Good practices in mission-oriented innovation strategies and their implementation

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Innovation for Transformation –
Fostering innovation to address societal challenges

Results Paper 1

Good practices in mission-oriented innovation strategies and their implementation

Results Paper 2: Networking and exchange in mission-oriented innovation processes
Results Paper 3: Addressing societal challenges through disruptive technologies
Results Paper 4: Fostering innovative startups in the pre-seed phase
Results Paper 5: An agenda for the future: Innovation for transformation

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Scientific analysis

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Foreword

We have long known that Germany and Europe face enormous challenges. From climate change to demographic change, from digital transformation to declining innovative capacity, and from the need to expand social systems to the lack of future-oriented education for young people, these challenges will be even more acute in the aftermath of the coronavirus pandemic.

Strengthening innovative capacity is the key to creating a sustainable society.

We are aware of the facts and the problems associated with each challenge. Europe's economies still have a high standard of living and deliver considerable technological know-how. But the problems persist and grow with each passing day. Over the coming decades, it will be our duty to identify and develop solutions to these problems. A failure to do so will put our societal, political and economic systems at risk; moreover, coming generations will lose the foundation on which societies develop and stabilize, which will endanger their very existence.

Innovative capacity, combined with the further development of political and societal systems, thus constitutes the principal point of departure in the search for sustainable solutions. This is the cornerstone of a free, just and open society that is built on a forward-looking educational system. In Europe, we can look back on a long tradition of invention and innovation. Even today, our companies and research institutions continue to deliver brilliant ideas. However, the innovations we produce often mark no more than small steps forward. In international comparison, we all too rarely make genuinely ground-breaking changes. The question of innovation is thus of the greatest relevance for both our present and future lives. When tied to ethical norms, innovation is both a prerequisite to technological competitiveness and the key to sustainable economic development able to deliver solutions to society's greatest problems.

The Bertelsmann Stiftung's Reinhard Mohn Prize is traditionally focused on issues of such expansive significance. In line with our founder's guiding vision of "learning from the world," we identify strategies from around the globe that promise to help us find answers to these questions. For the Reinhard Mohn Prize 2020, we set out to find innovation policies that aim to generate both economic and technological competitiveness and advance societal progress. We have packaged our findings, derived from many discussions around these issues, into five results papers based on good practices from 13 countries. With these, we hope to make a constructive contribution to the debate.

We are awarding the Reinhard Mohn Prize 2020 to Nechemia Peres for his outstanding commitment to promoting innovation that serves the economy and society in equal measure. Embodying the spirit of "Startup Nation Israel," Nechemia Peres shows us how innovation can serve as a catalyst for prosperity and peace. We can learn much from his example, and from the other good practices featured in each results paper. Although circumstances vary from country to country, we can identify several fundamental elements of a modern innovation landscape:

- An ambitious, cross-sectoral innovation-policy strategy is essential to future-oriented change. In this regard, it is crucial to link support for new key technologies with the goal of solving societal problems.

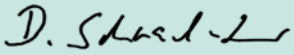
- Innovation arises through creativity, dialogue and a diversity of perspectives. Thus, it is critical to have instruments that facilitate exchange and networking between actors from all areas – not just the business and research sectors, but also politics and civil society.

- Disruptive innovations can help us overcome major challenges. To this end, there must be a willingness to take risks in every sphere of society, paired with the courage to step off the beaten path.

- Young, innovative companies are integral to driving transformative change forward. They need sustainable support and financing.

Efforts in line with these aims are effective tools in strengthening innovative capacity. We must have the courage to realize our potential in order to foster innovation that ushers in economic and societal progress alike.

Dr. Brigitte Mohn, member of the Executive Board, Bertelsmann Stiftung



Dr. Daniel Schraad-Tischler, director of the "Shaping Sustainable Economies" program, Bertelsmann Stiftung

Key findings

- Both Germany and Europe face enormous societal and economic challenges. Conventional policies and the structures within which they operate are ill-equipped to solve problems such as climate change, demographic change, the overexploitation of natural resources and the coronavirus pandemic. We need fundamental transformative change across existing systems in which societal, economic and technological developments complement each other. Achieving this involves advocating "Innovation for Transformation." And this process begins with innovative capacity, as innovation is a central lever in efforts to promote sustainable development and address the major challenges of our time.

- The coronavirus pandemic offers a unique opportunity to revise existing innovation policies and reach agreement on priorities.

- However, despite all the economic and societal potential harbored in Germany and Europe, the intensity of innovation in both has diminished in recent years. Particularly in terms of key technologies such as digital technology and in generating disruptive innovations, other regions of the world are increasingly outpacing us.

- The study presented here points to the ways in which an ambitious and mission-oriented policy of innovation can counteract this trend. Drawing on extensive research on good practices, the study highlights several stand-out strategies and institutional practices in Canada, Japan, the Netherlands, Sweden, and the United Kingdom. As model approaches, these examples offer valuable input for efforts in Germany and Europe to advance innovation policy.

- The study shows how appropriate strategies and governance structures can effectively combine the paradigm of "strengthening innovation and technological competitiveness" with that of "solving societal problems through innovation."

- This type of approach is also reflected in the United Nations' Sustainable Development Goal (SDG) 9, which explicitly emphasizes innovation as essential to fair and sustainable economic and social development.

- Whereas innovation policy once aimed at increasing GDP growth and strengthening competitiveness – particularly during the postwar era – the focus today often rests on socially relevant goals, or so-called missions.

- A mission-oriented innovation policy focuses on people and their needs, addresses the challenges facing society, and thus drives forward transformative change.

- Success factors include setting clear priorities, defining strategic objectives (directionality and intentionality), coordinating innovation activities across disciplines, sectors and ministerial portfolios (coordination) and involving all relevant stakeholders in negotiation and decision-making processes.

- Navigating this complexity effectively requires approaches that go beyond traditional innovation policy. A modern mission-oriented policy is underpinned by innovative strategy-development processes and new configurations of actors, institutions and practices.

- As a framework for innovation in Germany, the country's High-Tech Strategy highlights various areas in need of improvement. This includes in particular the formulation and specification of missions, cross-cutting coordination (e. g., across disciplines, sectors and ministerial portfolios), the allocation of responsibilities, and involving communities in decision-making and solution-creation processes.

- A mission-oriented innovation policy begins with ambitious strategies that explicitly aim to link competitiveness with societal progress. These strategies help flesh out specific action areas, set clear time frames, and define ownership and accountability for particular innovation activities. The United Kingdom and Canada offer good examples of this.

- Innovation should not be treated as an end in itself but used as a tool in advancing the development of society as a whole. Norms should therefore clearly drive strategies and missions. Such efforts can be based on ethical principles (as in Canada), the SDGs (as in Sweden) or on a model of societal progress (as in Japan's "Society 5.0" vision).

- The example of Canada, where the Montreal Declaration serves as a normative frame of reference in the application and development of key digital technologies, demonstrates how a country can embark on its own ambitious values-driven path of development. Europe could draw on this example in developing its own "third way" that distinguishes it from countries such as the United States and China.

- Innovation is a product of dialogue and openness to overcoming professional, cultural and spatial boundaries. Coordinating across organizational and institutional silos as well as partnership-driven negotiation processes are the only means of identifying societal needs and generating the necessary commitment. Participatory processes also increase public acceptance of fundamental transformations. The institutional practices of Sweden's National Innovation Council and the Netherlands' polder process stand out as models of such efforts.

- Negotiation processes should lead to a formulation of results and as-specific-as-possible approaches. Once again, the Montreal Declaration stands out here as the product of several public consultation processes.

- Specialized agencies established to target innovation such as Vinnova (Sweden) or UKRI (UK) are an important success factor in the development, coordination and implementation of innovation policies. As "change agents," they bundle expertise, orchestrate innovation processes and serve as liaisons across sectors and levels of activity. Germany should consider also establishing a similar institution.

- Demonstrating the willingness to take risks and the courage to fail are important prerequisites for a modern innovation policy, particularly with regard to promoting disruptive innovation. Fostering disruptive innovation can also involve targeting societal objectives. Aiming to promote societal change through high-risk technology projects, the Japanese ImPACT program offers a good example of this.

- Public institutions should act as consumers of socially relevant innovations and aim to promote both the development and diffusion of such innovations. This can be implemented through public innovation agencies or dedicated procurement authorities such as Sweden's National Agency for Public Procurement (Upphandlingsmyndigheten).

- The study emphasizes the need for a diverse blend of instruments in processes involving the development of a strategy and governance in order to strengthen innovative capacity as a means of advancing transformative change. Further success factors and good practices in line with the guiding vision of "Innovation for Transformation" that target specific aspects of innovation (e. g., disruptive innovation, open innovation processes, networking mechanisms and startup environments) are presented in other papers in this series (see www.bertelsmann-stiftung.de/innovation-for-transformation-en).

REINHARD MOHN PRIZE 2020

Fostering Innovation. Unlocking Potential.

Germany stands on solid economic ground in terms of growth, exports and employment. But in order to remain technologically competitive and to solve the most pressing societal problems of our time, we need more innovation. The global challenge posed by the COVID-19 pandemic has created even greater pressure for action and exposed structural weaknesses everywhere. But the current crisis can also be leveraged by societies and communities worldwide to establish the framework conditions needed to unlock their potential, unleash their innovative energy, and pave the way forward toward a better future.

Germany has in recent years performed well in international rankings of competitiveness and innovation capability. Without question, the country features several strengths and a deep potential that justify its good placing in international innovation rankings and the esteem it enjoys more broadly. Other encouraging economic developments in the country – before the coronavirus crisis triggered a deep recession – have supported this view: Following a long period of growth, many had grown accustomed to the image of Germany persistently claiming the title of "world export champion," proving able to enjoy a strong flow of tax revenues and record-high employment rates.

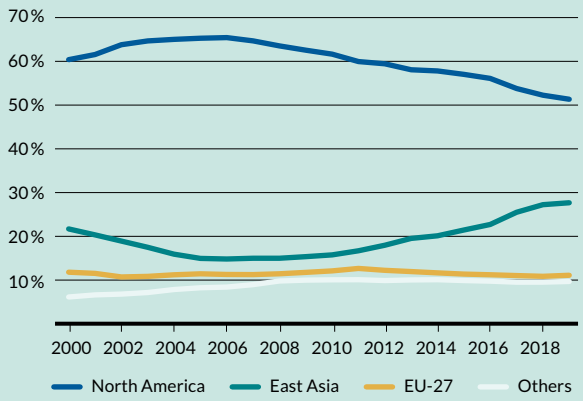
However, even before the coronavirus crisis, the focus on key economic indicators and macroeconomic trends risked obscuring certain structural weaknesses and challenges. These weak points are becoming increasingly relevant as digital transformation and technological change race ahead and require a rapid pace of innovation in order to keep up with global competition. At the same time, it is becoming increasingly clear that accelerated and targeted innovation propelled by, for example, a mission-oriented innovation policy, is the only way to meet the fundamental challenges we face.

As an industrial powerhouse, Germany has, until now, depended on its leading position in terms of technology and innovation. However, a closer look shows a declining degree of innovation in the country in recent years. We see a similar development underway across the European continent. The Bertelsmann Stiftung study "World-class patents in cutting-edge

technologies," which examines the international distribution of top patents in 58 cutting-edge technologies, highlights this development: While in 2010 Germany numbered among the three nations worldwide with the most world-class patents in 47 of the 58 technologies examined, by 2019, it had the most such patents in only 22 of these technologies. This development can also be seen in Germany's traditionally strong industrial and mobility sectors. When it comes to key digital technologies such as artificial intelligence (AI), blockchain and quantum computing, and in terms of the digital data economy more generally, the United States and China are advancing more quickly than Germany.

Figures 1 to 3, which break down the global share and dynamics of so-called world-class patents in key cross-cutting digital technologies, show the extent to which Germany and Europe have fallen behind (Bertelsmann Stiftung 2020b).

FIGURE 1
DIGITALIZATION
World-class patents in the field of digitalization technology (AI, blockchain, virtual reality, big data, quantum computing), 2000–2019



Germany also lags behind in terms of disruptive innovation. While German companies are good at incrementally optimizing existing technologies, products and procedures, they are rarely the source of innovations that revolutionize entire business models and value chains. Together with the German Economic Institute (IW Köln), the Bertelsmann Stiftung conducted a representative survey of 1,000 companies in the manufacturing and services sectors that points to a basic problem in this context (see Figure 4; Bertelsmann Stiftung 2019):

- Nearly 50 % of all German businesses have failed in recent years to adapt their innovation profile to the current situation.
- Only a quarter of German companies have the innovation expertise, organization and culture needed to maintain a competitive position in the long term. This means that many businesses do not have the appropriate R&D departments, the openness and ability (innovation culture) required to network with other actors (open innovation). In addition, many also lack the knowledge capital needed to innovate.
- Some 16 % of the companies surveyed innovate by chance. They lack both a clear innovation strategy and structured approach to innovation.
- Another 19 % are so-called passive innovators that lack internal innovation expertise and therefore feature low levels of innovation.
- As many as 11 % of the companies surveyed hardly engage in any innovation at all. These companies are caught up in an ongoing cycle of not wanting and/or not being able to innovate.

