AD HOC IMPULSE

The Coronavirus Crisis:

Keeping the economy running, meeting basic necessities, maintaining innovation

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Intervention – Stabilisation – Stimulation

This acatech Impulse presents the Academy's initial reflections on the coronavirus crisis. We will explore the issues in greater depth over the coming months.

The coronavirus crisis is putting our healthcare system under **unprecedented pressure**. Hospital capacity in particular will be pushed to its limits if the number of infections is allowed to grow unchecked. Our hospitals will not be able to cope with an explosion in the number of severely ill patients requiring intensive medical care. Moreover, we do not yet have a testing infrastructure that can reliably identify the majority of people infected with the virus from an early stage.

As a result, the government's current strategy is primarily centred on social distancing in order to slow down the number of new infections and check the spread of the virus.

In order to **protect the public**, these measures must **have the utmost priority**. However, they also have economic implications. Economic activity has been brought to a standstill on an unprecedented scale. And this has happened simultaneously, not just in Germany, but in virtually every economy around the world. A global economic crisis is inevitable, although it is still too early to make meaningful predictions about its duration and scale. At the moment, however, precise economic forecasts are not a priority – what we need to do is recognise the **overriding importance of preventing the economy from coming to an abrupt and long-lasting standstill**. This is particularly essential so that the healthcare system can perform as effectively as possible – after all, it too is part of the economy and thus vulnerable to economic impacts. It is also necessary to ensure that people's basic necessities are met in all the other areas of their lives.

The government has recognised this in principle and is supporting its strategy for containing the epidemic with a range of supplementary economic policy measures. These include regulations on short-time work, liquidity assistance and tax deferrals designed to compensate for loss of income in households and prevent companies with sound business models from going bankrupt purely due to liquidity issues. These **support measures** are absolutely critical and must be **delivered** rapidly and in a targeted manner. The Federal Government must also provide strong **organisational support for the economy during the crisis** and establish its own expert task force to **monitor** developments.

This publication provides suggestions for how to address the challenge of **implementing the necessary measures in practice**.

It is divided into three parts:

1. We begin by focusing on the immediate **crisis interventions** needed to support the healthcare system, get through the short-term economic shock and mobilise entrepreneurial potential.
2. We address the implications of a potentially longer-term economic shutdown by examining some of the **industries that provide the basic necessities** required to maintain social **stability**.
3. We argue that we should already start preparing economic **stimuli** for the "post-coronavirus era" in order to get the economy out of crisis mode and back on a (sustainable) growth path as soon as possible. At this time, it is more important than ever to **forge ahead with strategic innovation policy projects**.

New technologies and innovations play an important role in all three areas.

Priority area 1: INTERVENTION

Tackling the public health crisis and mitigating the economic crisis

The interventions to tackle the coronavirus crisis must address two separate crises at the same time: firstly the public health crisis, and secondly the economic crisis that will occur as a direct or indirect consequence of the policy interventions needed to combat the public health crisis.

The current predicament: a double-edged challenge

The only way to prevent the healthcare system from being completely overwhelmed is to **rapidly contain** the COVID-19 outbreak within a matter of weeks. We need a strategy that prevents the system from being overwhelmed while at the same time **minimising the resulting impacts** on society and the economy.

The least disruptive approach would be to pursue an *individualised* strategy based on rapid and reliable identification of the majority of people infected with the virus so that only they and the people who have come into contact with them need to be systematically isolated for as long as they could be infected. This strategy would rely on the ability to continuously carry out very large numbers of tests and rapidly analyse the results. However, in the absence of the necessary testing capacity and administrative procedures, at this point in time it is not (yet) possible to switch to this strategy.

Consequently, the only alternative that currently remains is to *almost completely* ***avoid*** all physical forms of social contact. Since doing so effectively deprives many businesses and households of their livelihood, it is essential to support this strategy with the relevant economic **stopgap measures**. However, an **exit strategy** is also needed, since this approach is unsustainable in the long term. In particular, it is necessary to create conditions that will allow companies to rapidly resume their business and invest in the future.

However, if the exit strategy itself is to be sustainable, it must not result in a fresh surge in new infections that requires the reintroduction of widespread restrictions on economic and social life in order to avert the need to ration healthcare capacity. Consequently, in the medium term there is no alternative to an **individualised strategy** based on mass testing and systematic isolation. Shielding of high-risk groups will need to remain in effect until a vaccine or effective treatment is available. It will be vital to develop vaccines and drugs as quickly as possible.

Making sure the healthcare system can cope with the crisis

The number-one priority is to make sure that the healthcare system has the support it needs to cope with the current crisis and avert a humanitarian disaster. The measures required to manage the coronavirus crisis include the following:

- **Ensure needs-based care**: Provide sufficient numbers of intensive care beds and ventilators. At the same time, make capacity available outside of intensive care units to keep patients who are in a serious but non-critical condition under observation, and ensure adequate staffing for this purpose. Make sure that coronavirus patients are only hospitalised for as long as is medically necessary.
- **Mobilise reserves of ventilators and other materials (e.g. personal protective equipment)**, for example from hospitals that are able to scale back the number of surgical procedures they perform. Incentivise or even compel manufacturers to speed up and increase production. The

allocation of ventilators to Germany's regions should be coordinated centrally, and resources such as video tutorials should be used to train assistants.

- **Temporarily lift bureaucratic requirements** (e.g. verification procedures of the health insurance funds, requirements relating to the recording of mechanical ventilation times, certain types of billing documentation). Temporarily suspend the requirement to obtain official authorisation before setting up makeshift patient care facilities in locations such as shipping containers.
- **Provide liquidity assistance for hospitals** that will suffer a significant drop in revenue from postponing elective surgery in order to provide emergency care during the crisis. In order to ensure that hospitals' financial stability is not jeopardised, adequate compensation should be provided for any interventions in the system required by the crisis.
- **Mobilise medical personnel reserves**: Encourage part-time staff to go full-time. Use medical professionals from other fields and medical students to assist in intensive care units. Facilitate volunteering by offering (virtual) crash courses for carers and people with no previous medical training.
- **Create transparency regarding local resources** so that staff and material shortages can be quickly identified. Use a central platform and mobile app for hospitals and other service providers to exchange information – the platform of the Robert Koch Institute and the German Hospital Federation could be used as a basis. Create transparency regarding regional differences in treatment capacity utilisation so that patients can be transferred to other hospitals if necessary.
- **Prevent collateral damage to other patients due to the prioritisation of coronavirus patients**

Priority area 2 takes a more detailed look at the staff and material **shortages** connected with the coronavirus crisis, particularly in intensive care units.

