased risk of domestic violence during continued lockdowns. Women make up a high proportion of the majority of occupations particularly affected by the lockdown. In already underpaid jobs, women must now fear losing their employment and thus their income. In addition, there are restrictions in routine care in the area of women's and children's health, especially in prenatal care and obstetrics. Yet, in media reporting on COVID-19, the voices of women have not been heard much so far. The ratio of men to women on the federal government's panel of experts on the relaxation of measures is 6:1, while among external advisors to the federal government, it is 20:1 (unpublished data, WGH-Germany).

## Demands for the time during and after COVID-19

Strengthening health care systems and supporting health care workers should be at the center of all efforts. Women working in health care must be remunerated fairly and have secure working conditions. They and their families must have access, where needed, to adequate personal protective equipment, hygiene products, and COVID-19 tests. Compensation in case of illness should be an objective. Sustainable structures and resources must be built up or made available for times of crisis which can be mobilized rapidly when needed. Health information should be addressed directly to women as those primarily responsible for family health, particularly in Africa.

In this way, prevention measures can be implemented better and more efficiently. In addition, it will be necessary to collect health data in a consistently gender-and-diversity-sensitive manner. Women all over the world are particularly affected by the COVID-19 pandemic, to a surprisingly comparable extent. It is important, therefore, that they take on managerial roles so as to pass on their experiences, interests, and perspectives themselves. They must be equally represented on advisory and decision-making panels and involved in all decision-making processes.

## Sustainability through international networks

At both national and global levels, networks are essential to furthering and supporting the establishment of sustainable structures for gender equality, articulating demands for gender parity, and raising public awareness. Studies have clearly shown that health care systems are more resilient when female health care workers are involved in decision-making processes, in the development of national health plans, and in health policy. Women in Global Health (WGH) is a worldwide active network with the aim of achieving more equal opportunities in global health and thus contributing to the improvement of health worldwide. In the meantime, there are networks, so-called "chapters", in many countries that regularly exchange information and network women on a national and global level. WGH-Somalia was founded in 2019 and now has 64 members ([www.womeningh.org/wgh-somalia](http://www.womeningh.org/wgh-somalia)). WGH-Germany was established as the first chapter in 2017 and can call on 170 women, including women at the Technical University of Munich.<sup>4</sup> WGH's objectives are increasing the visibility of women in the health care sector, achieving gender parity in senior positions in the health care sector, and enabling women to take their position in decision-making processes. At the outset of the COVID-19 pandemic, WGH additionally started an "Operation 50/50" campaign articulating five demands ([www.womeningh.org/covid5050](http://www.womeningh.org/covid5050)). WGH-Germany has taken up these demands and published a statement on the subject ([www.womeningh.org/wgh-germany](http://www.womeningh.org/wgh-germany)).

Overall, this crisis has again shown that gender equality is a basic prerequisite for promoting and protecting health worldwide and makes a significant contribution to achieving the Sustainable Development Goals.<sup>5</sup> The World Health Organization reinforces this by calling on its member states to consider gender aspects in the context of the COVID-19 pandemic.<sup>6</sup> On 15 May 2020, the New York Times published an article entitled "Why are women-led nations doing better with Covid-19?"<sup>7</sup> The author makes the point that the success of these women may offer insights into how countries can manage health crises and discusses how a female leadership style tends to be more inclusive, caring and thoughtful. These insights are valuable not only for the current pandemic, but also and especially for the future, so that strong prevention structures can be established for successfully preventing future health crises.



**Amina Jama Mahmud, BSc, MPH, PhD**  
Women in Global Health – Somalia, Sidra Institute, Garowe, Somalia; and Department of Women's and Children's Health, International Maternal and Child Health, Uppsala University, Sweden



**Professor Dr. Clarissa Prazeres da Costa**  
Center for Global Health, Institute for Medical Microbiology, Immunology and Hygiene, TUM



**Professor Dr. Sabine Ludwig, MA MSc**  
Women in Global Health – Germany, Center for Global Health, Charité – Berlin University Hospitals, and Department of Applied Health Sciences, hsg Bochum University of Applied Sciences