FIGURE 2
ARTIFICIAL INTELLIGENCE
World-class patents in the field of artificial intelligence, 2000–2019

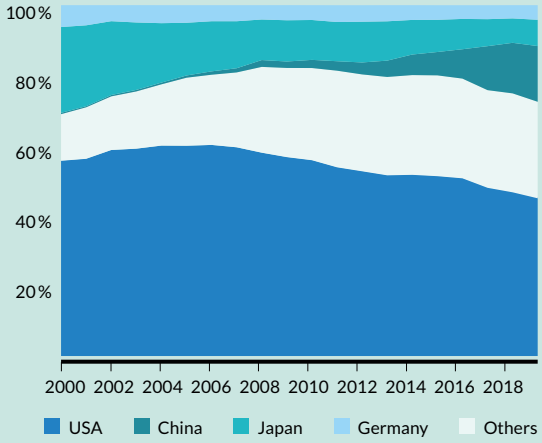


FIGURE 3
BLOCKCHAIN
Number of world-class patents in blockchain technology, 2012–2019

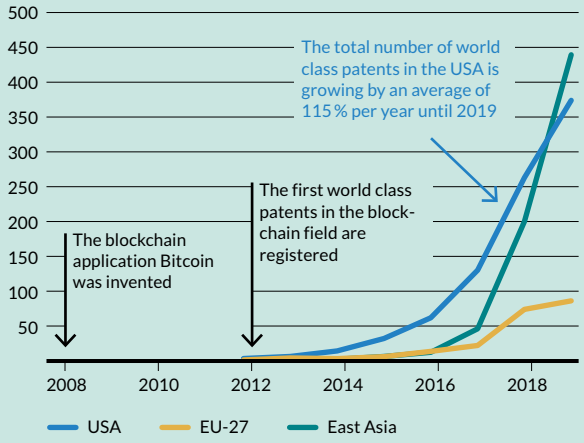
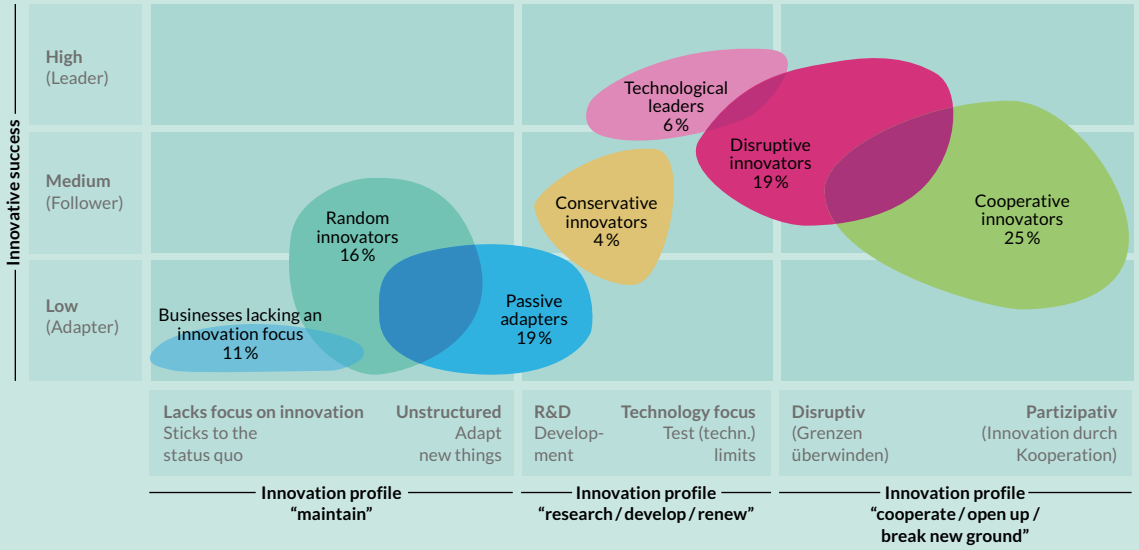


FIGURE 4
INNOVATIVE MILIEUS
Innovative Milieus in Germany (share as a percentage of all companies), 2019



N = 1.002, | Sources: IW Consult (2019); IW Zukunftspanel Welle 32, own calculation, own presentation.

Overall, in terms of innovative capacity, we see a growing gap between large companies and small-to-medium-sized enterprises (SMEs). While large companies have increased their spending on innovation in recent years, spending by SMEs in this area has been on the decline (ZEW 2019). A protracted crisis threatens to exacerbate existing disparities between the two. Many companies, impelled by the pressure to adapt during the crisis, have developed new digital solutions, products, business models and workflows in a very short space of time, seeking to rapidly modernize their organization. While they have certainly been able to unleash innovative potential, the coming distortions are nonetheless likely to be significant. The longer the crisis lasts, the more difficult it will be for many companies that previously neglected to engage in systematic digitalization to withstand the market's consolidation and selection process. Many SMEs in particular, whose research and development expenditures were already declining before the crisis, will find themselves unable in the current situation to initiate new innovation projects and will be unable to increase their investments in digital transformation. This puts them at risk of being left further behind.

Past crises have shown that companies' overall research and development expenditures show a procyclical trend. Thus, companies spend less on these tasks during recessions (Dachs and Peters 2020). This is also evident today: The coronavirus crisis has already led many companies to reduce their research and development activities significantly, or even to suspend them altogether.

The total number of new firms is also on the decline. In 2018, for example, Germany saw a 4% decline in the number of new companies founded, which marks the strongest annual decline since 2014 (ZEW and Creditreform 2019). Finally, we need to improve the conditions for the creation of (high-tech) startups by strengthening both supply – by financing growth in particular – and demand. In contrast to Israel or the United States, for example, there are far too few founders in Germany who dare to take the step from a university research context into entrepreneurship with an innovative business. This is in part due to bureaucratic red tape but is also a factor of disincentives within academia.

These weaknesses are even more evident in most other European countries. Overall, the EU as an innovation region trails behind countries such as South Korea, Canada and Japan (European Commission 2019). In order to keep pace with competitors in key economic areas and to open up new opportunities in economic and societal development, Germany and Europe must do more to foster innovation.

This involves promoting a public debate that emphasizes the need for openness to technological innovation and the opportunities it provides – without ignoring the risks involved. Addressing risks is important because sociocultural factors always play a role in cultivating the capability for innovation and an openness toward innovation. The results of our pan-European survey are remarkable in this regard: More than two-thirds of European citizens would like to see increased cooperation between European countries in the field of innovation (Bertelsmann Stiftung 2020a). This finding shows that EU citizens clearly see the need for action and can therefore be interpreted as an appeal to national governments to strengthen Europe as an innovative region through joint innovation policy efforts and thereby unleash the continent's potential.

Boosting economic and technological competitiveness and solving urgent societal challenges – innovation as a lever for transformative change

A fundamental global and overall societal challenge such as the coronavirus pandemic makes it very clear that the issue of innovative capacity is of great significance not only from an economic perspective, but also from the societal point of view. The acute upheavals caused by the coronavirus pandemic are of such magnitude that they have even temporarily crowded out what in the long term is likely to be a much greater challenge – climate change – from the media discourse. And yet we also continue to face a series of societal challenges on a global scale that are manifest most starkly in the United Nations' Sustainable Development Goals (SDGs).[1] This raises the question of how innovations in technology can help solve urgent societal problems. How can modern technologies help overcome challenges such as those associated with demographic change or climate protection? How can innovations help foster a resource-efficient economy or provide solutions to the medical challenges associated with aging societies and global pandemics?

How can innovations and modern technologies help solve urgent societal problems?

1 See www.bertelsmann-stiftung.de/de/unsere-projekte/sustainable-development-goals-index.

The deep disruptions caused by the coronavirus crisis now offer a valuable opportunity to review and adapt societal and economic priorities, and to combine them meaningfully with an agenda for more innovative capacity. The process currently evident in many countries, of trying to understand and reprioritize our societies' fundamental transformation goals, highlights the particular relevance of a holistic, mission-oriented approach to innovation.

Innovation is an essential lever in the promotion of sustainable development that encompasses economic, social and ecological aspects.

This kind of approach, which links the paradigm of "strengthening innovation and technological competitiveness" with that of "solving societal problems through innovation," allows each to mutually reinforce the other. Formulating ambitious goals aimed at solving the challenges facing society as a whole can serve as an especially effective lever with regard to promoting new technologies, driving innovation forward, increasing competitiveness and improving future crisis resilience. Today, this is particularly evident in the healthcare sector, the societal relevance of which has increased still further as a consequence of the coronavirus crisis.

Even the ambitious targets for sustainable economic development on the European continent (e. g., in the form of the Green Deal), set by the EU Commission before the emergence of the coronavirus challenge, expressed an implicit drive toward fundamental transformative change which is impossible without innovation. If one takes the objective of a sustainable economy seriously, the question of innovation capability is crucial. Given the fact of a contracting workforce potential, combined in particular with the finite nature of increasingly overexploited natural resources, the extent to which we can increase productivity levels and use resources efficiently will necessarily be determined by innovations.

This is also the underlying trajectory of SDG number 9, which targets resilient infrastructures, sustainable industry and the fostering of innovation. As an essential lever in the promotion of sustainable development and its economic, social and ecological aspects,

innovation enhances economic competitiveness and helps societies become more sustainable. Innovations can thus drive forward the kinds of transformative change that involve not only the economy but society more broadly.

Through our work, we aim to highlight new ways of strengthening European and, in particular, German innovative capacity and thereby facilitate transformative change. This raises another key question: If fostering innovation also involves processes of societal transformation, how can we ensure that technological progress is always aligned with our European values? At the Bertelsmann Stiftung, we believe that people must always be placed at the heart of technological progress that is designed to serve their needs. Our democratic and liberal values must therefore always guide our actions. This means that in the field of artificial intelligence, for example, we should strive only for those innovations that are in line with the democratic values of open societies and which respect privacy while guaranteeing transparency and fairness. With regard to AI in particular, Germany and Europe could clearly distinguish themselves – particularly vis à vis competitors such as China or the United States – by taking the lead and forging a "third" European way. Coupling competitiveness with a mission-oriented approach could then become a normative imperative, as it were.

Reinhard Mohn Prize 2020 Fostering Innovation. Unlocking Potential.

As part of the "Reinhard Mohn Prize 2020: Fostering Innovation. Unlocking Potential." project, we have sought to answer these questions by identifying noteworthy examples of innovation-promoting initiatives, mechanisms, institutions and strategies that could be applied to promoting innovative capacity in Germany and Europe. The aim is to ensure on the one hand that Germany remains technologically – and thus economically – competitive. On the other hand, the goal is to address societal challenges while ensuring humane, democratic and inclusive economic development. We start from the premise that two paradigms – "strengthening innovation and technological competitiveness" and "solving societal problems through innovation" – can be combined to mutually reinforce each other. In line with Reinhard Mohn's guiding vision of "learning from the world," we are therefore taking a closer look at particularly strong examples of good practices from around the world. After all, it is the exchange with other countries that allows us to unlock our own potential.

Actions must always be guided by our democratic and liberal values.

With this vision in mind, the Bertelsmann Stiftung conducted an extensive international good-practice research study (see 5.1 in the appendix) and, in cooperation with the Fraunhofer Institute for Systems and Innovation Research ISI, bundled the findings in four results papers. Each paper has a different focus but explores the extent to which competitiveness can be linked with mission-driven approaches to societal issues.

- The **first paper** (present study) outlines the theoretical framework used for the global study and draws on selected international case studies to show how a broader umbrella strategy for innovation can effectively combine technological and economic competitiveness with efforts to solve societal issues. The paper explores in particular the aspects of governance involved with innovation policy and shows what Germany has to learn from examples in other countries.

- The **second paper** examines how the development and diffusion of new and societally relevant technologies can be promoted through appropriate networking mechanisms that engage actors in business, research, politics and civil society in open innovation processes. The paper thus features several examples of good practices found in other international contexts that both Germany and Europe can learn from.

- The **third paper** takes a close look at how the framework conditions for disruptive innovations in particular can be strengthened. It also describes the lessons learned in countries such as Israel, Japan and the United States that are relevant for Germany in its efforts to become a top location for innovation.

- The **fourth paper** is devoted to the question of how to improve the conditions for establishing and growing societally relevant (high-tech) startups in their initial phase of being founded. The paper thus presents a variety of good practices from examples around the world and discusses their key takeaways.

- **Conclusions** derived from all four papers are integrated into the **"An Agenda for the Future: Innovation for Transformation"** publication.

Each paper is available at www.bertelsmann-stiftung.de/innovation-for-transformation-en.

In the future, only communities that face up to global competition and repeatedly demonstrate their ability to innovate and perform can succeed and endure.

Reinhard Mohn

CONTENT

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1.

Fostering innovation – tackling societal challenges

Climate change, cancer, water pollution, CO_2 emissions in urban areas, rising levels of inequality and risks to the sustainable supply of healthy foodstuffs are urgent societal challenges affecting the lives of citizens in Europe and Germany in equal measure (European Commission 2020). With the adoption of the 17 Sustainable Development Goals, the member states of the United Nations have declared their intention to redirect their innovation policies and focus on addressing societal problems of this kind through 2030 (UN 2019). The European Union, too, is currently positioning itself at the forefront of such policymaking. In the context of the Green Deal, the EU wants to invest around €100 billion by 2027 in making Europe increasingly climate-neutral, while at the same time increasing the continent's competitiveness and innovative capacity.

The paradigms of "strengthening innovation and technological competitiveness" and "solving societal problems through innovation" can be effectively combined through the use of appropriate strategies and governance structures.

The German economy is also benefiting from technological innovation, for example within the automobile, medical technology, mechanical engineering and logistics sectors (HTS 2015). While this is creating new opportunities to expand sales within global markets, it is also positioning the country as a pioneer in the development of strong solutions to urgent global challenges that could change the lives and work of much of the global population. Innovations in the areas of quantum technology, artificial intelligence and electromobility could also make important contributions in this regard.

As a result, expectations regarding what innovation policy can or should deliver have expanded significantly in recent years. In addition to the "traditional" goal of fueling companies' growth rates and strengthening a country's competitiveness through measures that foster innovation, today's innovation policy is increasingly called upon to stimulate innovations that make critical contributions to solving problems in society. However, the "how" of such policies often remains obscure: What are the key factors contributing to success? What elements of governance are needed in order to ensure that, in practice, innovation policy effectively links the two paradigms of competitiveness and mission-driven approaches?

The current study formulates answers to these questions and discusses the degree to which the two sets of goals can, in practice, be combined in innovation policy. In doing so, it examines international good practices from the Netherlands, the United Kingdom, Sweden, Japan and Canada. To begin with, the following chapter presents the conceptual and theoretical foundations of an innovation policy that targets both competitiveness and solutions to societal problems. In addition, it identifies those elements that are essential to such a policy's success.

2.