The availability of **immunological tests** will be critically important. Several such tests are currently being trialled and could become available in a few weeks' time, making it possible to identify those members of the population who are immune to the virus. It is likely that many people have been infected without experiencing any symptoms. Since it can be expected that these people will be immune for the foreseeable future, they could potentially step in to perform certain jobs as a stopgap measure. (However, it is important to ensure that this does not lead to discrimination against non-immune workers in the labour market.) The tests will also make it possible to prioritise treatment of high-risk population groups and carry out an epidemiological assessment of the risks of relaxing social distancing rules. Every effort should be made to make these tests available as soon as possible.

In its ad-hoc statement of 21.03.2020, Leopoldina recommends a number of additional health policy measures concerning the protection of particularly vulnerable and systemically relevant population groups, diagnostics, the development of drugs and vaccines, and information and education.

Effective implementation of economic policy measures

There is no doubt that Germany **is better placed than many other economies** to cope with the economic fallout of the coronavirus crisis. This is thanks to factors such as its comprehensive insurance coverage, the availability of short-time work and sick pay schemes for employees, and the social partnership that exists at company level. In addition, growing numbers of companies now allow their employees to work from home. Nevertheless, **the government will still need to intervene by implementing major support measures** to keep the economy running.

The government has recognised this in principle. Its **extensive package of economic policy measures** puts liquidity before profitability. An emergency budget worth €122.5 billion has been passed to support these measures, which include assistance for **freelancers and micro-enterprises**. The Federal Government funding will be supplemented by funding from the budgets of the Länder.

A €400 billion **Economic Stabilisation Fund** is also being established to deliver extensive **liquidity assistance** via direct grants and credit guarantees provided by the federal and regional governments. The aim of the fund is to prevent otherwise sound businesses from going bankrupt through no fault of their own due to liquidity issues. If necessary, the Federal Government can use some of this money to acquire equity stakes in larger companies. However, it is currently still not clear whether businesses that have been ordered to close by the authorities will be entitled to compensation. The government needs to clarify this point as soon as possible.

Administrative initiatives include the decision to suspend compulsory insolvency applications for the next six months and measures making it easier to defer tax payments. These measures are designed to buy businesses time so that they have a better chance of surviving the crisis. The Federal Employment Agency is also pouring significant amounts of money into the expansion of the **short-time work allowance** in a bid to help businesses avoid having to lay people off.

Background information: KfW coronavirus aid

From 23.03.2020, companies, self-employed persons and freelancers experiencing financial difficulties as a result of the coronavirus crisis will be able to apply to their regular bank for investment and working capital loans, provided that they were not already experiencing financial difficulty as of 31.12.2019. The KfW will assume part of the risk on behalf of the regular bank (up to 90% in the case of SMEs), thereby significantly improving the chances of such loans being granted. The maximum value of the loan depends on the size, financing requirements and indebtedness of the company applying for it. The KfW can also participate directly in syndicated investment and working capital loans of €25 million and over.

The development banks of the Länder and the European Investment Bank are offering similar forms of assistance.

This decisive action and the scale of the programmes is to be welcomed. **The State must do whatever it can to prevent a runaway economic collapse.** Fiscal policy – which within the EU is still the responsibility of national governments – will have a key role to play. Thanks to the fact that it has reduced its debt-to-GDP ratio in recent years, Germany has plenty of scope for taking decisive fiscal policy measures to manage the crisis. However, fiscal strategies for tackling the crisis will also need to be coordinated at European level to ensure that countries like Italy, which were already highly indebted before the crisis, do not lack the resources they need to finance their crisis response. This is not something that can simply be left up to the common European monetary policy of the European Central Bank (ECB).

However, the magnitude of the measures that have been announced (described by the German Finance Minister as a “bazooka” that will be used to do whatever it takes) does not in itself guarantee that the aid package will be effective. **It is also vital for the money to reach the right people as quickly as possible.** The Federal Ministry for Economic Affairs and Energy should establish an **expert task force** for at least the next 12 to 18 months, in order to carry out detailed **monitoring** of the **implementation** of the economic policy measures (with regard to structures, access and procedures) and make timely recommendations concerning any necessary adjustments to the interventions. This monitoring should also include coverage of basic necessities (see priority area 2).

While it is of course important to protect the integrity of established structures, it is equally essential to provide targeted support for start-ups, which are especially vulnerable to liquidity shortages and are therefore unlikely to survive a prolonged crisis. Because they are often not “creditworthy” in the

traditional sense and do not usually have a regular lending bank, few of them will be able to access the KfW loans. The Bundesverband Deutsche Startups (German Start-Ups Association) has proposed a four-stage plan to **protect start-ups**. The plan targets companies' different requirements depending on their development stage (early-stage vs. growth-stage) and type of financing (with/without venture capital).

The government must not underestimate the importance of this issue. Start-ups are **of systemic importance to innovation in Germany**, both in the healthcare sector and in other high-tech industries. Last year, Germany passed new healthcare legislation allowing the use of digital solutions to provide support in regular healthcare settings (for example electronic health records and health apps on prescription). These technologies rely mainly on German digital health start-ups which also provide services that are now in demand due to the coronavirus crisis, such as video consultations, medical decision support systems and digital therapeutics.

A wave of bankruptcies and a sell-off of high-tech start-ups to foreign buyers would cause serious damage to the healthcare system and the German economy as a whole. It would be almost impossible to make up for the resulting loss of talent, know-how, innovations and transformative power. The loss of more mature high-tech start-ups that are on the verge of really taking off would be particularly devastating. Accordingly, it is vital for the Federal Government to incorporate its planned measures to **strengthen growth finance** in Germany into its start-up rescue package.

Creating incentives for shareholders to keep investing in their companies

In order to overcome the crisis in the long term, it will be necessary to mobilise the entrepreneurial potential of the German economy as effectively as possible. As well as protecting start-ups, the State should therefore also **provide targeted incentives** to encourage **existing investors** of companies affected by the crisis to keep investing.

In this context, the Gesellschaft für Restrukturierung recommends that **shareholder loans** granted during the coronavirus crisis should not be legally subordinate in the event of subsequent insolvency proceedings, provided that they are granted in order to combat the impacts of the epidemic. This exemption would provide an incentive for shareholders to inject capital into their companies and would be particularly valuable to small and medium-sized enterprises.