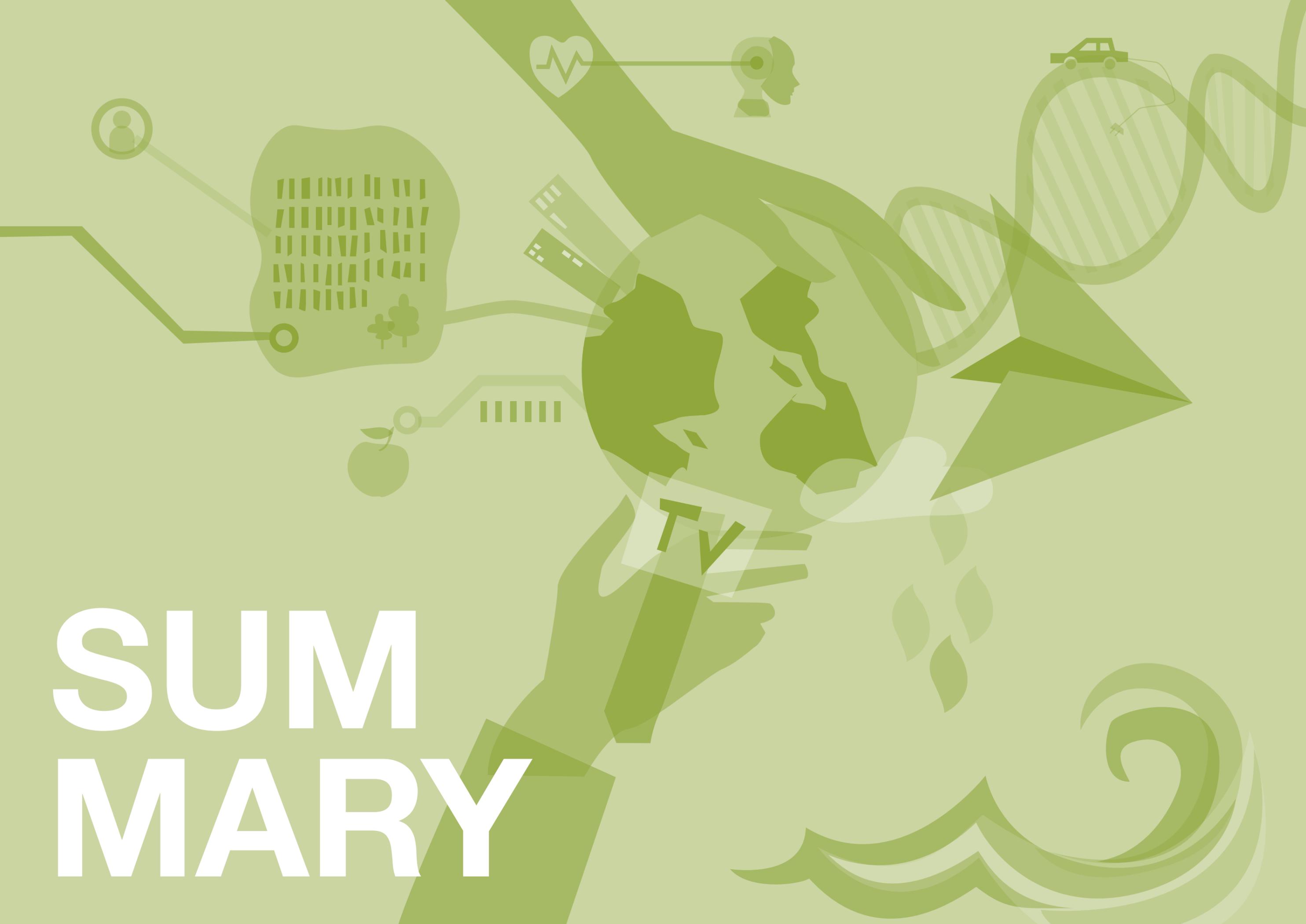


**Professor Dr. Dr. Andrea Sylvia Winkler**  
Center for Global Health, Department of Neurology, TUM; Centre for Global Health, Institute of Health and Society, University of Oslo, Norway

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# SUMMARY



## Summary

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# CHANGE

After the coronavirus, will the previous dynamics that have determined our lives so far unfold again unchanged? Or will the topic of sustainability finally gain the necessary foothold? This question was the impetus for the collection of the present thought-provoking impulses. Climate change and the decline in biodiversity are extremely critical situations and make a significant change in human behavior unavoidable. The coronavirus crisis represents a turning point and offers a number of opportunities in this respect. These opportunities must be seized!

Currently, science – especially virology and epidemiology – is booming. Many people working in science think that they should take even more responsibility for human dignity, society and the natural foundations of life. They demand that we focus on the essentials. The path to a philanthropic future is to be found through reason, research creativity and optimism. It is also necessary to learn again that cultural wealth implies renunciation of the superfluous, as well as solidarity with the disadvantaged. With a global population of almost 8 billion people, the rationality of sustainability is urgently needed.