Innovation for transformation involves linking competitiveness with a mission-driven approach

The desired benefits associated with innovation and thus with innovation policy have fundamentally changed over the course of the last few decades. During the post-war decades, attention focused on what contributions the diffusion of inventions and innovations in markets and applications could make to economic development. In accordance with this view, innovation policy was primarily oriented toward strengthening companies' innovative capacities by providing appropriate funding, setting incentives and developing effective regulatory frameworks. This paradigm remains characteristic of the design and implementation of innovation-policy measures in most developed countries today. However, more recently, an additional demand on innovation has gained weight within the discourse: Given the urgency of societal tasks such as combating climate change, adapting to changing demographics and creating a sustainable agricultural system, the expectation that research, technology and innovation efforts will prove essential to addressing these challenges is growing.

These two paradigms differ not only in terms of their objectives, but also in terms of the rationales underlying the policies and instruments they inform, and the specific challenges associated with the implementation of such interventions. As a consequence, coherently combining the two innovation-policy paradigms involves substantial effort, as it requires a careful expansion of existing approaches, arrangements and instruments. In the following (2.1 and 2.2), we will delineate both paradigms and then illustrate the possibilities associated with a productive combination of the two approaches (2.3).

Research, technology and innovation must contribute to solutions addressing societal challenges.

2.1 TRADITIONAL INNOVATION POLICY

Strengthening competitiveness by improving innovation expertise, capacities and networks

Since the end of World War II, the achievement of primary economic goals such as growth and competitiveness has constituted the dominant justification for research-, technology- and innovation-policy measures. The rationales underlying this basic approach to innovation policy have shifted over time as both the problems being addressed and research findings regarding the conditions for innovation have changed.

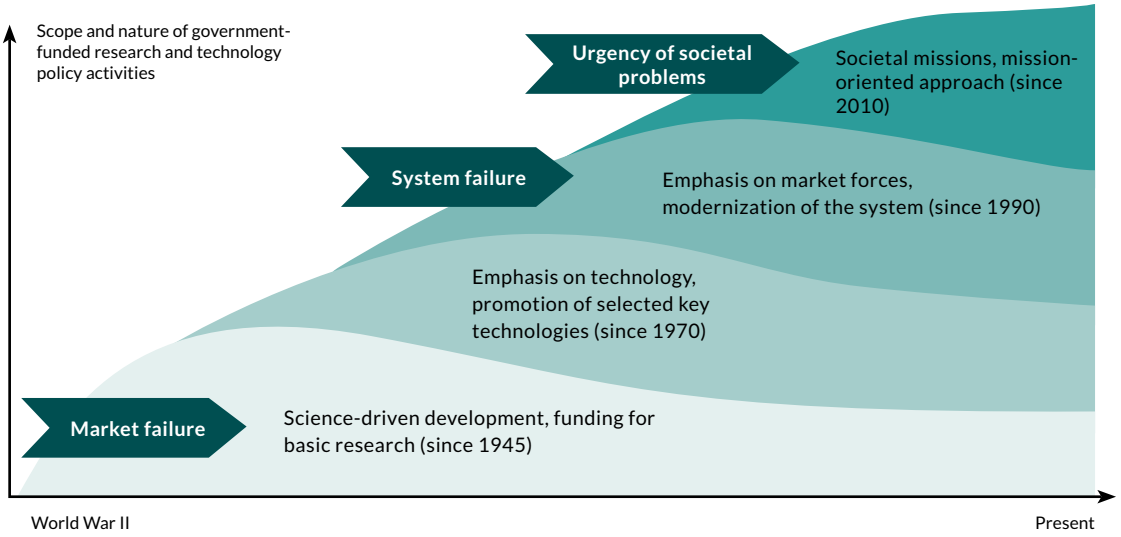
- Initially, research, technology and innovation (RTI) policy was justified primarily by pointing to market failures in the generation of knowledge.
- Beginning in the early 1990s, a shift in perspective set in that led innovation policy to focus instead on addressing apparent weaknesses in (national) innovation systems.
- More recently, a further shift has taken place that sees a stronger focus on societal challenges as a requirement for legitimacy (for details, see 2.2).

Figure 5 provides a schematic depiction of the priorities and legitimacy requirements of in-novation policies over time.

FIGURE 5

RESEARCH AND TECHNOLOGY POLICY

Scope and nature of government-funded research and technology policy activities (based on Daimer et al., 2012; Gassler et al., 2006).



2.1.1

Market failure as a legitimation for innovation policy

The focus on market failures in the initial post-war decades was driven in large part by the contemporary state of knowledge in economics regarding the role of science and technology in explaining economic growth (Solow 1957). At that time, it was assumed that new knowledge, which is primarily generated in research and development processes, was the most important source of innovation. Due to the assumed public-good character of knowledge and the associated free-riding problem, as well as the generally high levels of uncertainty regarding the chances of successfully bringing research results to market, the argument was made that the investments needed to generate knowledge would not appear if left solely to market mechanisms (Arrow 1962; Nelson 1959). The justification for many state innovation-policy interventions were – and continue to be – based on this understanding of market failure, which is grounded in the neoclassical school of economic thought.

Though this has now been largely superseded, this early school of thought regarding innovation policy was closely tied to a linear conception of change. This view regarded innovation as being primarily the commercialization of scientific discoveries which, in turn, were driven largely by the economic logic of private investments and the expectations of returns. It was assumed that the production of knowledge would result almost automatically in spill-over effects in the form of technological application.

Against this background, innovation policy in the true sense can be said to have emerged only in the 1970s, as policy measures before this time were aimed primarily at the generation of knowledge that was comparatively insulated from the market, and which thus had only a tenuous link to innovation per se. Funding polices of the time were focused on indirect impact rather than on direct innovation by companies.

Among the approaches used to address the phenomenon of market failure in generating knowledge, many measures focus on the early phases of scientific discovery and invention and give secondary priority to the later phases of commercialization and application. Thus, the most significant instruments based primarily on the rationale of market failure include:

- Public funding of university and basic research, with the aim of securing the knowledge base for future innovations.
- Financial incentives and direct support or subsidies, with the goal of stimulating and strengthening companies' research and development activities, which would be low-er in intensity or altogether absent without such aids.
- Intellectual property rights and copyright regimes intended to create incentives for private sector investments in knowledge. This type of instrument is meant to address the underlying cause of market failure in knowledge generation (Edler and Fagerberg 2017).

On the institutional level, the rationale of market failure in the initial post-war decades was typically reflected in the gradual establishment and expansion of national research-funding agencies. The need to coordinate research-funding policy measures, for example between different ministries, was extremely low.

2.1.2

Using innovation policy to modernize systems

Beginning in the 1970s, a number of factors led to a thorough revision of both the theoretical and conceptual foundations of innovation policy. On the one hand, the long period of high growth and employment rates in Western developed countries came to an end, even as economic competition between nations intensified. On the other hand – in a phenomenon closely linked to the changed economic circumstances – essential basic assumptions regarding the relationship between knowledge and innovation were called into question, as empirically observable phenomena could no longer be explained using the concepts deemed valid to that point. For example, research had shown that technological knowledge could not be transferred unconditionally between actors for the purposes of economic exploitation, as had previously been assumed in the theory of market failure. Rather, most such knowledge is implicit, requiring extremely sophisticated measures to be absorbed and adapted to specific contexts (Cohen and Levinthal 1989; Hippel 1994; Metcalfe 2005). For example, manufacturers of wind turbines cannot simply purchase complex sub-components such as gears and generators on the market. They must instead innovate in order to ensure such components can be integrated into their systems and manufacturing processes (Jackwerth 2019).

In addition, the linear conception of innovation that had prevailed to that point was replaced by a non-linear, recursive understanding that emphasized the significance of interactions and relationships between different actors – such as those who develop and those who use the technology – in the innovation process (Etzkowitz and Leydesdorff 1997; Gibbons et al 1994; Kline and Rosenberg 1986). These reconceptualized ideas, coupled with the growing interest among political actors and the research community in the relationship between technological innovation and economic development, led to the swift rise of a new analytical and interpretative framework – that of the "National Systems of Innovation" approach (Freeman 1987; Lundvall 1992; Nelson 1993). This innovation-system approach remains, to date, the most important framework for innovation policy. It continues to guide many governments and international and supranational organizations such as the OECD and the European Union in their formulation of conceptual frameworks and strategies.

The innovation-system approach begins with the premise that innovation is the result of interactive and interdependent processes involving the participation of a variety of actors from different subsystems. Thus, in this systemic perspective, innovation is not an isolated process that takes place within a company, but is instead a collective process involving a range of different actors (such as firms, universities, research centers, state institutions, and so on). The actors' behavior is influenced by institutions and structures – that is, laws, regulations, norms and behavioral routines – which can, in turn, facilitate or stymie innovation. The various actors and institutions constitute the components of systems in which knowledge is generated, and in which products are developed and ultimately commercialized. These "innovation systems" therefore comprise both the actors involved in the processes of innovation and the most important legal, social, economic and political factors that influence innovations (Edquist 2011).

Learning processes are regarded as one of the key drivers in the innovation-system approach. The generation of new knowledge and/or the novel (re-)combination of existing knowledge stocks is assumed to lie at the heart of innovation processes. Interactive learning between firms and other actors within an innovation system is characterized by complex relationships, diverse feedback loops and reciprocity. In addition to the emphasis on interactive learning processes and the role of relationship structures between the actors, innovation is recognized as an evolutionary, nonlinear process, in which path dependencies and historical contingencies play a critical role. Finally, this approach accords the state a constructive and quite active role in the innovation system.

These basic assumptions of the innovation-system approach have far-reaching implications for innovation policy. The point of departure in this regard is the analysis of the strengths and weaknesses of institutional conditions and the (comparative) performance of the innovation system. Typical innovation-policy measures are therefore aimed at remedying identified system deficits (for an overview of significant system deficits, see Weber and Rohracher 2012).

Two primary starting points for innovation policy can be derived from the underlying logic of the innovation-system approach:

1. Measures that contribute to improving the provision and availability of resources necessary for innovation processes, such as different types of knowledge, capabilities, capital, supply and demand, and so on.

2. Improvements in the relationships and interactions between the actors in the innovation system, as well as in the skills and capacities necessary for productive exchange (Edler and Fagerberg 2017).

The typical instruments used to address the ways in which the system falls short include:

- Measures promoting the development and expansion of the skills and capacities needed to generate innovations and bring them to market. This may include education and training programs, as well as entrepreneurship-support measures and the provision of other support and advisory services.

- Policy instruments that focus on supporting interaction and learning processes between relevant innovation actors. This includes initiatives promoting the creation of networks and other cooperative relationships between actors. Traditional cluster policies also fall into this category.

- Targeted instruments for the stimulation of demand for innovation, such as public procurement measures or innovation competitions. These are a relatively recent phenomenon, complementing the majority of measures in this area that have focused on the supply side.

- Regulatory instruments and standards, a category that plays an important role in shaping a favorable environment for innovation.

As the significance of innovation-policy measures aimed at modernizing systems has grown in both a de facto sense and in terms of the quantity of individual measures, the demands on governance associated with the numerous funding and other support activities have also increased. In many countries, for example, a considerable number of specialized organizations, agencies and institutions – whether state-operated, semi-state or private – have been created and entrusted with various aspects of innovation support (technology transfer, startup support, innovation funding, network creation, etc.). At the government level, responsibility for this area had often previously been placed within a single ministry, typically the ministry for research and education or the ministry of economic affairs. Now, in the context of innovation policy's growing importance for economic development, this responsibility has been redistributed across a larger number of portfolios. This is, in turn, associated with a significantly increased need for horizontal coordination and agreement. But viewed along the vertical axis too, a complex web of policy measures has now developed that range from the supranational down to the local level, and which accordingly increases the need for multilevel governance.

In sum, it is clear that each of the two innovation-policy rationales outlined here – market failure and the need to strengthen systems – focus on the economic effect of innovation, with the ultimate aim of enhancing competitiveness and fueling economic growth. From this perspective, innovation is considered to be desirable per se, as it is seen as the central driver of economic growth and national competitiveness. This has remained the dominant goal of established innovation policy up to the present day, even as key assumptions about the role of knowledge in innovation processes, and indeed the conception of innovation itself, have changed.

Innovation is a driver of economic growth and competitiveness.

2.2 A NEW MISSION-ORIENTED INNOVATION POLICY

Achieving clearly defined societal goals through innovation

In recent years, we have seen national governments increasingly focus on clearly defined societal goals, or so-called missions, which are to be fulfilled using the instruments of innovation policy (JIIP 2018b; Kuittinen et al. 2018a; Larrue 2019). Such mission-oriented innovation policies are a fundamentally new phenomenon. To be sure, the definition of state missions or priorities employed by science and research is hardly a novelty. Traditionally, however, these missions have not been designed to achieve societal goals. The legitimation for promoting basic research has always been based on the idea that scientific knowledge finds its way into application through the market or through relevant state policies (health policies, security policies, etc.).

In the 1960s and 1970s, key selected technologies and/or scientific fields were defined as being deserving of special support, with the expectation that setting such priorities would have an indirect positive economic effect on international competitiveness. This targeted promotion was premised on the anticipation of potentially wide-ranging benefits associated with basic research and selected technologies. However, this form of innovation policy typically made no overt effort to influence the downstream societal effects generated by the ways in which this knowledge or these technologies are implemented.

In recent times, this has changed. In contrast to established policies supporting the generation of knowledge and selected technologies and innovation activities, this new mission-oriented approach to policy begins with clearly defined societal problems and strongly promotes innovation as a means of helping solve these problems. Figure 6 clearly shows that the specific priorities of the new mission-oriented approach differ from previous priorities in state-level science, research and innovation policies.

The new mission-oriented approach fosters innovations that contribute to solving societal problems.