The Bundesverband Deutsche Startups has proposed a **matching fund** through which new investments by existing start-up investors (business angels and venture capital companies) to help the start-up through the crisis would be matched in a fixed ratio by government co-investment. No due diligence would be required for these co-investments, since the existing investors already know the company and are thus well placed to assess its future prospects. The fact that they are prepared to invest their own money would send a signal to co-investors about the attractiveness of the investment. The matching fund could be administered by existing institutions such as Coparion, KfW Capital or the High-Tech Gründerfonds.

Both of these proposals are to be welcomed, since they seek to support market-based decisions and enable the rapid **mobilisation of private capital in order to tackle the crisis**. Moreover, the fact that well-informed existing investors have skin in the game reduces the investment risk for the State.

On the other hand, if venture capitalists pull back in a VC freeze, further measures will be required to maintain capital inflow and provide restructuring expertise. These tasks would need to be performed by the receivers.

Using new technologies to tackle the crisis

New technologies can save lives, both in general and in particular during the coronavirus crisis:

- **Artificial intelligence** (AI) is being used to develop **vaccines** for the coronavirus (Sars-CoV-2), to develop **drugs** to treat COVID-19 and to predict the spread of the virus in the population.
- Chinese tech company Alibaba is testing an **image recognition system** for diagnosing COVID-19 using CT scans of patients' lungs. The software is intended to assist doctors in making a diagnosis and will initially be available to several hundred healthcare facilities. Munich-based start-up Smart Reporting is helping to tackle the coronavirus crisis by offering free templates that can be used by radiologists to structure, digitise and analyse lung CT scans.
- AI-based **self-learning systems** can support the **prioritisation of medical care**, particularly in facilities treating large numbers of patients. A use case developed by Charité Berlin and the Plattform Lernende Systeme shows how e-triage systems can help to direct patients more efficiently from the moment they arrive at the hospital right through to treatment and provide upstream support for the medical staff treating them. The assistance system's tasks include assessing data provided by the patients themselves while they are in the waiting room, supplemented by additional findings from preliminary examinations. This approach relies on high-quality real-world data from sources such as electronic health records and research and clinical platforms, accessed via a trustworthy digital infrastructure.
- Deutsche Telekom has been authorised by the Federal Commissioner for Data Protection to share recent anonymised mass data from its mobile communications network with the Robert Koch Institute, in order to **map people's movements** during the coronavirus crisis and quantify the effectiveness of government measures to restrict movements and prevent social contact. This can help to reduce the number of new infections in the population, prevent the health service from being overwhelmed and mitigate the overall economic impacts.

  Given the scale of the current crisis, there is good reason to argue that these measures are justified, provided that 1) they abide by the applicable legislation/data privacy regulations, 2) the data is only used for the stated purpose, 3) the data is only held for a limited period of time before being deleted, and 4) the possibility of de-anonymisation can be ruled out as far as possible.
- In South Korea, people who have come into contact with infected individuals use a **safety app** to report on how they are feeling to the authorities twice a day. If the authorities don't hear from them, they contact the individuals in question themselves. South Korea is also using **self-diagnosis apps** for people entering the country.
- In Shanghai, people are being asked to scan **QR codes** to authorise entry into buildings and when boarding metro trains. If necessary, the data collected in this way can be used to rapidly trace an infected person's contact history. Data about people's movements can provide an effective tool for containing the epidemic. In Germany, however, the introduction of similar measures to protect public health would be in conflict with data privacy regulations.

New technological solutions can also help with administrative tasks, freeing up resources for other tasks that have become more urgent and important as a result of the crisis.

- The local authority in the district of Soest recently went live with a self-learning **chatbot** to help answer the rapidly rising number of public enquiries as efficiently as possible and above all to ensure that the information provided is precise, accurate and up to date. The deployment of this technology, supplied by Munich-based start-up Convaise, has freed up staff to perform more urgent tasks.

- Hamburg City Council has invested in digital document management, e-billing, user-friendly websites and communication tools, electronic payments and a strong social media presence. As a result, Hamburg was named Germany's smartest city by the industry association Bitkom in 2019. **Digital administrative processes** also help to keep council services up and running while social distancing is in force.
- In collaboration with the French government, Paris and London based company New Vector is operating a secure **communication platform for the public sector** based on open-source software. Featuring an instant messenger app that provides an alternative to WhatsApp, the project is currently being rolled out throughout the public sector in France. In times of crisis, seamless and secure communication is particularly critical to the public administration, the health service and all the associated actors.
- Israeli start-up Carbyne provides digital **emergency communication platforms** that reduce emergency service response times and help to prevent hospitals being inundated with patients all at the same time. In the current situation, their video screening technology can be used to allow emergency medical personnel to see and remotely diagnose patients with coronavirus symptoms. The company also offers location solutions that can be used to monitor quarantined patients, for example.

Innovative projects and solutions can have a positive impact on society's resilience and innovativeness long after the end of the coronavirus crisis. Consequently, the State should **have the courage to keep investing, even during these times of crisis**.

And even once things return to normal, we will still need to harness the **benefits that the digital transformation can provide** both in the workplace and in our everyday lives. The ongoing development and networking of digital systems calls for continuous analysis, balanced discussion and new social compromises, for instance with regard to conflicts between healthcare and privacy protection during times of crisis. This will be key to building **fundamental confidence** in the controllability and benefits of new technologies, methods and applications. Openness to innovation is an important contributor to a country's prosperity and – in the event of a major crisis – even to public health.

Connecting decentralised decision-makers

Many decisions relating to the management of the crisis are taken at a decentralised level, by regional governments, municipalities or the private sector. Digital platforms can help to connect decision-makers so that they can share experiences and **learn from each other** during the crisis. Regardless of whether they are initiated by the State or the private sector, it is essential that these platforms should have low entry barriers and be user-friendly and easily scalable.

Digital platforms can also help private actors to collaborate with each other, share experiences, and disseminate **creative ideas** for dealing with some of the day-to-day challenges thrown up by the coronavirus crisis. The Federal Government hackathon #WirvsVirus (Us vs. the virus) is one good example. In the field of medicine, it will also be essential to use new digital technologies and methods to enable even closer, international collaboration between private companies, academic institutions and physicians, for instance in order to develop vaccines and drugs. The State should provide **targeted support for these forms of cooperation**.

Keeping a crisis logbook and learning lessons for the future

The lessons learned during the current crisis will be invaluable for dealing with other crises in years to come. Documenting and analysing any new developments as thoroughly as possible will allow us to learn targeted lessons for the future. Once the current crisis is over, the experience gained could give rise to process fragments that can be creatively recombined in the event of a new crisis, enabling **faster response times and more effective coping strategies**. The learning process should also aim to enable **better interpretation of early warning signals** in future crises.