## Sustainability

The UN Agenda 2030 pursues a number of goals that serve sustainability. It is about a life-affirming future that provides education, health and prosperity for all, involves preservation of a clean environment including intelligent use of energy, care of biodiversity, and responsibility in production and consumption, and ensures justice and peace. It is in this spirit that the present collection of forward thinking is written. The authors are aware that sustainability cannot be defined in general terms and at the same time precisely for all circumstances. Against the background of the entirety of the articles, the following can nevertheless be stated in summary: Sustainability means that the endangered stability of the earth system of animate and inanimate matter is preserved and thus the basis of life for future generations.

The brochure was prepared by the TUM Senior Excellence Faculty and the TUM Institute for Advanced Study (IAS) with the participation of the IAS-based “Institute for Earth System Preservation” and external experts. It is well-founded and committed to the TUM-wide interdisciplinary approach: Natural, technical, economic, life sciences and medicine are combined with education, philosophy, sociology and politics. The authors draw on extensive experience and international recognition in their respective fields. Many of them are members of important academies and scientific societies.

The following summary cannot consider each of the highly interesting articles separately. However, we try to describe the essence of each chapter. In doing so, we look at change and opportunities, but also at balance and preservation of well-established concepts. This is done in an imaginary dialog with society and politics.

Considerations about the underlying way of thinking of a sustainable civilization link the contributions to the introductory chapter. The metaphor of war, which is frequently used in the COVID crisis, is certainly not adequate for a life-friendly approach to nature. But can we be sure that a “peaceful let it roll” of natural processes would always be humane? The coronavirus pandemic teaches us the opposite. So it depends on human intelligence, which has to take another step in its evolutionary development. It is imperative to better understand the regulatory processes of the natural earth system – as well as the capitalist processes of the economic system – and to courageously implement the knowledge gained for the purpose of sustainability. Natural processes urgently need more space and less interference (apart from special processes such as the COVID pandemic), while capitalist value creation must be domesticated in a sustainable and humane way, without suffocating it. The insights are developed by science, which requires sufficient freedom to do so. The goal, i.e. being humane and respecting biodiversity, is defined by culture. This is associated with challenges that we must not evade and from which we must not hide under the wings of Mother Nature or under the dominance of misunderstood processes of artificial intelligence.



## Politics & Society

International organizations like the UN are under attack from many directions and are in a continuous crisis. Multilateralism, which has become fragile, is one of the big questions for international politics, also from the point of view of achieving the UN’s sustainability goals. International organizations are, however, the key actors in a world order that preserves peace. Re-establishment and strengthening of multilateral forms of cooperation is one of the great political challenges of our time.

Part of the hope in this respect rests on the democracies. Their rights of freedom and participation form the soundboard for new initiatives oriented towards the common good (e.g. “Fridays for Future”). Domestically, democracies have a sufficient degree of trust from society and social capital. They have the potential to use the crisis as a starting point for a sustainable transformation.

For modern societies, the self-image of a “TechnoSociety” has become important. The diversity of new technologies provides the opportunity for sustainable change. This opportunity should be taken. The video conferences that are currently becoming widely established are one of many examples. In addition, the TechnoSociety holds new design options for all social actors (science, politics, media, teachers, carers, employees and employers, parents, young people, children etc.) and also possibilities to counter conspiracy theories, for example.

In a highly complex world, the question of dialog with politics and society is of great importance for science and the media. Transparency, clarity and, if possible, simplicity are indispensable for credible transfer of knowledge and information. Transparency also includes making it clear time and again that science is a never-ending learning process. “Good scientists know about the aspects of contingency, and even unavailability in all finding processes” (F. W. Graf). Thus, even the statements of reputable and established researchers cannot be universally congruent.



## Fundamental Research

The public rightly asks time and again what importance should be attached to fundamental research in comparison with applied research. The chapter underlines that innovations start with the scientific processing of fundamental questions. The discovery of X-rays, for example, has greatly advanced modern developments in civilization. Today X-rays are used for clarification of molecular structures (DNA, proteins), surveying of the cosmos, material testing, examination of paintings etc. They are not only used in medicine. Currently we are learning that basic research in virology and immunology results in the development of vaccines and therapies.

At the starting point, research formulates their hypotheses in order to work on them experimentally. Models based on mathematics help to fine-tune and further develop questions and problems. Statistics and artificial intelligence accelerate the transfer from the scientific basis to application.