FIGURE 6

SCIENCE AND INNOVATION POLICY

Differing priorities in science and innovation policy

SCIENCE-BASED DEVELOPMENT

Basic research: open scientific processes lead to technological solutions
Legitimation for state action: finances basic research in order to address market failures but sets no priorities beyond prevention-related research

TECHNOLOGICAL PRIORITIES

Top-down determination of key technologies, with the expectation that market forces will allow these technologies to have a broad economic and societal impact
Legitimation for state action: addresses market and system failures and sets political priorities based on expectations

ECONOMIC ORIENTATION AND MODERNIZATION OF SYSTEMS

Goals: competitiveness, growth, jobs
Constitutes the core of traditional innovation policy, and is the primary rationale for science policy
Innovation as a policy goal in itself (economic effect determined by market forces); science as a means of innovation
Legitimation for state action: need to remedy system failure

SOCIETAL MISSION

Begins with defining specific societal problems
Involves the expectation that innovation policy can make a critical contribution to solutions; innovation is seen as a means to a defined end
Legitimation for state action: urgency of identified societal problems; remedy market/system failures by solving problems

Over the last 15 years, mission-oriented innovation policy has shifted attention toward addressing the so-called grand challenges through innovation policy. Since about 2005, the idea has taken hold particularly at the European level that innovation policy cannot be limited to economic growth. Rather, due to the urgency and scale of societal challenges such as climate change, obesity and species extinction, it should be purposefully oriented toward solving problems (Aho 2006; Lund Declaration 2009). At the global level, the United Nations' Sustainable Development Goals (SDGs) have had a broad impact, which is reflected in numerous countries in the form of new innovation-policy initiatives. The idea of problem-oriented innovation policy has found a foothold in numerous national RTI policies and thus complements the conventional means of legitimizing innovation policy. As a consequence, the mission-oriented approach has become, in a narrower sense, the operational translation of the problem-driven approach into specific objectives (JIIP 2018b). Particularly at the EU level, this has become the centerpiece of future-oriented innovation policy (Lamy 2018; Mazzucato 2018).

2.2.1 RATIONALE

Advancing transformative change

The justification for placing innovation policy at the core of mission-driven policy lies in the aspiration of achieving goals more quickly and effectively through the development of innovations. In this regard, it is significant that mission-driven goals – for example in the areas of climate change or sustainability – cannot be achieved solely with the introduction of new products or services. Indeed, it is essential that various innovations, behavioral changes and infrastructural adaptations mutually reinforce each other. When this is the case, mission-oriented innovation policy de facto contributes to transformative change.

Here's an example: In order to realize the mission of establishing sustainable, CO_2-neutral transportation concepts within a municipality, a comprehensive transformation of "municipal mobility" systems and how they operate is required. This involves developing new technologies, services and infrastructures, changed mobility behavior, and adapting to existing regulations (see Figure 7).

Missions can therefore be understood as more or less comprehensive contributions to the holistic transformation of systems that, in some cases, require entirely new configurations of actors, institutions and practices.

FIGURE 7
TRANSFORMATIVE CHANGE: THE EXAMPLE OF ELECTROMOBILITY

The desired shift toward electromobility illustrates the societal implications of a mission-oriented policy. It presupposes a well-coordinated interplay of different instruments. These include:

- **Infrastructure conversion** through a new network of charging stations.
- Significant financial **incentives, subsidies or tax rebates** in order to motivate citizens to purchase electric cars.
- The further **development** of legal **regulations** and the **development of new standards** in order to provide legal and behavioral certainty for actors.
- **Funding of research** into alternative drive technologies, including aspects such as battery life, hydrogen-based technologies and hybrid models, in order to make such advances reliable and suitable for everyday use.

The aim and implementation of mission-oriented innovation policy must be seen in this broader systemic context. It bears the following distinctive features:

- Clearly defined goals that target transformative change. Policy must orient innovation behavior toward the support of transformation, in part by establishing specific and substantive priorities.

- A cross-sectoral structure that spans departmental or ministerial portfolios. This is required by the systemic nature of the transformation needed.

- A focus on the demand for and diffusion of innovations. This is necessary because innovations must be widely adopted in order to achieve the goal.

The specific rationale for state intervention can be linked to a democratic imperative and four bottlenecks that can render transformative change more difficult despite the best intentions of the social and political actors involved. The democratic imperative consists in the observation that once a society has not only identified certain problems as urgent and serious, but has elected to seek collective solutions to them, promoting innovation while steering it toward specific objectives (directionality) is a sensible and effective mechanism of state policy. The four bottlenecks to the deep system-level transition that is needed to solve problems (Weber and Rohracher 2012) derive from the fact that in the absence of a state-driven mission-oriented innovation policy:

- the direction of the desired change will not be determined in a binding manner;

- societal needs will not necessarily be reflected in market demand, particularly in the case of radical innovations;

- the coordination across policy areas will prove insufficient;

- it will be difficult or impossible to mobilize the strategic-analytic capacities needed to focus on mission goals or transformative change, and thus difficult to define appropriate measures.

Overcoming these bottlenecks through consensus requires political instruments and governance structures that go beyond the traditional innovation-policy mechanisms.

Clearly defined goals that target transformative change characterize mission-oriented policy.

2.2.2

Instrumentation and governance

Real-world implementation of mission-oriented innovation policy remains in its infancy. Moreover, due to the diversity of missions and institutional conditions found in different countries, there is to date no clearly discernible pattern among the various policy instruments or governance approaches. Nevertheless, it is possible to identify some key elements that can be regarded as basic conditions of success. These are described below.

- Given the aspiration to design innovation systems in ways that address societal challenges, a broad societal acceptance of missions and processes is necessary. This typically requires the widespread involvement of diverse actors from business, politics and civil society (users and stakeholders) in the process of defining missions and setting out mission paths.

- In addition, the actors should also be involved in the coordination of appropriate policy instruments; in recent times, this has implied a mix of different instruments (JIIP 2018a; Larrue 2019). Particularly crucial in this mix of instruments are the mobilization of demand (Edler 2016) and targeted regulation and standardization efforts, each of which plays an important role in supporting and stabilizing mission paths once adopted (Blind 2016a, 2016b).

- The complexity of deep system-level transitions increases the need to employ a broad range of methodologies during the mission-definition phase (for example, the use of forecasting processes), as well as in analyzing system changes and specific policy contributions.

- Generally speaking, mission-oriented innovation policy demands new approaches in government that support learning, reflexivity, reversibility, dynamism and openness ("tentative and reflexive governance") (Kuhlmann and Rip 2014; Lindner et al. 2016).

2.2.3

Specific challenges of mission-oriented innovation policy

Mission-oriented innovation policy is additionally characterized by a series of specific challenges that go beyond those of traditional innovation policy. First, a mission-oriented approach necessarily leads to a new, unprecedented politicization of innovation policy. This is because the establishment of mission goals also entails making binding decisions regarding societal priorities; these are often normatively controversial, and generate "winners" and "losers" in a material sense.

This implies a major challenge for policymaking actors, who must develop new processes for reaching agreement on these societal priorities. Ultimately, this calls for a state-moderated process that defines the corridors of societally acceptable transformation paths (Weber and Rohracher 2012). Securing the involvement of the broad groups of actors necessary to this task also presents a technical challenge to state governance capacities. The state must strike a balance, keeping the effort expended on this task at a manageable level while also eliciting the greatest possible societal support for missions.

Second, mission-oriented innovation policy is associated with a fundamental problem of state coordination. Innovations and their diffusion are often only a necessary, not a sufficient condition for missions to be accomplished. In most cases, one or more policies within specific sectoral areas are needed to contribute to the fulfillment of the mission or to remove obstacles. The strategic ownership of a mission is largely determined by its framing and instrumentation. However, strategic ownership can also create ideological, instrumental or power-political friction that conflicts with other sectoral policies that are essential to a mission's success. The specific role of innovation policy in the context of a mission-oriented approach is therefore fundamentally indeterminate. On the one hand, it may function at the very least as a facilitator of the expertise needed to achieve a mission driven more actively within other sectoral policies. On the other, it may itself be the driver, providing active support for concrete structural transformation and behavioral changes (Edler and Nowotny 2015).

FIGURE 8

CHARACTERISTICS OF MISSION-ORIENTED INNOVATION STRATEGIES

(see Kuittinen et al. 2018b)

- **Directionality** (specific and well-structured objectives)
- **Measurability and time limits** (clear milestones and time frames)
- Focus on multiple **bottom-up solutions** (multiple simultaneous research projects that offer different solutions, but with a common objective)
- **Reflexivity** (periodic monitoring and evaluation of ongoing projects) and **flexibility** (dynamic allocation of resources according to need/success/failure)
- **Societal relevance** (missions that reflect and address societal challenges)
- **Interdisciplinary, cross-sectoral** and **multi-actor engagement**
- Active participation by relevant **stakeholders**
- Clear lines of **responsibility** and **leadership** (centralized responsibility for the mission)
- **Measures** addressing both the **supply** and **demand side** ("complete policy package")
- Creation and / or application of **knowledge** (basic and applied R&D)
- Mixed public and private **funding** (promoting the development of public goods, but also enabling the commercialization of new technologies)
- Sufficient **budget** (enabling effective impact and the achievement of objectives)


ROBOT

2.3 COMPETITIVENESS AND SOLUTIONS TO SOCIETAL PROBLEMS

The relationship between the two paradigms

An innovation policy that aims to combine the benefits of the two paradigms described above – an orientation toward competitiveness and toward the solution of societal problems – must specify from the outset how the two paradigms relate to one another, both conceptually and at in terms of implementation. What are the possible tensions? What are the complementarities between the two paradigms, and how can these be mobilized to produce synergetic and mutually reinforcing benefits? To date, the conceptual literature has had little to contribute to these questions. As noted above, this literature has in recent years focused very strongly on the opportunities and limitations of mission-oriented innovation policy itself, as well as on the different types of missions and associated challenges for governance. The potential range of interactions with the growth- and competition-oriented approach has not yet been sufficiently analyzed.

To help in understanding the interplay between the two approaches, Figure 9 summarizes the fundamental differences between the two. We distinguish here between the types of justification, the bases for societal acceptance (legitimacy), and the necessity for systematic support of both the policy-development and implementation processes as a basic prerequisite for success.

Figure 9 shows that the ambitions underlying the mission-oriented innovation policy approach are considerably more expansive and involve more prerequisites than is the case for traditional innovation policy. For example, the mission-oriented innovation policy approach looks beyond efforts to improve the generation of innovation and the resulting economic effects, taking in the utilization and diffusion of these innovations as well. Its success is then measured by the degree to which its mission has been fulfilled. While traditional innovation policy focuses on the needs of and bottlenecks experienced by public research institutions and firms in their research and innovation development, a promising mission-oriented innovation policy must:

- Take all actors important to the mission's success into account, and then mobilize them to work toward achieving the mission.

- Influence the absorption and use of innovations in the manner envisioned in the mission plan, while identifying and as necessary addressing obstacles in the attitudes and behavior of all relevant actors, both on the supply and demand sides.

- Ensure that regulatory environments and infrastructures are in place that promote the envisioned use and diffusion of innovations. This requires very comprehensive knowledge of the relevant constellations of actors, markets and underlying conditions, as well as an idea of how the innovation-policy intervention is capable of fulfilling the mission.

What does this comparison of the two approaches of traditional and mission-oriented innovation policy – presented here in simplified ideal forms – tell us about their relationship, in conceptual terms?

First, traditional and mission-oriented innovation policies can mutually reinforce each other, either through deliberate investment or through unintended but positive side effects. For example, an innovation policy focused on fulfilling missions could create a dynamic in the affected economic sectors and value chains that increases competitiveness more broadly. This, in turn, can trigger positive economic effects that spill over into other economic and societal areas. Conversely, the comparatively undirected, broader strengthening produced by innovation policy might additionally render innovation systems more capable of solving problems. A policy that broadly makes companies more innovative will indirectly increase the probability that innovative solutions generated through market mechanisms will also contribute to societal benefits.

A positive link of this kind can be pursued through the facilitation of lead markets (Beise-Zee 2004; Edler et al. 2012; Jänicke and Jacob 2004; Quitzow et al. 2014). The basic idea behind this tack is that within a system (typically a country), an initial market is created for certain societal needs by using a mix of supply-oriented, regulatory and demand-oriented instruments. Such approaches typically define areas of focused support in such a way as to facilitate the development of products or services for which there is also need and demand in other countries (Beise-Zee 2004; Edler et al. 2012; Jänicke and Jacob 2004; Quitzow et al. 2014). This concerted approach subsequently leads to a competitive advantage for the domestic industry relative to other countries. In these approaches, therefore, the satisfaction of important domestic societal needs is linked synergistically with the provision of economic benefit to domestic companies and thereby also caters to international demand through the export channel. The most important examples of such approaches can be found in the area of energy-efficient technologies (Beise-Zee 2004; Edler et al. 2012; Jänicke and Jacob 2004; Quitzow et al. 2014).

Traditional and mission-oriented innovation policy can mutually reinforce each other in positive ways.

FIGURE 9

COMPETITION AND MISSION-ORIENTED APPROACHES

Characterization of competition-oriented vs. mission-oriented innovation policy (based on Boon and Edler 2018)

	COMPETITION-ORIENTED (TRADITIONAL) INNOVATION POLICY	MISSION-ORIENTED INNOVATION POLICY
Justification for state policy	• Intervention aimed at modernizing the system without substantive direction. • Market and system failures. • Focus on technology and actors. • Innovation policy as economic policy.	• Intervention that targets transformative change. • Focus of research and innovation activities (solution supply) and markets (demand) on specific problems. • Innovation policy as problem-solving policy.
Results-based public acceptance	• Innovation performance (better performance through more innovation). • Growth, competitiveness, increase in exports as a basis for prosperity.	• Solution to societal problems. • Societal progress through fulfillment of the mission.
Process-driven public acceptance	• Coordination with R&D organizations, economic associations. • Credibility with regard to innovation system due to institutionally coordinated exchange in networks.	• Involvement of actors from research and development sector (private, public) and from societal groups (users, stakeholders). • Credibility necessary both with regard to innovation and the mission context.
Expertise and methodological support ("strategic intelligence")	• Established methodology for ex ante and ex post evaluation of research and innovation instruments, from both technological and economic perspectives.	• Ability to define missions and generate public support. • Knowledge of all conditions throughout system in order to fulfill the mission. • Use of appropriate instruments, such as foresight methodologies. • Societal impact analyses; evaluation of degree to which mission has been fulfilled.