The collection and processing of the relevant **data** will be absolutely key to a successful learning process. One potentially valuable approach would be to combine public sector data (e.g. from the health authorities) with data from private companies and research institutions. Many digital applications are already using real-time data to help tackle the current crisis. For example, the logistics company DHL is drawing on weather data, traffic and congestion reports, media reports and social media trends to stabilise supply and logistics chains. The DHL Resilience360 software platform aims to help businesses predict, assess and mitigate the risk of supply chain disruptions. A special service provides daily updates with early warning intelligence on the coronavirus epidemic and recommendations for business contingency planning.

Priority area 2: STABILISATION

Monitoring economic sectors that provide basic necessities and maintaining social harmony

Let's start with the good news. **At present, there are no signs of any fundamental disruption to the provision of basic necessities in Germany**. However, depending on how the epidemic unfolds, which containment strategies are pursued by policymakers, and what the economic repercussions are, it will be an ongoing challenge to prevent any significant shortages in the supply of basic necessities. After all, as an open economy, Germany is not just an exporter – it also imports many of the goods needed to meet its basic necessities, such as food and energy resources.

It is currently **almost impossible to formulate reliable projections and scenarios** relating to the availability of basic necessities, in part due to the complexity of global value networks. This makes it all the more important to carry out detailed, **centralised monitoring** of the economic sectors that provide our basic necessities. This is another task that should be assumed by the proposed Federal Government expert task force (see priority area 1).

For each sector, this central monitoring function should involve a) building up a systematic, up-do-date picture of the current situation (status quo), b) formulating scenarios relating to potential shortages (forecasts of the foreseeable future) and c) developing recommendations. A joint process that includes the key government agencies, market players and experts will ensure that all the actors are in a position to take faster, coordinated action if required. The monitoring process would make a direct contribution to guaranteeing the supply of basic necessities and would increase overall **responsiveness and resilience** in the event of unforeseen developments. The findings of the monitoring process should also provide a **key point of reference** for the Federal Government's **public information policy**.

The need to ensure that basic necessities are met will also require us to revisit questions of national and European sovereignty, for example with regard to utilities and technology. It should be stressed that **sovereignty is not the same as autarky**. By sovereignty, we mean the ability to make our own, independent decisions, which is not automatically the same as saying that we should rely entirely on our own domestic resources. Supply strategies can still be geared towards an appropriate level of **international supply chain diversification**. The Federal Government should initiate a regular dialogue with academia and industry on this topic, focusing systematically on the relevant supply sectors and key technologies.

These discussions could become particularly highly charged if **foreign investors** try to take advantage of the crisis to buy up large numbers of German or European companies on the cheap. While the corporate acquisitions market should in principle remain open to foreign capital, a frantic sell-off of tech, infrastructure and utility companies could seriously damage the economy.

One of the keys to successfully overcoming the economic crisis will be to stabilise the **European single market**. The Federal Government should use Germany's presidency of the EU Council during the second half of 2020 to promote this goal as strongly as possible. As well as detracting from the economic benefits of trade, international trade restrictions could potentially also threaten our ability to ensure the targeted allocation of basic necessities to the places where they are most urgently needed.

The following sections present an initial brief overview of aspects that will need to be addressed in detail by the monitoring process in some of the sectors that play a role in providing our basic necessities.

Food and agriculture

Given its role in putting food on people's tables, agriculture has quite rightly received a lot of attention during the current crisis.

It is widely agreed that our basic food supply is not in danger.

Many of our main crops, such as wheat, barley and rape, were already sown last autumn. The exact size of the harvest will depend on weather conditions over the next few months, but on the whole the crops are growing well. Plenty of seed and fertilizer is available for the potatoes and sugar beet that will need to be sown in the coming months.

Germany is in a strong position thanks to its high self-sufficiency level (meat 117%, milk 113%, potatoes 135%, sugar 125%, wheat 106%). Nevertheless, the agricultural sector relies on imports of seed, mineral fertilizers, plant protection products and animal feed. Even if we were completely self-sufficient, we would still need **open borders** to obtain these resources. This should therefore continue to be a top policy priority.

However, Germany's high level of self-sufficiency should not blind us to the fact that the **crisis will cause significant changes in agricultural markets**. In the domestic market, demand for agricultural produce from the catering trade has almost completely collapsed, whereas food retailers have experienced a sharp increase in demand from private households. However, the fact that Germany is more than 100% self-sufficient in some products means that prices and incomes in the agricultural sector are also heavily dependent on exports. A global recession and new trade barriers could pose a serious threat to sales.

The self-sufficiency level for **vegetables** (37%) and **fruit** (22%) is substantially lower, and **shortages are likely** for these labour-intensive crops. This will be the case for the harvests of permanent crops like asparagus and strawberries (and e.g. apples and wine in the autumn) if there is a shortage of seasonal labour from other EU member states. **Open borders for seasonal workers are therefore indispensable.** The sowing or planting of crops such as salad and cucumbers also depends on seasonal labour, and we will probably not be able to rely on the usual level of imports from countries such as Italy and Spain during the summer months. As a result, fruit and vegetables will become scarcer and **more expensive**, with the lower income brackets likely to be the hardest hit.

Bottlenecks could also occur in the processing of agricultural produce in labour-intensive sectors of the **food industry**. Slaughterhouses are an example of a labour-intensive trade that relies on labour from countries outside the EU. Farmers will be exposed to price pressures if shortages of labour or other resources such as packaging materials cause a drop in processing industry demand for unprocessed produce.

Germany is critically dependent on imports of **animal feed** for the dairy and meat industries. The EU imports around 50% of its feed protein, mainly in the form of soya from Latin America. Any disruption to trade will cause feed prices to rise. Many dairy and meat producers could experience financial difficulties in the coming months if they are confronted with rising costs on the one hand and pressure to lower their prices on the other.

As a result, many farmers will have to rely on financial support to help them through the crisis. It is essential for the State to take measures to facilitate **access to labour** and maintain a reasonable level of regional and international trade flows (a "green corridor"). Due to the complex interdependencies in the food chains, **the adoption of a coordinated approach within the EU** is clearly preferable to a scenario where individual nations try to go it alone.

Implications for health and nutrition:

It is likely that the developments outlined above will cause our diets to become somewhat less varied and balanced.

There is no fundamental danger of malnutrition or deficiencies in Germany. As long as we have a secure supply of **staples** such as wheat, potatoes and meat, there is no danger of acute or serious impacts on people's health. In particular, the findings presented above indicate that we will have access to enough calories, protein, fat and carbohydrates.