## Technology, IT & Networking

The question of how much technology, IT and networking we need is associated in our society with euphoria, but also with fears, mistrust and prejudice. However, the key roles of these aspects became clearer than ever before during the coronavirus crisis. A powerful, reliable Internet infrastructure, large computing capacities with all the useful software tools for communication, cooperation and intelligent processing of data are proving to be essential for survival. And this is just the beginning. With the “Internet of Things”, new usage potentials of digitalization are being developed and make sustainable business models possible, for example in “pay-per-use” concepts. However, total surveillance of the population (“social scoring”) must be avoided, and the increasing power of commercial “data leeches” in the Western hemisphere must be stopped by democratically legitimized regulation.

In the meantime, the potentials of “red” (medicine), “green” (plants) and “white” (industry) biotechnology have become a particular focus. And not least, increased impetus is needed for energy system transformation, whereby alternatives such as hydrogen technologies must also be considered. In all cases, in addition to the private sector, the state is in demand as a driver and investor.

The chapter shows – resting on the laurels is not an option! We constantly need technological innovations, in particular significant progress in digitalization and the use of artificial intelligence in business, administration and society, while guaranteeing legal certainty and data protection. Above all, there is also an urgent need for European efforts to increase the technological sovereignty of this sustainability-oriented continent and reduce global dependencies.



## Habitats, Rurality, Urbanity & Mobility

The turning point, we are currently experiencing raises fundamental questions on the topics of habitats and mobility: How is the social status and character of cities changing? Although their viability massively suffers from traffic restrictions, the observed changes in behavior in terms of mobility (cue: cycling) and shopping (cue: digitalization) could lead to a new, high-quality urban awareness in the sense of a city worth experiencing and with short distances. But what will become of public transport in view of the crisis-related trend towards the use of private vehicles? It is pretty obvious that the opportunities for a redirection of our transport systems towards e-mobility and autonomous driving must now be used to achieve the climate targets. On the other hand, do we see the long hoped-for revival of rural areas on the horizon and can we thus come closer to the goal of achieving equal living conditions in the sense of “spatial justice” (and not only in Bavaria)? So, does “the countryside now have a future again”? Yes, if the change equally involves the economic, social and ecological management of agricultural production areas in order to ensure sustainable, environmentally conscious land use.

An important and often underestimated role is played by urban and landscape architecture as well as architecture in general as an art and ability to build humane and functional housing. Construction and housing will have to change, as well as the entire field of work, even if working from home will not become the standard solution in many industries. The living environment will become multi-functional up to “vertical farming”, i.e. economically and ecologically sensible food production in urban areas. Sustainability in architecture can be achieved through innovative, waste-reducing use of materials and intelligent simplicity of construction concepts. But this requires a change in thinking.

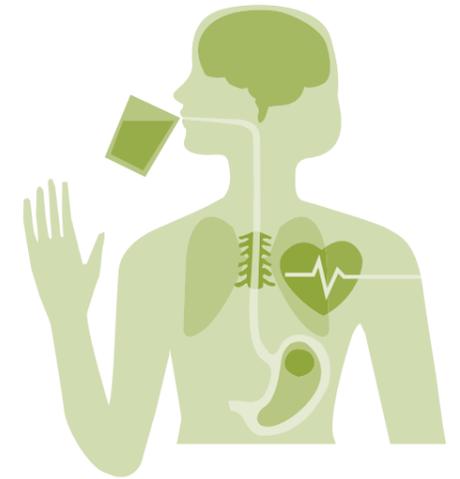


## Economy

The question can be asked whether the economy is the actual “glue” that holds the social world together at its core. One thing is clear: COVID-19 will accelerate the change in the economy: value-added processes, market supply and, above all, the organization of the world of work. Those who were better positioned in terms of digital solutions during the coronavirus crisis clearly had competitive advantages. These experiences should also be understood as an accelerator and potential for sustainable innovations – for the working world of tomorrow, for networked economic cycles, locally and globally, and thus also for new concepts of the international division of labor.

As an Entrepreneurial University, the TUM has focused on the role of start-ups for innovation during the past years of growth. The results show that young companies make important contributions to society as solution providers and innovation drivers. This is particularly evident in the areas of digitalization and the flexibilization of value creation in companies and markets. Established companies that want to invest in the future should therefore turn their attention to start-ups, their objectives and innovative solutions. Medium-sized companies must not be neglected either. Together with the very large companies, they significantly contribute to value creation in Germany and also deserve support in digitalization and the associated change in products and business models.