Second, traditional and mission-oriented innovation policies may at the same time also have conflicting goals. Mission-oriented policy has the consistent aim of achieving its objectives as efficiently and effectively as possible. Economic effects are assigned a secondary priority behind the primary goal of solving societal problems. This can in some cases lead to a situation in which policy measures produce significant benefits for foreign actors, or for those otherwise outside the system. For example, if the demand for innovative energy-efficient technologies used for the achievement of climate-policy goals is deliberately enhanced through public procurement or demand-side subsidies, this demand for innovation may be satisfied to a significant extent by foreign providers, which as a consequence further improve their competitive position relative to domestic providers. Such effects have been discussed in the photovoltaic-cell and wind-turbine sectors in Germany, for example, and have been demonstrated in various economic studies (Edler 2016; Peters et al. 2012). Thus, in this case, the demand-oriented innovation policy motivated by climate-policy goals has at least short-term adverse effects on domestic competitiveness. Conversely, the dominance of traditional innovation-policy considerations can limit the range of societal problems that can be addressed by innovation policy. Similarly, traditional measures may bolster the innovative capability of industries which, due to the role they play in structural terms, do not – beyond meeting growth demands – contribute in the medium term to efforts targeting sociopolitical goals. In some cases, these industries are perhaps even detrimental to such efforts.

Some countries anchor their mission-oriented innovation policy in an innovation agency such as Vinnova.

Finally, linked to the question of how different goal systems interact, each paradigm is also associated with different constellations of relevant political actors. Traditional innovation policy is typically defined and implemented by innovation ministries, ministries of economic affairs, or specially created innovation agencies (Edler and Fagerberg 2017). As a consequence, innovation policy is often situated between science and research policy on the one hand, and economic policy on the other. The respective constellations and divisions of labor are in this regard very different in different countries.

The definition and implementation of mission-oriented innovation policy is less clear-cut than that of traditional innovation policy. In many countries, it is overseen by the institutions responsible for traditional innovation policy. These countries are thus attempting to implement a new mission-driven policy by building on the logic of modernizing the system, or on that employed by traditional technology-oriented objectives. However, this structure can make it difficult for individual ministries to fulfill the mission-oriented innovation policy prerequisites identified

in Figure 8. This is particularly true with respect to the requirements for broad knowledge regarding actor constellations and societal problems, and for the ability to employ the instruments appropriate to achieving the mission. In other countries, by contrast, mission-oriented innovation policy approaches are situated within innovation agencies whose expertise combines the otherwise siloed expertise associated with a specific mission and type of innovation. For example, the Vinnova innovation agency in Sweden pursues a holistic approach of this kind (see 3.2.3 and Marklund 2019). A third variant is being pursued at the European level, for example with the European Environment Agency (EEA). As a mission-driven agency (for issues having to do with the environment and climate change), the EEA promotes sustainable transformation using innovation-policy approaches, among other tactics. Within this constellation, the achievement of environmental policy goals predominates, but direct economic effects are not a subject of the agency's consultations or policies.

The relationship between the two paradigms is thus already inherent to the actors' responsibilities. It is therefore essential to understand what configuration of actors and what policy-coordination mechanisms will be most beneficial for the combination of traditional innovation policy and mission-oriented innovation policy. Empirical research on appropriate governance approaches remains in its early days (Polt et al. 2019). However, it can be said that an effective blend of traditional and mission-oriented innovation policy requires a combination of cross-sectoral expertise and a broad mobilization of actors. In order to ensure a fruitful interplay between competitiveness and a mission-driven approach, this should take place both within the innovation system per se and in the arena in which the mission itself is being pursued. The specific details of this combination will inevitably depend on the political system and the scope of innovation-policy ambitions. However, in conceptual terms, a holistic, cross-sectoral approach is presumably required in order to derive the greatest possible synergies from the union of the two paradigms while, at the same time, maximizing desired interactions and minimizing undesired effects.

An effective blend of traditional and mission-oriented innovation policy requires broad mobilization.

3.

Fresh momentum for German innovation policy

The conceptual framework provided in the previous chapter illustrates at a very basic level the opportunities and potential associated with a deliberate combination of the two main innovation-policy paradigms identified above. We assume that with a mission-oriented innovation policy, solutions for societal problems can be generated more swiftly and effectively at the same time that key economic goals such as competitiveness, technology leadership and economic growth are addressed. However, shortcomings can be observed with regard to the efficacy of linking the established competition-driven approach with the still-novel mission-driven approach, especially within the German context. Against this background, this results paper presents selected examples of international good practices as a means of providing impetus for the further development of innovation-policy strategies, structures and instruments within Germany. For this discussion, we start by examining the key challenges in the implementation of the German federal government's High-Tech Strategy (HTS).

A mission-oriented innovation policy can help generate solutions to societal problems more quickly and effectively.

3.1

Challenges in implementing Germany's High-Tech Strategy

The High-Tech Strategy (HTS) constitutes the central framework for the conception and implementation of federal innovation policy in Germany. Since the release of its first iteration in 2006, the HTS has been revised several times (in 2010, 2014 and 2018), with each successive version having a different emphasis (Daimer et al. 2017). Each of the high-tech strategies to date have taken a cross-sectoral research- and innovation-policy approach, thus aligning a significant portion of the federal ministries' various research- and innovation-related funding programs and measures behind the goals of the HTS. Despite this cross-sectoral approach, the German Federal Ministry of Education and Research (BMBF) has taken and continues to take a leading role with regard to shaping and implementing the strategy. While this integrative, interministerial aspect can be observed in each of the HTS generations, a greater amount of change has been evident at the thematic level. The first HTS still focused primarily on supporting selected high-tech sectors and improving regulatory conditions within these sectors. However, by the second issue of the HTS in 2010, the strategy had already shifted to focus on societal challenges.

In the current High-Tech Strategy 2025, this reorientation has been driven systematically forward, finding its expression in the explicit formulation of 12 different missions addressing a broad spectrum of societal problems. These include the missions of "combating cancer," "substantially reducing plastic discharged into the environment" and "putting artificial intelligence into practice" (BMBF 2018). These missions are anchored in strategic statements addressing the targeted support of key technologies and the further development of the country's thriving innovation environment – in both cases with the explicit goal of fostering competitiveness, growth and prosperity. At least at the strategic-target level, this indicates that a connection has already been made between a new solution or mission-oriented approach and the traditional competition-oriented approach. All HTS iterations have had an accompanying advisory committee (currently the so-called High-Tech Forum); however, the composition of these committees has differed from body to body, at times substantially.

Drawing on the considerations presented in Chapter 3, a series of interlinked challenges can be derived for the design and implementation of the current HTS. These can be summarized and categorized within three fields of activity:

1. **Directionality and intentionality:** With a mission-oriented approach, a considerable number of normative decisions are made regarding the direction of innovation policy and priorities relating to the solution of societal problems. There is thus an urgent need to develop processes facilitating agreement on goals and follow-up measures. Moreover, there is a need for innovation-policy instruments able to ensure that the research and innovation being conducted is in fact contributing to the fulfillment of the defined mission. Given the ongoing preference within German RTI policy to focus primarily on strengthening innovation systems, there is room for improvement in this regard.

2. **Coordination across disciplines, sectors and ministerial portfolios:** Most missions have a cross-disciplinary, cross-sectoral and interministerial character, resulting in a great need for coordination. This differs somewhat from the traditional innovation-policy paradigm aimed at a modernizing a system. Typical obstacles to successful coordination include a lack of relevant capacities among the actors responsible, departmental rivalries and conflicts of interests. Differences in technical opinion regarding the mission's goals and practical measures also play a role in this regard. Even before the introduction of a mission-oriented innovation policy, significant coordination shortcomings were evident in Germany's RTI policy. These have not diminished in the current HTS.

3. **Bottom-up negotiation, decision-making and solution processes:** The development and use of approaches and procedures able to generate widespread societal support for the desired transformation path also constitutes a challenge in the context of the HTS. As yet, there are no established mechanisms able to fulfill this task. Nor has the culture and practice of involving a broad spectrum of societal actors been sufficiently developed. With regard to the inclusion of stakeholders and societal actors, the various high-tech strategies have indeed made efforts to integrate advice and ideas from within the broader environment. For example, special accompanying advisory bodies have been created for each of the HTS iterations. However, these have been very different in their composition, with civil society actors and actors from outside the scientific or business communities being generally underrepresented. This is also true of the current High-Tech Forum associated with the HTS 2025.

While it is too early to draw final conclusions, there is ample evidence that the High-Tech Strategy 2025 has not exhausted the potential or opportunities arising from a systematic combination of the competition- and mission-oriented approaches (Daimer et al. 2017). Overall, while the approach is promising in strategic terms, it does not appear to have resulted in the consistent formulation, instrumentation or coordination of missions.

Figure 10 summarizes the explicit challenges experienced by the German HTS.

FIGURE 10

GERMAN HIGH-TECH STRATEGY

Challenges in the implementation of the German High-Tech Strategy

DIRECTIONALITY AND INTENTIONALITY

- There is no proven process for the formulation of missions and the coordination of mission paths. Instead, existing programs simply tend to be reformulated as "mission-oriented." This limits the ability to track progress and conduct meaningful evaluations of mission activity, and it also hampers the development and elaboration of appropriate measures.
- A mission-oriented approach requires a high degree of political steering capability and will. Effective implementation requires a high level of commitment among all relevant actors.
- In its work, the BMBF tends to pursue a thematic-technical allocation of funds on the basis of the performance-plan system.[2] The (interministerial) cross-cutting character of missions is not taken sufficiently into account, particularly during the conception and coordination phases.

COORDINATION ACROSS DISCIPLINES, SECTORS AND MINISTERIAL PORTFOLIOS

- Strategic ownership with regard to the mission-oriented innovation policy is currently unclear: The HTS is a formal federal government strategy, but is de facto strongly influenced by the BMBF, which takes a lead role on most missions.
- In some cases, the allocation of responsibilities between ministries is implausible (e. g., the mobility mission is situated in the BMBF, and not in the Federal Ministry of Transport and Digital Infrastructure (BMVI)).
- Both within and between ministries, there is an insufficient level of understanding of mission-oriented innovation policy. In addition, there is an evident lack of precision in the formulation of missions.
- Cross-sectoral cooperation currently appears to function only in response to high-level pressure, in situations with high levels of visibility (e. g., in the context of the Climate Cabinet or the Mobility Summit).
- The culture of consensus between ministries is weak (units often act separately, with different socialization practices, mentalities and working methods – for example between lawyers, economists and others – making consensus-building somewhat more difficult).
- In contrast to foreign agencies furnished with considerable resources and strong mandates (e. g., Vinnova), the mandates given to lead agencies in Germany are rather weak.

BOTTOM-UP NEGOTIATION, DECISION-MAKING AND SOLUTION PROCESSES

- There currently appears to be no active approach aimed at securing broad-based involvement and stakeholder participation. This is particularly true with regard to civil society representatives at the regional and supra-regional level. In this regard, there appears to be a lack of established practices able to serve as guides or models.
- The High-Tech Forum (HTF) does not currently serve as an academic advisory council or vehicle for stakeholder involvement. The focus of the HTF's work is on meta-themes such as social innovations rather than on specific missions.

2 See https://www.datenportal.bmbf.de/portal/en/bufi.html (accessed Oct. 28, 2020).

3.2 SELECTED GOOD PRACTICES

What Germany can learn from international examples

In the following, we look at examples drawn from the Netherlands, the United Kingdom, Sweden, Canada and Japan, five countries whose innovation-policy landscapes can be regarded as exemplary for a variety of reasons. The empirical evaluation is based primarily on visits to each respective location, along with interviews conducted by the Bertelsmann Stiftung and Fraunhofer ISI (see 5.1). Particular attention is given to the national innovation strategies and their implementation tools, which are presented and assessed according to the dimensions set out in section 3.1 (see also Figure 8 on page 37).

We can learn from the examples of leading innovation systems in other countries.

FIGURE 11
TOP SECTORS IN THE NETHERLANDS

TOP SECTORS

1. **Horticulture and propagation materials**
2. **Agri-food**
3. **Water**
4. **Life sciences and health**
5. **Chemicals**
6. **High tech**
7. **Energy**
8. **Logistics**
9. **Creative industries**

CHARACTERISTICS OF A TOP SECTOR

- Offer a platform for cooperation between the government, companies, universities and re-search centers.
- Are jointly responsible for the formulation of missions and the development of solutions.
- Remain themselves responsible for how they want to achieve missions (e. g., choice of missions, knowledge and innovation agen-das, R&D projects).
- Have final decision-making powers over the use of their allocated funds.

3.2.1 THE NETHERLANDS

Consensus-driven negotiation underlies mission fulfillment

A collaborative elaboration of action priorities and a clear mission-oriented approach – these are the factors that make Dutch innovation policy so exemplary. Consensus-oriented cooperation in addressing collective challenges has a long tradition in the Netherlands. Indeed, since the 12th century, residents have worked together to win land from the sea using "polder" (land reclaimed using dikes and drainage canals). This mechanism has found its way into today's political vocabulary with the term "polder process."

In the innovation context, an example of this would be the public consultation procedures used by the employers' associations and institutions of basic and applied research to develop 16 long-term research priorities that are strongly oriented toward the population's needs (e.g., "using big data responsibly," "personalized medicine" or "smart, liveable cities") (Graaf and Kan 2017; OECD 2014). This priority-setting process is intended to ensure that innovation activities respond to actual demand. Since 2019, there has also been increasing effort at the government level, across sectors and disciplines, to identify areas in which action is needed and determine priorities for action – and subsequently to link innovation funding to societal challenges more strongly than has previously been the case. This was highlighted by the April 2019 Dutch cabinet decision to provide stronger financial support to the innovation-policy missions, and to integrate them into the existing national research and industrial policy (EZK 2019). Thanks to its shift toward mission orientation, the Netherlands is a leader in facilitating innovation that combines the economic benefits of greater competitiveness through technological innovation with the positive effects of a mission-driven approach. The country's structured approach and efforts to build a consensus along the way is particularly noteworthy.