However, there could be issues with access to **dietary fibre**, 40% of which is provided by fruit and vegetables. Even under normal circumstances, people's diets do not contain enough of some of these nutrients, partly as a result of dietary preferences. According to the latest figures, 85% of the population do not consume the recommended quantity of vegetables, while between 40% and 60% fall short of the recommended daily intake of fruit. If the price of these products rises, these figures could get even worse, especially among low income groups.

The picture is similar for vitamins. Even before the crisis, around 80% of people in Germany were not getting the recommended dietary intake of folic acid (15% of which comes from fruit and vegetables) and Vitamin D (50% of which comes from fish and fish products). The availability of the relevant products is highly dependent on international supply chains. A lack of fruit and vegetables could also lead to insufficient intake of Vitamin C. Vitamin deficiencies can have **long-term health effects** such as an increased risk of high blood pressure or diabetes.

Logistics

In a joint press release issued on 19.03.2020, the associations of Germany's haulage, transport and logistics industry stated that although supply chains are under pressure, they remain **stable** and are able to reliably deliver high levels of goods for households and businesses. The associations welcome the suspension of the ban on driving HGVs on Sundays. However, they stress that the exemption should apply to the transport of all types of goods, so that supplies can be maintained not only for supermarkets but also for manufacturing companies. They also call for measures to facilitate the **cross-border movement of goods**. The long queues that are sometimes occurring at national borders are tying up transport capacity that could be used elsewhere. In order to guarantee a smooth flow of information and transparency regarding the different and in some cases country-specific regulations, they call for central coordination of the information, for example through crisis management centres.

From an academic perspective, it is currently impossible to make even partly reliable and widely applicable predictions about the effects of the coronavirus crisis on the logistics sector. **The impacts will vary significantly from one individual supply chain to another**. This means that it is only possible to develop highly specific scenarios and adaptation strategies.

Nevertheless, the coronavirus crisis provides another reason for the logistics sector to accelerate the adoption of **open platforms** that use software components to enable automated contract negotiation and payment. This is something that could be regarded as a no-regret measure.

In the **B2C market**, the platforms of companies that dominate the market, such as Amazon and Alibaba, have already succeeded in taking over business and logistics processes across the whole economy. Now, the race for supremacy in the **B2B market** is also set to be decided – and not just in the logistics industry. The winners will be open, federated digital platforms and AI algorithms that succeed in leveraging efficiency gains and establishing de facto standards and are adopted throughout the logistics sector and the whole of industry. By supporting **more flexible** logistics, these Industrie 4.0

platforms can contribute to a secure supply of goods for households and businesses. Moreover, they promote competition, helping to prevent the market from becoming over-dependent on a handful of large providers.

Individual German logistics companies will not be able to succeed in the logistics platform economy by going it alone. The market must be persuaded to commit to the immediate, agile implementation of an open, federated and effective **open-source logistics platform**. Since speed is of the essence, not all market players need necessarily be involved at the beginning of this process. However, it should be possible in principle for all market players to use the new solution. Furthermore, the platform should have a **Europe-wide requirement** to observe social standards and goals, even during a pandemic.

Health

The primary challenge currently facing the health service is to ensure that it is ready for patients who are expected to develop severe coronavirus symptoms that require **intensive care**. The following resources will be necessary:

- A logistics system that enables knowledge-based management and regional distribution of coronavirus patients
- Beds in suitable spaces with appropriate facilities
- Medical equipment to help patients breathe, stabilize their circulation and prevent complications
- Appropriately qualified staff
- Remote virtual ICU technologies to support intensive care units (e.g. video consultations, remote patient monitoring)

It is particularly important to protect medical staff, and not just on ethical grounds – **medical staff are currently the scarcest "resource".**

Protecting medical staff

Providing intensive care requires a lot of experience. These duties cannot simply be handed over to former medical professionals who have returned to work, students, or lay volunteers who have received basic training. Hospital staff must therefore be afforded the greatest possible protection, especially in areas where there is a particularly high risk of infection such as A&E and ICUs. In Spain and Italy, approximately one fifth of all medical staff have become infected with the virus while performing their duties. The risk of infection is greatest among those members of staff involved in treating infected patients. The following measures should be taken to ensure that staff receive adequate protection:

- **Mandatory wearing of masks in hospitals:** Staff who have become infected with the virus but are not yet displaying any symptoms are particularly likely to spread the infection in hospitals. The only way to reduce the risk of transmission is for **everyone** to wear protective masks. Standard protective masks do not protect the wearer against infection, but do prevent them from infecting the people they come into contact with. On the other hand, FFP masks protect both the wearer and the people they come into contact with, but are currently in short supply.
- **Tackle PPE shortages:** Even in big hospitals, there is currently a shortage of protective masks and clothing. Almost all personal protective equipment is made in Asia. It is vital that Germany and other European countries should start producing PPE as soon as possible. The products must be

thoroughly tested to ensure that they are fit for purpose, but this should be done as quickly and unbureaucratically as possible.

- **Tackle sanitizer shortage:** It is currently impossible to get hold of sanitizer products in the German market. There is an urgent need to increase production of sanitizers, most of which are ethanol-based. At present, ethanol's main use is in the production of bio-diesel for motor vehicles. The ethanol used in this industry must be immediately diverted to the healthcare sector.
- **Redeploy staff who are immune to the virus:** Depending on the duration and overall trajectory of the pandemic, staff who have already had the virus and are now immune could replace staff in particularly critical functions who have not yet developed immunity.
- **Use remote technologies** to allow **infected staff** to keep working, provided that they are willing and able (e.g. by performing video consultations or remote monitoring).

These measures should be complemented by additional management interventions:

Optimise equipment procurement and ensure adequate supply of consumables

While the government recently ordered 10,000 ventilators, intensive care units also require other equipment such as monitors, Infusomats, syringe pumps, suction devices and the corresponding consumables. The Federal Ministry of Health has placed several major orders with German manufacturers for these types of equipment, relegating hospitals to a subordinate role in the procurement process. While the political pressure on manufacturers is undoubtedly justified in the current crisis, it is also important to ensure **needs-based distribution of the equipment**. This is something that must be done centrally and cannot simply involve sharing the equipment out equally in the interests of "fairness". What is needed instead is a staggered distribution process within regional supply clusters, that takes into account the experience, staffing and equipment levels of the hospitals receiving the supplies. This will require competent local organisations with extensive decision-making powers.

Provide pandemic training

Even highly-trained professional staff need specific pandemic training for the current crisis. This should focus on how to protect themselves and their patients, and on how to implement protective measures in practice. It should include information about how often protective clothing should be changed, the recommended frequency of hand washing with alcohol-based sanitizers, and the wearing time and reusability of protective masks.