The European and national support programs for stimulation of the economy after the global lockdown also offer high innovation potential in the sense of “sustainable innovation”. These support programs concern the areas of the so-called green economy and green technology as defined by UN Agenda 2030. They should also create incentives for the innovative concepts of recycling management and for environmentally conscious and resource-saving consumer behavior.



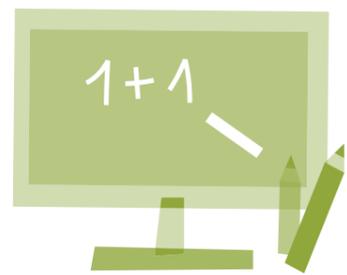
## Health & Medicine

When it comes to the topic of health, society and politics must ask themselves where the future priorities are to be set in terms of structures and in research funding. Prevention, including nutrition, early diagnosis and data-based medicine, are of the utmost importance.

Even more than the control of infections, the preventive and therapeutic care of the many potentially or obviously chronically ill in a world population that is getting older and older is a challenge. It is in the interest of these affected people, but also of societies, to ensure the longest and best possible quality of life for everyone. The best personalized prevention and treatment based on the collection and analysis of data and state-of-the-art digital infrastructure offer great opportunities. There is an urgent need for further expansion of epidemiological research with defined questions, especially in view of the increasing number of cancer patients.

Epidemiological findings ultimately serve to improve the targeting accuracy of control mechanisms and the efficiency of structures and thus the sustainability of maintaining the physical and mental health of global societies. Generally speaking: In health-related research and in the design of workflows in medicine, digital instruments, including artificial intelligence, represent the key to a better future.

The contribution to global health presents a concept that thinks about health in many directions and comprehensively, including migration and climate change. The holistic one health approach assumes that diseases and health are to be understood primarily in terms of the human-animal-environment interface.



## Education & the Working World

What is the purpose of school and university education? This question is related to the above-mentioned contrast between fundamental and applied research, insofar as education can be purpose-free or competence-oriented. If we skip this basic debate and focus on preparing young people for the working world of the future, the next question that arises is what schools, universities and later companies will have to do to make their working environment humane and performance-enhancing? The chapter “Education and the Working World” looks at this question from different angles. Pupils and students stress the advantages of learning using IT, but also clearly describe why it is important to have classroom teaching and direct communication with each other and with teachers.

In the future, companies will have to establish structured and organized life long learning. The aim is to design digital work with a humane attitude and to establish secure mastery of demanding work processes and creative processing of new requirements in the long term. The TUM will provide increased support for the economy in this respect and offer corresponding teaching programs for their own employees.

With a view to reconciling family life and professional development, especially for women, sustainability also means not falling behind the level already achieved – even in crisis situations. Crises offer opportunities, but also the risk of gambling away what has been achieved. Science and universities must set an example here.

## Africa

The question of relations between Europe and Africa is still complicated by colonialism and a lack of knowledge about history, traditions and cultures. Nevertheless: Fair cooperation is of great interest to both sides, not only in the political and economic context. With a view to sustainability, cooperation in the training of young Africans also plays an essential role. The far-reaching commitment of the TUM to Africa should be seen in this sense. In November 2018 a symposium of the “Emeriti of Excellence” in cooperation with the TUM School of Governance was dedicated to this topic under the title “Sustainable Development in Africa – TUM as a Partner in Education, Research & Realization”. The Africa chapter outlines among other things the partnership of the “Kwame Nkrumah University of Science and Technology” in Ghana with the TUM. Specific further discussions also concern the epidemiology and health of women in Africa and the corresponding cooperation.

The principle of the rule of law has only been able to assert itself in Europe after a long struggle and is a highly vulnerable asset, as German history of the 20<sup>th</sup> century also shows. What opportunities are available for African countries in the rule of law and, more generally, in good governance (separation of powers, democracy, anti-corruption, transparency in economic life, protection and care for children, especially girls, etc.) is impressively described in the Africa chapter.

## Conclusion

At the end of the summary we take a brief look at the chapter “Education and the Working World”, in the article by Gerhard Müller, Vice President of TUM for Studies and Teaching. He writes about the responsibility of universities to trigger paradigm shifts. In doing so, he points to the separation of the individual disciplines, which has been established since the Enlightenment and is still extremely successful not only for science itself, but also for progress in civilization in general. At the same time, however, he raises the question of the extent to which we have neglected the holistic view in the face of undeniable misguided developments in the thinking and organization of university education profiles. Certainly the term “holistic” is not unproblematic. But we know what is important in the future, what “change” means: more responsibility towards societies, responsibility towards future generations, responsibility towards the biosphere, the ecological balance and the earth system as a whole – on a national and global level.