Societally relevant missions as new guiding principles

In practice, this has been reflected in an expansion of the nine established top sectors ("Topsectoren" in Dutch, see Figure 11) to include four thematic areas with societal relevance.

If the country's policies were previously oriented toward increasing competitiveness within these top sectors, opening up new export markets, internationalizing R&D cooperation and expanding the country's skilled-labor potential, future work within these sectors is meant to prioritize the four thematic areas, thus contributing to the development

FIGURE 12
MISSIONS IN THE NETHERLANDS
(selected examples)

ENERGY TRANSITION AND SUSTAINABILITY	Reduction of national greenhouse-gas emissions by 49 % by 2030; reduction of emissions by 95 % in comparison to 1990 by 2050.
AGRICULTURE, WATER AND FOOD	Reduction of the use of raw and auxiliary materials in agriculture and horticulture by 2030, and creation of the maximum possible value from all end products and residuals by utilizing them as fully as possible (circular agriculture).
HEALTH AND CARE	Increase in the life expectancy of all Dutch citizens by at least five years by 2040; reduction of health-related inequalities between the lowest and highest socioeconomic groups by 30 % by 2040.
SECURITY	Significant decrease in the profitability of organized crime by 2030, for example thanks to better insight into illegal activities and cash flows.

of concrete solutions. This is accomplished in part through the allocation of additional state funds for public-private cooperation. The thematic areas are further broken down into 25 specific missions and in the following way:

1. Energy transition and sustainability (includes six missions)
2. Agriculture, water and food (includes six missions)
3. Health and care (includes five missions)
4. Security (includes eight missions)

Examples of specific missions are provided in Figure 12.

Consensus-driven discussions inform goals
Particularly worthy of note is the participatory and cross-sectoral nature of the process involved with defining these mission goals. Eight ministries participated in their development,[3] along with companies and research institutions from the various top sectors. In the course of operationalization, knowledge and innovation agendas for the 2020-2023 period have been drafted that describe the planned mission paths for the top sectors from the point of basic research through the introduction of new solutions into the market. Spokespersons for the top sectors coordinate the resulting strategies closely with the government, for example by submitting specific proposals regarding which technologies or R&D projects should receive investment.

The implementation of the missions thus entails coordinated interaction between industry, the scientific community, regions, policymaking bodies and investors, for example in mission-specific steering committees such as the "Climate Committee," or decision-making groups that include representatives from the top sectors and the basic and applied research institutions, ministers, state secretaries, and representatives of the provincial governments. This organizational structure makes it easier to coordinate the realization of the mission across systems and sectors before the government makes any decision on the allocation of funds.

Finally, with regard to future societal needs and challenges, it should be emphasized that an important substantive concern of Dutch innovation policy consists in providing targeted funding to key fields such as quantum and digital technology, the chemical industry, and the bio- and nanosciences. Whether this entails "smart" production robots able to produce any conceivable product inexpensively and without waste, or laser technologies for precise and complication-free operations, these potential application areas are manifold, and show that these technologies in particular have the ability to contribute to the country's societal development.

3 Economic Affairs and Climate Policy; Defense; Infrastructure and Water Management; Agriculture, Nature and Food Quality; Justice and Security; Social Affairs and Employment; Education, Culture and Science; and Health, Welfare and Sport.

Lessons learned with relevance for Germany

The Dutch example illustrates how mission-oriented intentionality and sectorally diversified, consensus-oriented coordination and negotiation processes can be combined. While it is too early to judge the success of the current strategy, the country's government has credibly substantiated its intention to make more resources available to address the four major societal challenges. With regard to the concrete formulation of missions, by contrast, the highest decision-making level has remained relatively hands-off, with a bottom-up approach dominating instead. The strategy offers incentives to industry to orient its activities toward addressing the challenges, largely by providing opportunities for profit within the long-term innovation programs.

The outstanding strengths of the Dutch model seem above all to be the cross-sectoral coordination and the negotiation processes dealing substantively with the mission goals and measures. Building on an already strong culture of cooperation and established channels of dialogue – particularly within the context of top sectors that continue to serve as platforms – it succeeds in meeting the complex challenges of an innovation policy that cuts across traditional ministerial and sectoral boundaries. The development of adequate solution paths is aided by the active use of existing networks and communications channels between the various actors. One success factor in this regard appears to be the fact that the current strategy can build directly on the previous strategy's lessons and established structures. Building on top of existing structures minimizes hurdles related to participants' need to adapt to new programs and ensures a broad level of involvement among relevant stakeholders.

The close relationships and effective dialogue between the participating actors ultimately make it easier to access the expertise and experience needed, while also instilling a strong sense of responsibility and commitment in these actors. For example, representatives from the top sectors are entrusted with the responsibility of developing solutions and have quite significant autonomy in implementing missions and using their funds. The resulting shared responsibility and sense of ownership in turn ensures a serious engagement with the mission goals.

Overall, with regard to the challenges of innovation policy in Germany, the following potentially useful takeaways can be identified:

FIGURE 13

LESSONS LEARNED

from the Dutch innovation system with relevance for Germany

DIRECTIONALITY AND INTENTIONALITY

- Balance between top-down signal from the government and bottom-up solutions from society and the business sector.
- Reference to historical example of collaborative cooperation.

COORDINATION ACROSS DISCIPLINES, SECTORS AND MINISTERIAL PORTFOLIOS

- Use of existing policy concepts and organizational structures (in top sectors) as important platforms for cross-sectoral dialogue on innovation policy.
- Consensus-oriented dialogue between companies, ministries and academic community, acting as partners.

BOTTOM-UP NEGOTIATION, DECISION AND SOLUTION PROCESSES

- Culture of consensus-oriented decision-making and problem-solving that includes all relevant actors.
- Shared responsibility and ownership of missions through participatory negotiation processes.

FIGURE 14
THE FOUR UK MISSIONS
(UCL 2019)

CLEAN GROWTH	Reduce the energy and resource consumption of new and existing buildings by at least half by 2030.
ARTIFICIAL INTELLIGENCE AND THE DATA ECONOMY	Use data, artificial intelligence and innovation to improve the prevention, early diagnosis and treatment of chronic diseases using interoperable AI, data tools and standards by 2030.
AGING SOCIETY	Improve the health-related quality of life over the course of increasingly longer life spans by 2035.
THE FUTURE OF MOBILITY	Provide by 2040 safe, sustainable and accessible transportation systems that are free of congestion, emissions and accidents.

3.2.2 UNITED KINGDOM

The interplay of business development, a mission-oriented approach and bottom-up initiatives

British innovation policy is characterized by its combination of a traditional competition and productivity-oriented approach with the clearly identifiable aim of achieving societally relevant missions. The innovation strategy is largely implemented by a tech-oriented funding agency with close ties to industry whose work is complemented by the non-profit innovation foundation Nesta.

The combination of competitiveness and mission-driven approaches to societal issues is integral to the UK government's economic and industrial policy. This can be seen in the Industrial Strategy adopted by the UK government in 2017, which aims to close the productivity gap with competitors such as France and Germany and strengthen its domestic industries. At the same time, the goal of the strategy is to transform the UK economy so that it more effectively serves citizens and society (Industrial Strategy 2017; Atkinson and Ezell 2012; HM Government 2017). The strategy therefore seeks to implement innovation programs designed to generate and market new products and services while also fulfilling specific missions.

Focused on four key areas – clean growth, AI and the data economy, an aging society and the future of mobility – it aims to initiate cross-sectoral R&D programs and accelerate those bottom-up innovations that can help the government fulfill its missions within a defined timeline (see Figure 14). In terms of economic policy, the strategy seeks to ensure the UK's position as a global leader in key digital technologies such as artificial intelligence. In addition, it aims to maximize the advantages for UK industry of the shift to clean growth and expand opportunities for UK companies to sell mission-driven solutions in global markets.

A key element of the Industrial Strategy involves a significant increase in public R&D spending. By prioritizing missions, the strategy also communicates to the business community the government's commitment to making long-term investments. Some of this investment flows into the "Industrial Strategy Challenge Fund," which links its funding to solving societal problems and is therefore not limited to the development of individual technologies.

UKRI: An innovation agency that combines business development with a mission-oriented approach

Established by the UK government, the Industrial Strategy Challenge Fund has become a core mechanism geared to support mission-driven innovation programs. The fund is managed by the UK Research and Innovation (UKRI), which is mandated with promoting and coordinating mission-relevant innovation activities. Created in 2018, UKRI is a merger of Innovate UK, elements of the Higher Education Funding Council for England and seven existing research councils. With an annual budget of nearly £7 billion, UKRI receives financing from the Department for Business, Energy and Industrial Strategy's budget in the form of a "grant-in-aid." The agency employs some

500 people at its main locations in London, Swindon and Bristol, as well as its foreign offices in Brussels, New Delhi, Washington, D.C. and Beijing. As a government agency specializing in innovation issues, UKRI works for the most part across ministries, thus relieving established authorities of having to carry out innovation-oriented activities. And despite being a state-run agency, UKRI enjoys a relatively high degree of independence from the daily grind of political processes. Our interview partners described the agency's role as that of a "neutral convener" which – drawing on the involvement of all relevant stakeholders – is tasked with translating the missions of the Industrial Strategy into concrete measures.

Clearly, this involves a certain bias toward economic and industrial concerns, but this is in part due to the agency's institutional history. As a result, promoting innovation in this sense is designed to fulfill missions as well as meet market demand (Glennie and Bound 2016). The goal is to make the United Kingdom a top global location for innovation. Reducing the risks involved in establishing and entering new markets is a key aspect of achieving this goal. This market economy orientation is also reflected in the agency's personnel: Many of its employees have experience in industry or a background in technology. Professional experience with technology is important because innovation work focuses heavily on new key technologies. Building on London's already strong digital scene, the UK strategy aims to make the UK a global AI and digitalization hub. This is manifest in programs such as the UKRI-funded Digital Catapult, which provides resources for and expertise with developing and diffusing digital technologies.[4] In the long term, this is intended to support the digital transformation of the UK economy.

That said, UKRI does not promote business development, but rather the early adoption of new technologies that serve both economic and societal purposes. The importance of UKRI's role in the UK's innovation system is demonstrated by the fact that the agency was instrumental in formulating the country's first missions. Together with the relevant ministries, universities and research institutions, UKRI is also responsible for further specifying these missions in ways that allow four-to-five-year R&D programs to be launched. A total of 20 different mission-oriented R&D programs have been developed and budgeted so far. The strongest ideas for projects were collected in open calls for proposals that were then selected by UKRI. The agency has received a strong mandate from the government to design mission-oriented R&D programs and to coordinate their implementation, including monitoring and evaluation efforts. This mandate also gives the agency a stronger role in mobilizing companies or investors to engage with long-term R&D programs. On a positive note in this context, the agency is not obliged to serve the particular interests of individual ministries, but rather takes a whole-of-government approach while remaining mindful of the business interests of the companies, which our interview partner at UKRI sums up as follows:

"Signalling to industry and investors: this mission is important for the UK and we are willing to take the lead in coordinating the involved actors."

4 See www.digicatapult.org.uk (accessed on Aug. 5, 2020).

For this kind of work, the agency has built up a staff with specialized skills. These employees include the so-called Challenge Directors, who are responsible for designing innovation programs in line with the available budgets and setting up suitable evaluation systems for each. In addition, the industrial and technological expertise of many of the agency's employees helps facilitate the promotion of new products and services. In order to keep abreast of current developments on the markets and in research, the agency also engages in regular exchange with representatives from science and industry.

Nesta: A non-profit innovation foundation with a bottom-up approach

Nesta, a non-profit organization whose strengths lie in its inclusion of bottom-up perspectives and ability to break with traditional ways of thinking, complements the work of UKRI. The history of Nesta (originally the National Endowment for Science, Technology and the Arts) goes back to a UK Parliament initiative which, in 1998, created a lottery revenue-sourced fund to promote innovation. In 2012, Nesta was transformed from an executive body into a non-profit organization, calling itself "The Innovation Foundation" (Department for Business Innovation and Skills 2011). While Nesta focuses primarily on projects within the UK, it is involved with projects that extend across several continents and also thinks in terms of international impact.

In line with its slogan "We bring bold ideas to life to change the world for good," Nesta pursues the goal of supporting innovation activities in areas where there are major challenges facing society while helping new ideas that have been neglected by traditional innovation policy reach market maturity. Its action areas include fields such as health, education, the creative industries and culture, government innovation, innovation policy and futurescoping. Given the importance of new key digital technologies, AI and data analysis are identified as priority sectors. Though its designation of these areas and sectors is not uncommon, Nesta's functional instruments and organizational features can certainly be characterized as innovative. Nesta's instruments include a series of labs and experimental forums in which innovations of all kinds are discussed, conceived and (further) developed (e. g., Health Lab, Share Lab, Innovation Growth Lab and the Centre for Collective Intelligence Design). Factors contributing to success include the combination of theoretical with practical knowledge and the inclusion of digital technologies. The consistent goal of each instrument is to develop solutions that are both implementable and scalable. And despite the ideals expressed, the foundation exercises a certain pragmatism, as our interview partners emphasized. Nesta itself accompanies innovations only up to the point at which they are adopted and developed further by other actors.

A strong characteristic of Nesta's work is its bottom-up approach. In its search for promising ideas, it relies on the involvement of many actors and the incorporation of unusual points of view. This approach is reflected in the organization's inner workings, which are characterized by flat hierarchies that enable participation and agility. The employees themselves combine a wide range of professional and cultural backgrounds, which is in line with a holistic and multi-perspectival understanding of innovation. This fosters credibility, particularly within the startup scene. Finally, Nesta can be seen as a relevant change agent within the UK innovation system, whose advantages lie in the fact that it is politically independent and takes an open approach to innovation. Given that UKRI cultivates a closer relationship with business and is oriented more toward governmental requirements and regulations, the combined efforts of UKRI and Nesta are powerful.