Ensure ongoing treatment of other conditions

Hospitals must also maintain their ability to treat patients suffering from **other serious conditions** such as heart attacks and strokes, as well as less immediately serious conditions that will inevitably deteriorate without ongoing treatment (e.g. other types of respiratory disease and heart failure). Care for people such as dialysis and cancer patients must also be maintained. Germany's faculties of public health could contribute by developing new care strategies for these groups.

These measures are essential in order to ensure adequate public healthcare and must also be incorporated into the monitoring process of the expert task force recommended in this paper.

Energy

Reliable **energy service** provision is key to meeting the basic necessities of German households and businesses, especially at a time when there are restrictions on social contact and when manufacturing processes are coming under pressure. It is currently almost impossible to predict the impact that the coronavirus pandemic and its economic fallout will have on the **energy sector**, particularly at a time when demand is falling due to the decline in economic activity but there is also a possibility of supply problems. These factors could combine to create a scenario where there is not enough fuel to replenish existing stocks and energy grids are unable to cope with the fluctuations in supply and demand.

The lockdown in **China's Hubei Province** that began on 23.01.20 and is now gradually being lifted provides some initial pointers as to how things could develop in Europe. The overnight economic shutdown in Hubei caused demand for electricity to fall by 40%, meaning that **at no point was there any threat** to the energy supply.

Energy suppliers around the world are currently implementing their **contingency plans** to keep the electricity and gas grids running. Despite the widespread use of digital technology in the industry, **operating personnel** still need to be physically present on site. In some cases, staff are literally barricaded inside control rooms, eating, sleeping and working there in two-week shifts. Due to its critical infrastructure status, the energy industry already has contingency plans in place and provides its workforce with regular training.

This is also essentially true of **power plants**. Despite the sharp rise in the percentage of renewables in the energy mix, gas and coal-fired power plants are still necessary to ensure a secure energy supply in Europe. Most of the **fuels** needed to power them are imported from abroad and then transported to the plants. If these supply chains were to be disrupted – and it should be stressed that there are currently no signs of this happening – the **coal reserves** held at Germany's coal-fired power plants would be sufficient to keep them running for around 30 days even if demand remains at the same level as before the crisis. If the coal-fired power station reserves run out and Europe's gas imports also dry up – and again, there are no signs of this happening –, the high **gas reserves** held by Germany's gas-fired power stations would be enough to guarantee supply for six weeks.

The slump in economic output as a result of the crisis can be expected to cause a **reduction in energy demand**. For example, electricity demand during the first full week of lockdown in Italy was approximately 17% lower than the previous week. Depending on the percentage of total electricity demand accounted for by industry, experts in different European countries predict a drop in demand of between 10% and 25%. The fall-off in production and widespread restrictions on commercial activity are not compensated for by the slight uptick in domestic electricity demand. This will have financial implications for energy suppliers, who could also suffer from customers defaulting on outstanding payments.

One consequence of this could be that the energy industry has less cash to **invest** in the energy transition. 2020 could be the first year since the 1980s to see a decline in newly installed solar capacity compared to the previous year. Efforts to promote electric mobility could also suffer a setback if investment in the necessary infrastructure is shelved. The energy industry must determine which additional measures will be necessary for it to cope with the coronavirus crisis while at the same time still making an important contribution to climate protection.

Communication and data networks

Reliable **communication services** are vital to our economy. Here too, the news about the current situation is good. Communication and data network operators are monitoring capacity utilisation very closely, and Deutsche Telekom has stated that its network is **well equipped** to deal with the current

challenges. The Bundesnetzagentur (Federal Network Agency) is in close contact with the network operators. In a report published on 25.03.2020, it found no evidence of networks becoming overloaded due to the coronavirus crisis. However, networks in other countries where stricter rules about staying at home are in force have come under pressure due to increased use of a handful of particular entertainment services. At the request of EU Commissioner Thierry Breton, companies such as Netflix have agreed to significantly reduce the strain on networks by temporarily **cutting their streaming quality**. In principle, the network operators are also prepared for larger shifts in network load.

Maintaining social harmony

In psychological terms, epidemics are strongly associated with fear and insecurity, particularly due to a perceived loss of control. The longer restrictions on social and economic activity remain in place, the greater the need for policymakers to take specific measures to maintain social harmony. An **open and transparent information policy** that promotes confidence in policy decisions will be absolutely key. After all, most people will be required to participate actively in implementing the necessary measures. In South Korea, for example, the government gives two briefings at the same times every day, in which it provides updates on the latest figures and the measures it has taken. In general, South Korea has hitherto been particularly successful in its efforts to contain the epidemic.

At present, it seems that the vast majority of people in Germany are reacting calmly and sensibly to the crisis, largely observing the dos and don'ts, and accepting the restrictions on their everyday lives. However, it will be necessary to monitor the extent to which this acceptance endures over the longer term. Moreover, there is a possibility that **social conflicts** could (re)surface between the generations, between sectors of the population that are affected differently by the crisis and the lockdown, and between different income groups.

It is possible that **conflicts** concerning the **distribution** of State aid could occur between different groups in Germany and between different European countries. While the current situation has been strongly characterised by solidarity and a willingness to help at the local community level (although these attitudes have not extended to other countries), once the crisis is over it is quite possible that we will witness conflicts over the fair distribution of compensation measures and aid programmes. This social dimension should also be incorporated into the coronavirus crisis **monitoring process**.

Observing and even promoting new social norms

In terms of the wider medium-term economic repercussions, it will be interesting to observe whether the restrictions and involuntary self-sufficiency that people are having to accept during the crisis lead to **changes in our lifestyles** once it is over. While a trend towards greater self-sufficiency may at first sight appear welcome from a **sustainability** perspective, a weakened economy will be relying on a bounce-back in demand for goods and services after the crisis. Moreover, a dynamic economy fosters innovation, which is in turn key to solving the sustainability question.

Behavioural changes brought about by previous crises such as the BSE epidemic (e.g. switching to a vegetarian diet) proved to be short-lived. However, if the coronavirus crisis continues over the longer term, we may see the emergence of **new routines and social norms** that gradually become normalised over the course of the epidemic. In the context of sustainability, communication measures and other incentives could strengthen **desirable behaviours**, for instance with regard to consumption patterns. It is important to start work on these measures now so that they are ready to go live once the crisis is over.

The current situation is also providing a large-scale test case for virtual working. Effective monitoring will allow the social partners to learn important lessons about the regulations and equipment required for working from home. The crisis is also providing a test case for IT security in distributed systems and beyond organisational boundaries.