The sciences, especially the technical sciences, have always been committed to people and their well-being. In this respect, the “Human-Centered Engineering”, which the TUM has taken up in its Agenda 2030, follows in the footsteps of a good and very successful tradition. And the term is future-oriented! It shows under which perspective teaching and research at the TUM will stand in the future: The basic subjects in natural science promote approaches to the development of a wide variety of innovations. In “inventing” new concepts and products and in assuming responsibility for a humane future, the teaching and researching engineers also integrate the necessary impulses from design, economics and social sciences. The “density” of interdisciplinarity, which is given to a high degree at TUM in terms of quality and quantity, is increasingly leaving its mark on TUM research in engineering, but also in other areas.

We hope that the present thought-provoking impulses show that the forward-looking interdisciplinarity of the TUM is driven by an “algorithm” that links the disciplines in order to arrive at scientifically founded instructions for action and to pave the way for the idea of sustainability. Like all things, sustainability has two sides. This dualism includes apparent opposites, such as the supposedly useless as well as the useful, theory as well as practice, fundamental research as well as applied science. The “TUM Forum Sustainability”, founded by the TUM Emeriti of Excellence, feels committed to both sides of the coin because they are equally important. In cooperation with the Institute for Earth System Preservation (IESP) at the TUM Institute for Advanced Study (IAS), the Forum looks back on several successful years of activities, including the organization of symposia and other events, and the publication of brochures and books. This tradition, which has been started a while ago, is being given a further boost with this collection of forward thinking, which – according to our leitmotif – aims at the “chance of change” while consistently taking the idea of sustainability into account. Further corresponding events and publications will follow in the coming years. In 2021, for example, an interdisciplinary workshop on the topic of Circular Economy will take place.

The forewords by Thomas Hofmann, Wolfgang Schäuble and Markus Söder to our thought-provoking ideas point with optimism to the urgency of sustainability in future developments. M. Söder stresses the need for university research, W. Schäuble focuses on Europe. On 1 July 2020, Germany takes over the Presidency of the EU Council. In the grand coalition government declaration, Angela Merkel emphasizes that solidarity and cohesion in Europe have never been more important than they are now. The pandemic has revealed how fragile the European project still is and must be used to strengthen and accelerate CHANGE. In her speech emphasizing sustainability, the Chancellor states that the most important tasks for the future are: European cohesion and solidarity, greater assumption of responsibility by Europeans in world politics, German policy focus on Africa, climate neutrality of the EU by 2050 and digitalization. ┘



**Professor Dr. Dr. h.c. Michael Molls**  
Spokesperson of the TUM Senior Excellence Faculty; Director of the TUM Institute for Advanced Study (IAS); Professor and Former Director of the Clinic for Radiotherapy and Radiological Oncology, TUM



**Professor Dr.-Ing. Jörg Eberspächer**  
Co-spokesperson of the TUM Senior Excellence Faculty; Co-founder and member of the Center for Digital Technology and Management (CDTM), Munich; Fraunhofer Medal (2015); Professor for Communication Networks, TUM



**Professor Dr. Konrad Oexle**  
AG Neurogenetic Systems Analysis, Institute of Neurogenetics, Helmholtz Zentrum München; Institute of Human Genetics, Klinikum rechts der Isar, TUM



**Professor Dr. Claudia Peus**  
Founding Director of the TUM Institute for Life Long Learning; Vice Dean of Executive Education, TUM School of Management; Executive Vice President for Talent Management & Diversity, TUM; Professor of Research and Science Management, TUM



**Professor Dr. Dr. h.c. Ralf Reichwald**  
TUM Senior Excellence Faculty; Honorary Senator of the TU Freiberg; Professor of Business Administration – Leipzig Graduate School of Management (HHL); Professor of Business Administration – Information, Organization and Management, TUM



**Professor Dr.-Ing. Drs. h.c. Peter Wilderer**  
TUM Senior Excellence Faculty; Founder of the Institute for Earth System Preservation (IESP); Stockholm Water Prize (2003); Professor for Water Quality and Waste Management, TUM



**Professor Dr. Juliane Winkelmann**  
Full Professor of Neurology and Neuroscience, Stanford University (2013–2015); Executive Vice President for International Alliances and Alumni of TUM; Professor of Neurogenetics, TUM

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