Improved framework conditions for social innovation

Even though it is not the focus of this study, social innovation is worth mentioning in the context of the UK, where an entirely new framework for such innovation has been created in the past 20 years. The strategic focus here has been to tap into new – and in particular private – sources of financing. As early as 2001, the Labour government set up an interdisciplinary task force (Social Innovation Task Force, SITF) to investigate how innovative solutions could be developed for particularly profound social problems, that is, problems that could not be effectively tackled using conventional methods, such as intergenerational poverty (Social Investment Task Force 2010). As a result of the task force's recommendations, the world's first social investment bank, Big Society Capital, was founded in 2012, a variety of specialized investment intermediaries in the social market were established, and certain tax breaks were granted to impact-oriented investors.

The development and implementation of Big Society Capital as a private and publicly funded bank that invests in impact funds (i. e., funds designed for social impact) attracted global attention. Since its founding, Big Society Capital has invested nearly €2 billion, and an additional €1.3 billion have been developed by its partners. Big Society Capital's beneficiaries include more than 1,200 innovation-oriented social enterprises that are active in the market.[5] UK efforts in this regard were transferred to other countries in 2014 through an International Taskforce (the Global Steering Group for Impact Investment) and triggered similar initiatives worldwide that aim to promote social innovation through private investment capital (see the fourth results paper in this series). Approaches of this sort show how efforts to develop solutions to societal problems can be reconciled with the goal of strengthening competition in ways that promote innovation.

Lessons learned with relevance for Germany

Although any comparison with the UK is inherently difficult given the unforeseeable consequences of Brexit and the fact that economic activity in the UK is heavily concentrated in London, it is nonetheless worthwhile from a German perspective to take a closer look at the UK's innovation system. First, the example of the UK shows how combining the goal of competition with a mission-oriented approach can prove successful – even in a country that generally does not subordinate its economic policy to social welfare interests. Notably, in terms of advancing both social innovations and mission-oriented innovation policy, economic efficiency and solving societal problems are understood as symbiotic, not contradictory goals. This view is manifest in the clearly formulated missions boldly targeting future markets. And it is driven by the goal of opening up global sales markets through the development of innovative solutions. The ongoing development of appropriate measures and the specification of clear time limits are key factors contributing to the success of the missions formulated. Being able to deliver and communicate the details of such measures ensures a high level of commitment among the actors involved.

Another noteworthy and important factor is the research and technology focus that is integrated into the UK's approach to innovation. On the one hand, the UK can draw upon its traditional strengths in research. It promotes these strengths through increased funding, which is (at least in part) distributed by UKRI in the interests of mission fulfillment. Being able to centralize coordination in this way creates transparency and ensures that resources are applied as intended. On the other hand, the UK approach relies heavily on new technologies and sets ambitious targets, especially in the area of digital transformation. Both the country's traditional industrial and startup sectors play an active role in this approach.

5 See www.bigsocietycapital.com/investment-numbers/ (accessed on Aug. 5, 2020).

The combined efforts of two institutions that complement each other in a variety of ways in terms of coordinating innovation activities and generating ideas constitutes another noteworthy success factor. The national funding agency UKRI, which is deeply involved in the formulation and implementation of missions, nonetheless remains independent of individual ministerial interests. At the same time, the agency maintains close ties with representatives from business and science. The non-profit organization Nesta is equally independent, but takes a bottom-up approach to innovation and acts in the interest of "constructive disruption." Both institutions enjoy considerable credibility among stakeholders in their respective areas of activity, which is due primarily to the people they employ: Whereas UKRI hires individuals with business experience and technology backgrounds, Nesta's international and diverse staff renders it highly credible, particularly among start-ups. Irrespective of the precise form innovation policy takes, the example of the UK demonstrates the potential of nationally active, independent and multidisciplinary institutions that act as change agents in their tireless efforts to bring bold ideas to life. Germany, which lacks such an actor in its decentralized and rather fragmented innovation system, could draw on this example as it looks forward.

FIGURE 15

LESSONS LEARNED

from the UK innovation system with relevance for Germany

DIRECTIONALITY AND INTENTIONALITY

- Symbiotic linkages between competition-oriented and mission-oriented approaches that are based on societally relevant missions.
- Clearly formulated missions that feature concrete measures and specified time limits result in a high degree of bindingness.
- Burden placed on authorities previously responsible for mission-oriented innovation programs has been reduced by outsourcing promotion activities to a specialized agency tasked with promoting innovation.
- Focus on research and new technologies as drivers of economic and societal progress.

COORDINATION ACROSS DISCIPLINES, SECTORS AND MINISTERIAL PORTFOLIOS

- Funding agency is independent and benefits from a strong government mandate.
- Funding agency is responsible for coordinating mission-oriented innovation programs in close cooperation with stakeholders in industry and science.
- The funding agency's technological and economic expertise facilitates exchange with relevant actors.

BOTTOM-UP NEGOTIATION, DECISION-MAKING AND SOLUTION PROCESSES

- Non-profit organization (Nesta) promotes bottom-up innovation, thereby complementing government initiatives.

3.2.3 SWEDEN

Promoting transformative societal change through innovation agencies

As a consensus-oriented welfare state, Sweden has a number of interesting governance elements that could serve as sources of inspiration for the design of innovation systems in Germany and other countries. The country exhibits a decidedly cross-sectoral policy approach that consistently combines the two paradigms of "competitiveness" and "mission-driven approaches to societal issues" (Fagerberg 2016).

The latter can be clearly seen by examining Sweden's overall innovation-policy strategy. For example, in a November 2016 law called "Collaborating for knowledge – For society's challenges and strengthened competitiveness," the Swedish government formulated a set of 10-year guidelines orienting Swedish innovation policy explicitly around the aim of linking efforts to bolster Sweden's innovative capability with the solution of larger global and national societal challenges (Government of Sweden 2016). The law was also clearly oriented toward the United Nations' global development goals (Sustainable Development Goals; SDGs). Sweden's umbrella innovation policy strategy was adopted in 2012, subsequently producing the Framework Program for Research and Innovation, which lasts through 2020. While the strategy does not explicitly mention missions, a clear sense of directionality can also be discerned here (Government of Sweden 2012). The strategy covers six societal and technological areas that define the framework and its underlying innovation-related objectives:

1. Health, demographic change and well-being
2. Challenges for the European bioeconomy
3. Secure, clean and efficient energy
4. Smart, green and integrated transport
5. Climate action, resource efficiency and raw materials
6. Secure societies

Sweden has established a number of particularly effective institutional arrangements to implement the strategy and simultaneously drive transformative societal change within these prioritized areas. These practices clearly reflect the character of a consensus-oriented welfare-state model. For example, the traditionally strong position of the state and its public funding institutions within the Swedish innovation system is based on a broad social consensus regarding the fundamental orientation of the transformation process for the economy and the society at large.

Sweden's National Innovation Council as a key strategic body

Sweden's National Innovation Council holds a key strategic position in this regard. This body was created by the Swedish government in February 2015 with the goal of strengthening Sweden's innovative capabilities and competitiveness, while also helping to shape the direction of the process of transformative societal change through a holistic, cross-sectoral policy approach. The importance of this innovation

council is evident in the fact that Sweden's prime minister serves as chair of the body and takes personal responsibility for its work. Accordingly, it has a very strong political mandate as an advisory and strategy body, with high levels of visibility and political relevance. The council has a direct link to the Prime Minister's Office and, in line with Sweden's democratic consensus-driven political system, is made up of members of the government; leading figures from the business community, employers' associations and unions; and representatives from research and educational networks (Edquist 2019).

Vinnova acts as a consultant, designer and implementer of a mission-driven policy geared to enhance competitiveness and to address societal challenges.

This ensures that societal preferences are widely reflected in the strategic definition and coordination of transformation paths, and it prevents possible fundamental innovation-policy decisions from being distorted by any narrow thematic focus. At the same time, the composition of the council – unlike a purely academic or research-based expert committee – brings together considerable political, scientific and practical expertise from a wide range of disciplines and levels. Thanks to this orientation, the National Innovation Council is also of great importance for the cross-departmental innovation-policy work of the various sectoral ministries.

Organizationally connected to Sweden's central government, the council can shape effective cooperative international relationships, while at the same time integrating the various regional levels. This latter task is accomplished, for example, through the targeted involvement of regional and local stakeholders in two of the six annual meetings, both of which are held as regional meetings. When conducting regional meetings featuring thematic workshops and "policy labs," the council works directly with Vinnova, Sweden's innovation agency (see below for more detail), which carries out thematically focused policy labs. This results in a bottom-up process in which citizens' and consumers' societal preferences and innovation-related expectations are incorporated directly into strategic innovation-policy formulation.

The National Innovation Council also tests new innovation-policy instruments on a regular basis. In the early years of its existence, it was responsible for measures improving the venture-capital system, as well as for the introduction of an innovative public procurement system that can strengthen the promotion and diffusion of technology while helping address societal problems. This includes, for example, aiming to improve the availability of risk capital through state-owned Saminvest AB and thereby provide businesses the seed capital they need – particularly in the early stages of their innovation process when assessing the prospects of success is difficult, the risk of failure high and, as a result, private investors are reticent to invest (Edquist 2019). Another example involving demand issues is the shift that has taken place in public procurement policy. Instead of buying specific products, the state defines functional requirements or societal problems that need to be resolved (e.g., maintaining noise levels below a certain limit near railway stations). Innovation processes are thus initiated with a specific goal in mind. A new institution, the Upphandlingsmyndigheten (UHM; the National Agency for Public Procurement), was created specifically for this purpose (Edquist 2019).

Vinnova as a strong and independent change agent

Vinnova is Sweden's independent state innovation agency tasked with the specifics of implementing innovation-policy objectives. In both its orientation and its various functions, Vinnova is an exemplary embodiment of Sweden's innovation-policy approach, and of the link between economic and technological competitiveness and societal problem-solving.

With more than 200 employees, a headquarters in Stockholm, and branch offices in Brussels, Tel Aviv and Silicon Valley, the agency reports to the Ministry of Enterprise and Innovation, and is funded by the government. However, the government is statutorily prohibited from interfering in the agency's substantive work. Vinnova is thus an innovation agency that works independently of the particular interests of individual ministries, but at the same time has received a strong mandate from the government to act as adviser, implementer, orchestrator and designer of a policy oriented toward competitiveness and a mission-driven approach.

Since its inception in 2001, Vinnova has focused heavily on intensifying network activity within the Swedish innovation system. For example, more than half of the funding provided by Vinnova goes to SMEs in providing targeted support for their cooperation activities with academic and research-sector actors. The goal here is to ensure that this collaborative work strengthens the country's innovative capacity (Fagerberg 2016). By seeking specifically to forge links between a wide variety of innovation-system actors, Vinnova is a key orchestrator of cooperation. Thanks to these efforts, it has developed considerable credibility and enjoys high levels of trust among the various actors and groups within the innovation system.

The agency also maintains liaison offices abroad, allowing it to be constantly on the lookout for new technologies able to increase the country's competitiveness (Atkinson and Ezell 2012). In this sense, Vinnova also exercises an important foresight function that is crucial to the further development and adaptation of Sweden's innovation strategy. In addition, the agency draws on a number of sector-specific national and international networks. These include links to experts from the EU framework programs, the OECD, the TAFTIE network of European innovation agencies, and research communities working on the issue of transformative innovation policy.

Since 2011, the innovation agency has begun to focus more specifically on societal challenges. It has itself developed so-called challenge-driven innovation programs, which have provided dedicated support for technology developments with the dual aim of increasing economic growth and making a visible contribution to the achievement of the 17 UN Sustainable Development Goals through cross-sectoral cooperation (OECD 2016; Vinnova 2017).

The government has explicitly mandated Vinnova to develop programs involving actors from various sectors, industries and disciplines in the demand-oriented development of new solutions, for example by opening up new market niches (Glennie and Bound 2016). Companies therefore also consult Vinnova directly to find ways in which they can adapt their business models and value chains and thereby better meet and respond to urgent societal challenges.

A second generation of such programs developed by the agency are the so-called strategic innovation programs. These were crafted in cooperation with the Swedish Energy Agency and the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning with the objective of coordinating interactions between actors, networks and institutions, and thus promoting deep system-level transformation, all with the help of a holistic conception of policy (Grillitsch et al. 2019).

Within the framework of this research program, the agency funds R&D projects (on a co-financed basis, with a focus on SMEs) that are developing products and services falling into the country's six strategic thematic topics noted above. Overall, there are currently 16 programs, such as the bioinnovation program intended to transform the country into a bio-based economy by 2050 through cooperation between the forestry, chemical and textile sectors.

A second such example is RE:Source, with which Sweden intends to develop a globally leading circular economy by reducing waste, creating a sustainable energy supply and increasing the efficiency of resource consumption. These programs are implemented by consortia that bring together representatives from the business world, academic and research communities, and the public sector (Grillitsch et al. 2019). Here too, Vinnova serves particularly as orchestrator, bringing the actors together for various missions, and in this way initiating and advancing innovation processes targeted at SDG-related issues.

Another of Vinnova's important functions involves coordinating and moderating bottom-up consultation processes in the development of societal transformation paths. For example, during the most recent Swedish National Innovation Council meeting (see above), Vinnova led thematic workshops on the issues of e-health and sustainable water use, with the goal of developing innovation pathways and potential technological solutions in conjunction with stakeholders from a wide range of levels and areas. In this respect, Vinnova serves an important transmission function: On the one hand, the agency and its work make a significant contribution to the effective implementation of the umbrella innovation-policy strategy (top-down perspective). On the other, it also organizes the process of bottom-up strategy development by integrating citizens' and consumers' societal preferences and expectations, as well as the perspectives offered by companies and the research community, into the strategy process. In order to be able to formulate missions on the basis of broad-based consultation processes and coordinate solution paths, Vinnova has focused its efforts in recent years on building up internal expertise. The organization's diverse staff come from a wide range of disciplines.