Priority area 3: STIMULATION

Promoting innovation and securing our future

There is no question that our number-one priority must be to overcome the current public health and economic crisis. However, we cannot afford to lose sight of the future. As well as implementing a crisis management strategy that minimises the negative repercussions of the epidemic, the actions we take now should also be guided by the goal of securing the future of our economy and society in a peaceful and united Europe.

Despite the crisis, or perhaps even because of it, we cannot afford to put off investing in the future – at least not for any length of time. The urgency of the measures required to manage the crisis must not blind us to the need to find a balance between the protection of existing economic structures and their transformation into structures that will be viable in the future.

Rebooting the economy as soon as possible and stimulating economic activity

The temporary slowing down of economic activity to contain the epidemic is unavoidable. However, as outlined above, this does not mean that the economy should be allowed to come to an **abrupt and long-lasting standstill**, since this would seriously threaten the supply of basic necessities and overall living standards. It is nigh on impossible to predict how severe the decline in economic output and material living standards will be. Linear extrapolations based on normal cyclical fluctuations tell us little about disruptive changes on this scale, and in any case, small variations in the results would not provide any useful insights for guiding policy.

We also have to recognise that we have **little experience in the targeted shutting down and subsequent rebooting** of a highly specialised and connected economy. We know next to nothing about how long the impacts of measures to curb and stimulate economic activity in the current crisis might last. Moreover, the vast numbers of interdependencies between different developments make simulations and projections virtually impossible. We also have little idea about the potential **tipping points** for a downward economic spiral that could, under certain circumstances, make a controlled reboot of the economy extremely difficult. It is therefore important to treat the crisis management process as a **learning system**, be prepared to make **continuous adjustments** to it, and recognise the need for **transparent communication**.

However, there is one goal that should still be pursued, even in a "**crisis economy**". Alongside the government's epidemiological strategy – which, due to mutual interdependencies, will itself be closely tied to the evolution of the economy – policymakers must take measures to ensure that **economic output remains as high as possible**, for as long as possible. **Dynamism and innovation** will be key to overcoming the economic crisis and enabling the prospect of economic prosperity in the coming decades. A dynamic, innovative economy is also essential for tackling the major long-term social challenges that we were already facing before the coronavirus crisis, such as climate protection and profound demographic changes.

In other words, we cannot allow the coronavirus crisis to fundamentally threaten the **market economy**. The crisis will undoubtedly call for significant government intervention in the market, probably over a prolonged period of time. But the crisis economy will still need market price signals to ensure the efficient allocation of resources and competition to drive innovation and growth. The incentive effect of competition and the prospect of private profit are key to harnessing the economic potential that enables both high living standards *and* a caring society. The market economy is also highly adaptable, and its incentive mechanisms ensure that solutions are born out of adversity.

Learning from past crises and forging ahead with strategic projects

As a **centre of innovation** with a highly-skilled workforce, successful enterprises and hidden champions, a strong business IT sector and key technology know-how, **Germany** is well placed to successfully meet strategic challenges such as the digital transformation. Germany is a global market leader in the engineering and manufacture of complex, premium-quality products. However, to remain globally competitive in the platform economy, products must increasingly be digitally enhanced and expanded in order to deliver customised services. This requires new partnership models and open corporate networks.

Despite, or perhaps even because of the coronavirus pandemic and the economic recession that it will trigger, it is thus more important than ever to **forge ahead with strategic innovation projects** so that we emerge from the crisis in the best possible shape. The financial crisis of 2008-2009 emphatically highlighted the tremendous value of Europe's and in particular Germany's industrial core. Germany's outstanding and highly-specialised SMEs and its market-leading corporations in the machine and plant engineering, automotive, pharma and chemical industries are a rock of stability in troubled times.

Initiated by acatech, the strategic projects Industrie 4.0, Smart Service Welt and Autonomous Systems/Learning Systems aim to bring together the knowledge of different industries and service sectors, foster pre-competitive collaboration, provide **guidance** through use cases, best practice examples and guidelines, and formulate **concrete recommendations** for policymakers and the public. State innovation and funding programmes can also help to bridge periods of crisis and provide an additional stimulus for private sector investment, research and innovation.

Industrie 4.0 outlines a vision for the future of industry that can make the "Made in Germany" logo a hallmark of quality again in the context of the digital transformation. This vision is centred on **qualitative growth** in a social market economy model. Many countries around the world are eager to cooperate with Germany. The opportunities opened up by the Smart Service Welt can help us to develop a sustainable economic policy that embraces digital business model innovations and the platform economy. The Plattform Lernende Systeme brings together expertise in the field of **artificial intelligence**, engages with the public and supports Germany's efforts to become a global leader in AI technology and applications. Together with the National Platform Future of **Mobility**, which was established by the Federal Government, these initiatives demonstrate that academia, industry, government and the public are already working together in Germany to address the key strategic issues. Biotechnology is another important topic in this context.

We must not waver in our **determination** to systematically implement these strategic projects. The situation we find ourselves in calls for pioneering spirit and a willingness to shape the coming changes. Trailblazers who use these changes as an opportunity will play a key role.

Making a virtue of necessity and in investing in quality enhancements

The crisis is forcing businesses, public authorities, research institutions, schools and universities to completely reorganise some aspects of the way they work. While in many cases they are having to improvise, there will also be numerous opportunities to invest in **quality enhancements**, for instance in the areas of e-learning and the technical equipment required for mobile working. The productivity gains enabled by these investments will continue to have a positive impact once the crisis is over.

People who are currently unable to perform all of their usual duties while working from home should be allowed to use the extra time for **professional development** purposes. For example, Deutsche Telekom is working with its employee representatives to ensure that every effort is made to temporarily provide all its employees with rapid access to additional learning opportunities and support. The measures include providing planned on-site training digitally (for example some agile training sessions have been temporarily converted to digital formats). The company is also temporarily giving more people access to online training solutions such as Percipio and Coursera.

Many large enterprises have already been successfully using their own in-house learning platforms to promote lifelong learning for some time. The benefits of adopting these solutions have become particularly apparent during the current crisis. A recent report by acatech's HR Working Group describes a number of best practice examples.

In order to ensure that everyone has access to these opportunities, the State could issue people with **education credits** that could be used primarily for online courses.

Strengthening medical research

In addition to supporting infection research, government should act swiftly to create the legal and financial frameworks needed for large-scale **epidemiological** studies. This will allow us to gain a better understanding of pandemics so that future events can be managed in a more targeted manner. Research and funding should focus not only on **viral** pathogens but also on **bacterial** infections, with particular emphasis on antibiotics research.

Since researching and developing just a single antiviral drug costs billions of euros, pharmaceutical companies will only invest in this type of research if they think that the market will be big enough to make it worthwhile. However, predicting the size of the market is often far from easy. In order to accelerate the relevant research, it will therefore be necessary to invest several billion euros **without regard to potential market size**. International **partnerships** will be essential for these drug development initiatives. European cooperation in the field of space research could provide a model for these partnerships at European level.

As well as projects to develop specific compounds, Germany must also invest in **digital** and real-world infrastructures to accelerate the development of these compounds and enable real-time precision medicine. This will involve providing scientists with training in AI and data science, establishing leading-edge clusters in the digital life sciences, and systematically supporting the relevant enabling technologies such as molecular diagnostics, omics technology platforms (genomics, transcriptomics, proteomics, etc.) and AI in drug development.

Artificial intelligence techniques can make a particularly important contribution to **accelerating drug development**. Researchers at the Massachusetts Institute of Technology (MIT) recently used deep learning to identify antibacterial molecules by screening over 100 million molecular structures selected from a database. Laboratory tests are now being carried out to determine the efficacy of the antibiotic candidates identified in this way.

Digital technology should also be used for direct patient **care** (e.g. chatbots and symptom checkers to aid diagnosis and wearables to support patients in their homes). Many such products and solutions already comply with standard data protection regulations and the law on medical devices, and are thus ready for immediate use. In addition, greater access should be provided to data for healthcare research purposes.

Start-ups and research groups with ties to the start-up community form an important part of innovative **ecosystems** in the **digital life sciences**. As well as access to long-term funding and support with concrete challenges (e.g. technology platforms, laboratory infrastructure and experts), they also have a particular need for targeted networking programmes. Innovations in microbiome diagnostics, for example, require collaboration between disciplines as diverse as physics (basic technology), space technology (systems engineering), microbiology (microbiome expertise) and bioinformatics (data analysis).

Helping high-tech start-ups to weather the crisis

A few weeks ago, rumours of the potential sale of Tübingen-based company CureVac to the USA sparked widespread outrage. The biopharmaceutical company, which was founded in 2000, is currently developing a COVID-19 vaccine. According to media reports, President Trump tried to lure CureVac scientists to the US by offering them large sums of money in a bid to give his country **exclusive access to the vaccine**. CureVac has denied the claims that an offer was made for the company. Responding to the reports, Federal Minister for Economic Affairs, Peter Altmaier, declared that “Germany is not for sale”. He added that, where important infrastructure and national and European interests are concerned, the Federal Government will take action if it has to.

The CureVac case has turned the spotlight on the **deep tech** start-up scene. The deep tech start-up business model is based on cutting-edge technologies requiring lengthy R&D. Despite playing a key role in the innovation landscape, in the past these start-ups have tended to be overshadowed by large corporations in terms of media attention. As well as life science companies, they also include companies in fields such as robotics, 3D printing, cutting-edge materials, photonics and quantum technology. These businesses are also important innovation partners for established companies.

Compared to the US and Asia, European start-ups suffer from a lack of access to **venture capital**, especially during their growth phase. It would be a particularly devastating blow for innovation in Germany if deep tech companies that are on the verge of really taking off were to go bankrupt or be bought up by foreign investors as a result of the crisis.

According to a recent study by the Technical University of Munich, start-ups co-financed by foreign venture capital funds are *twice* as likely to be sold on to foreign investors or floated on foreign stock exchanges. In a 2019 publication produced in cooperation with KfW and Deutsche Börse, acatech presented a series of proposals for strengthening the domestic venture capital scene in Germany. The report also recommended improving access to “patient capital”. It is essential that the Federal Government should press ahead with the implementation of the wide-ranging package of measures that it was preparing before the coronavirus outbreak. These **measures to strengthen growth finance** in Germany should be incorporated into the plan to protect start-ups (see priority area 1).

However, start-ups don’t only use venture capital to finance their growth – they also use their own profits (**internal financing**). Studies have shown that prior to the 2008 financial crisis, over 85% of tech start-ups in Germany were already reporting profits even during their early years. When orders dropped off during the financial crisis, they were increasingly forced to turn to external sources of finance, but were unable to access enough venture capital to compensate for the loss of internal financing. As a result, investments were scaled back and innovation projects shelved. In fact, research-

intensive start-ups reduced investment spending even more than less innovative start-ups. Consequently, in addition to mobilising venture capital, it is now more important than ever for the **State** to stimulate **demand for the products and services** of innovative start-ups – and the main way it can do this is by buying these products and services itself. State funding programmes could also help to further **strengthen** networking and **collaboration between start-ups and established businesses**. The "industry in clinical practice" platforms funded by the Federal Ministry of Education and Research are a good example from the healthcare sector.

Strengthening the resilience of the economy and society as a whole

The nature of our critical infrastructure and the growing number of extreme events are making our **society increasingly vulnerable**. The increasing interconnectedness of the structures that are critical to our survival means that even **minor disruptions can have serious consequences** for the system as a whole. The critical infrastructures that need special protection in our modern society include the energy and water supply, the transport and traffic infrastructure, information technology and telecommunications, food, and healthcare (see priority area 2).

In order to be better prepared to cope with systemic risks, it will therefore be necessary to increase investment in building resilient systems and in social security and welfare institutions. **Resilience** describes a system's ability to continue functioning reliably in the event of unexpected disruption, or the ability to restore it to normal functioning as quickly as possible. Resilient societies are able to minimise the human, economic and environmental costs arising from adverse events by making flexible use of every conceivable, practicable solution, including technology, social tools – such as education or an open dialogue with the public – and economic incentives.

Funding programmes should be geared towards strengthening resilience as a **holistic strategy** for minimising the harmful impacts of adverse events on our society. Metrics and indicators for evaluating vulnerability and resilience are also necessary, as well as methods for modelling and simulating complex socio-technical systems. Other key factors include the research, development and implementation of resilient designs and construction methods for critical infrastructure (resilience engineering), strategies to sustainably strengthen people's self-reliance in the face of adverse events, and incentives for businesses to increase their resilience. Security research also has an important part to play.

Digital technologies can also help to strengthen the resilience of businesses, public authorities and other institutions. As well as helping us to overcome the current crisis, they can also make us **stronger** for the future. acatech will be publishing a number of examples of how they can do this in the near future.

Government, industry, academia and the general public must **all pull together** to overcome the coronavirus crisis, keep our economy running and meet our basic necessities even during these difficult times. Here at acatech, we too will be doing our bit.

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