Given the various functions that Vinnova fulfills within the innovation system, the agency rightly defines itself as a strong, independent "change agent." It is an active advocate for an ambitious innovation policy specifically aimed at addressing societal challenges. Like Finland's Sitra innovation agency or Israel's Innovation Authority, Vinnova plays a central, policy-shaping role within the country's national innovation policy (Breznitz et al. 2018) – or as one of the agency's staffers interviewed for this report noted:

"Vinnova has some weight to influence the policy process, but also has the mandate to do so."

Lessons learned with relevance for Germany

In Germany, the strong autonomy afforded each ministry in determining departmental policy (Ressortprinzip) makes it more difficult to shape policy across sectors. Moreover, the Federal Chancellery, as the central organizational office of the government, has relatively weak strategic-planning capacities (Rüb et al. 2019) These structural features also affect innovation policy, even though Germany's High-Tech Strategy is clearly conceived as a cross-sectoral umbrella strategy for innovation policy (see 3.1).

Sweden's National Innovation Council offers an example of how a holistic innovation-policy perspective can be adopted at the government level, and of how to more smoothly coordinate policy measures across ministries. Two success factors should be highlighted in this regard: First, Sweden's prime minister personally chairs the National Innovation Council, thus giving the body's work considerable political weight and a clear mandate. Second, the innovation council's composition and practical work ensure the development of a cross-ministerial perspective, while also producing strong networks that span all state levels and economic sectors. Unlike the primarily scientific or scientific-economic orientation of the high-level innovation-policy advisory committees within the German system, the Swedish council also involves (civil society) stakeholders from outside the academic and business communities. The broad involvement of a wide range of actors is of clear significance particularly with regard to the formulation and negotiation of innovation-policy goals, since normative decisions always have to be taken even within the context of a mission-oriented approach.

In addition to the innovation council's positive role with regard to improving cross-sectoral coordination and mission formulation, the example of Sweden illustrates the positive effects associated with a strong, independent change agent – in this case, the Vinnova innovation agency – with regard to linking technological and economic competitiveness to the solution of societal problems. Germany's decentrali-

zed innovation system has no comparable institution similarly able to take on multiple roles and functions in the successful implementation of a mission-oriented innovation policy. To be sure, the transfer of specific institutional practices from one country to another is no simple task, in large part due to institutional and cultural path dependencies. However, the various change-agent roles and functions described above can certainly serve as inspiration and a possible impetus for learning in Germany. For example, in order to generate a high level of societal support for the transformation path being pursued – a challenge certainly relevant in the context of the High-Tech Strategy – the (bottom-up) approaches and practices established by Vinnova and the Swedish National Innovation Council are a suitable policy instrument.

At the same time, by combining in itself a wide range of roles and functions, and by acting independently of the particular interests of individual ministries, the agency relieves the government and ministries of an enormous burden in the implementation of a holistic innovation strategy. This too seems to be an interesting institutional approach, particularly given the challenges in implementing the German High-Tech Strategy effectively. In order to prove effective in advancing transformative change, Vinnova acts as a strong moderator, orchestrator and coordinator. The agency develops the policy processes, instruments and methodologies necessary for this task, and with an eye toward carrying out ambitious missions, works to build consensus between relevant stakeholders, create networks between the actors necessary to the achievement of the mission goals, and ensure the provision of sufficient financial resources. It additionally acts as an innovative designer of policy by testing new methodologies on a regular basis, thus helping shape the further development of the innovation-policy strategy. This too is an interesting takeaway for the German context and the above-noted challenges, particularly with regard to the implementation and further development of Germany's High-Tech Strategy.

FIGURE 16

LESSONS LEARNED

from the Swedish innovation system with relevance for Germany

DIRECTIONALITY AND INTENTIONALITY

- Innovation policy aims to address major global and national societal challenges; as such, it draws on frameworks such as the SDGs to guide activity.
- Policymaking for holistic innovation policy (combining the two paradigms) is outsourced to the national innovation agency, thereby easing the burden on the government and ministries.
- Innovation agency with a strong government mandate to design and coordinate a holistic innovation policy.
- Innovation council with considerable political weight for the negotiation and definition of strategic goals.

COORDINATION ACROSS DISCIPLINES, SECTORS AND MINISTERIAL PORTFOLIOS

- Innovation agency with the necessary technical capabilities and organizational structures to coordinate innovation programs across sectors, industries and disciplines.
- Innovation council as strong cross-sectoral advisory body.

BOTTOM-UP NEGOTIATION, DECISION-MAKING AND SOLUTION PROCESSES

- Due to its multiple roles (policy designer, government advisory body, moderator, researcher, innovator), the innovation agency acts as a change agent within the innovation system.
- This role gives it a high level of credibility within the political, business and civil society spheres.

3.2.4 CANADA

Artificial intelligence as innovation-policy lever

In Canada, mission-oriented innovation approaches are particularly relevant within the government's technology-oriented AI program. Within the context of this study, looking at the federal government's current innovation-policy umbrella strategy (The Innovation and Skills Plan, 2017) would therefore be somewhat misleading, as the content of this strategy is somewhat "traditional." Its objectives include increases in competitiveness, productivity and the economic growth rate, whereas addressing societal challenges such as demographic change or climate change appear to be given secondary priority. The 2017 Pan-Canadian Artificial Intelligence Strategy, which places the country at the global forefront in terms of AI, is more relevant to the issues being discussed here.[6] The strategy and its implementation illustrate how new key digital technologies can act as a lever for values-based societal development. They show how cutting-edge research can be effectively interlinked with application needs while clarifying the roles to be played in such a process by networking and an international, interdisciplinary approach.

A values-based AI strategy underpins the innovation process

Canada is intent on pursuing an AI strategy that includes societal, ethical and legal considerations alongside its technological and economic aspects. This involved initiating a broad-based process of public consultation with citizens, experts, politicians, industry representatives and civil society actors that resulted in the development of 10 ethical principles and recommendations, which have been documented in the Montreal Declaration for a Responsible Development of AI of 2018 (see Figure 17). This document is intended to guide individuals and organizations in the development and use of digital technologies and AI systems, and can be signed by like-minded institutions and countries (Montreal Declaration 2018). Ultimately, this approach reflects Canadian actors' critical awareness of the relevant problems, and clearly demonstrates that the formulation of a transnationally shared value base can be regarded as a prerequisite for potentially groundbreaking technological developments. In this context, as our interviewees noted, the actors are focusing particularly on cooperation with Europe, which is seen as sharing key values with Canada. In addition, the approach is intended to underscore an independence relative to other regions of the world such as the United States and Asia.

The Canadian Institute for Advanced Research (CIFAR), a Toronto-based non-profit organization that has promoted AI research since its founding in 1982, was commissioned to implement the AI strategy. A total of CAD 125 million has been allocated for this purpose. A significant portion of the CIFAR's work can be summarized under the heading of "knowledge mobilization" – that is, it connects scientists and relevant stakeholders, promotes cross-border and cross-sectoral research dialogue, and designs missions on the basis of suggestions provided by the research community. The priorities for such work are chosen on the basis of 13 explicitly multidisciplinary areas, which are in turn directly or indirectly oriented

6 See www.cifar.ca/ai/pan-canadian-artificial-intelligence-strategy (accessed on Aug. 5, 2020).

FIGURE 17
MONTREAL DECLARATION FOR A RESPONSIBLE DEVELOPMENT OF AI

1. **Well-being:** The development and use of artificial intelligence systems (AIS) must permit the growth of the well-being of all sentient beings.
2. **Respect for autonomy:** AIS must be developed and used with respect for people's autonomy, and with the goal of increasing people's control over their lives and their surroundings.
3. **Protection of privacy and intimacy:** Privacy and intimacy must be protected from intrusion by AIS and by data-acquisition and archiving systems.
4. **Solidarity:** The development of AIS must be compatible with maintaining the bonds of solidarity among people and generations.
5. **Democratic participation:** AIS must meet intelligibility, justifiability and accessibility criteria, and must be subjected to democratic scrutiny, debate and control.
6. **Equity:** The development and use of AIS must contribute to the creation of a just and equitable society.
7. **Diversity inclusion:** The development and use of AIS must be compatible with maintaining social and cultural diversity, and must not restrict the scope of lifestyle choices and personal experience.
8. **Prudence:** Every person involved in AIS development must exercise caution by anticipating, as far as possible, the potential adverse consequences of AIS use, and by taking appropriate measures to avoid them.
9. **Responsibility:** The development and use of AIS must not contribute to diminishing the responsibility of human beings when decisions must be made.
10. **Sustainable development:** The development and use of AIS must be carried out so as to ensure strong environmental sustainability of the planet.

toward societal challenges. One prominent example is the AI & Society Program, which addresses the societal impacts of AI and examines how it can generate solutions in areas such as the climate crisis or healthcare.[7]

Multiple innovation centers provide for dialogue and networking

However, CIFAR is not the only institution responsible for AI development. One important element of Canada's AI strategy is to promote the establishment of innovation systems around three research institutes from three provinces: the Montreal Institute for Learning Algorithms (Mila) in Québec, the Vector Institute in Toronto (Ontario), and the Alberta Machine Intelligence Institute (Amii) in Edmonton (Alberta) – each of which are active in international networks. These institutes are embedded in a dense environment consisting of other research institutions and laboratories, universities, companies, and startup-support structures. This can be easily seen at the Vector Institute, located in the MaRS Discovery District,

7 See www.cifar.ca/ai/ai-society (accessed on Aug. 5, 2020).

which in turn is one of the largest startup accelerators in the world, with around 14,000 associated firms. The University of Toronto is nearby, and this location in the so-called Digital Corridor between Toronto and Waterloo, one of the most innovative economic regions in the Americas, provides for further synergistic effects (McKinsey 2016).

CIFAR and each of these three institutes currently enjoy outstanding global reputations, particularly in the area of mission-oriented AI research (Floridi and Cowls 2019; Floridi et al. 2018). This is largely due to the fact that they succeed in pursuing cutting-edge research that also targets application needs. CIFAR, for example, counts 20 Nobel Prize winners among its fellows. Mila is one of the world's largest non-university research laboratories in the area of machine learning, and also has access to a top-tier network of researchers. Nor is the work limited purely to academic topics, as can be seen in Mila's AI for Humanity program, which explicitly states the following goal: "To contribute to social dialogue and the development of applications that will benefit society."[8] The underlying concept of innovation thus aims at much more than simply generating growth and jobs, and the work is of course guided by the Montreal Declaration cited above.

Key success factors: Diversity and an international, interdisciplinary focus

The case of Canada also clearly shows that the development of modern, application-oriented technologies requires more than a well-equipped laboratory and ample financial resources. Another important success factor involves giving far-sighted talent management a sufficiently high priority. For example, the AI strategy's first goal is focused on increasing the number of highly skilled AI researchers in the country. Accordingly, all of the institutions cited above are engaged in a global talent-acquisition process, consciously seeking to recruit the leaders in the field. As our interviewees pointed out, this actively promotes diversity, and is also a recognition of Canada's broader cultural diversity. The CIFAR network of more than 400 researchers from 22 countries serves as an example in this regard. To a certain extent, this cross-national aspect can also be found in the substance of each institute's work, which has a strongly interdisciplinary character. The diversity of perspectives is seen as an innovation factor, and in general as the key to developing holistic solutions to multifaceted problems. In practice, this is in turn expressed in the matter-of-course and highly valued involvement of humanities scholars and social scientists.

This diversity is also reflected in the cross-sectoral character of the work carried out in Canada. As previously noted, Canada's AI centers aim at an integration of actors from the business (both large companies and startups), academic and political sectors. Innovation work is explicitly regarded as networking and dialogue work, and the participating stakeholders are encouraged to exchange insights and knowledge as partners (see Results Paper 2).

8 See https://mila.quebec/en/ai-society/ (accessed on Aug. 5, 2020).

Finally, the many cross-national working relationships formed in the course of Canada's AI activities offer a further robust demonstration of just how embedded they are in international and dialogue-driven processes. For example, an institution such as CIFAR may finance projects even if the participating teams are working abroad. This is based on the understanding that global challenges can only be overcome through global efforts. Accordingly, efforts are being made to establish and maintain sustainable frameworks for dialogue with actors from other countries.

Lessons learned with relevance for Germany

The formulation and implementation of the AI strategy reflects Canada's commitment to pioneering new ways of developing groundbreaking technologies that can be used as levers for societal progress. In doing so, the government has refrained from imposing strict substantive requirements. Rather, the adoption of the AI strategy has underlined the intention of becoming one of the world's leading nations in the AI field, and of creating the structural, financial and human-resources conditions to make this possible. This is evident in cities such as Toronto and Montreal, which offer excellent scientific and infrastructural conditions, and are already hotspots for AI development.

This approach is paired with a clear values orientation. Instead of retracing others' paths, Canadian researchers are consciously following their own approach, which is in harmony with societal preferences and is at once future-oriented and critically examined. The Montreal Declaration, which was drafted on this basis, can also be joined by institutions from Germany and Europe.

The strategic objectives are brought to life by various institutions whose network-like association forms the basis for locally anchored, yet cross-national and cross-sectoral innovation systems. Actors within these systems thus promote the link between scientific excellence and a practical application orientation. In general, Canada's example illustrates the importance of dialogue and exchange as an aspect of innovation, and in multiple respects: Serious efforts are constantly being made to transcend cultural, disciplinary, sectoral and national boundaries. This has several beneficial consequences; among others, it makes Canada a highly attractive destination for top-of-field researchers from around the world, and ensures that the actively involved stakeholders are highly committed.

Canada is committed to taking an approach that is in harmony with societal preferences.

FIGURE 18

LESSONS LEARNED

from the Canadian innovation system with relevance for Germany

DIRECTIONALITY AND INTENTIONALITY

- Prioritization and support of key digital technologies as a lever for growth and the solution of societal problems.
- Inclusion of ethical principles in the development and use of AI systems.

COORDINATION ACROSS DISCIPLINES, SECTORS AND MINISTERIAL PORTFOLIOS

- Strengthening of regionally anchored but internationally oriented innovation systems.
- Promotion of networking and dialogue across disciplinary, sectoral, cultural and national borders.

BOTTOM-UP NEGOTIATION, DECISION-MAKING AND SOLUTION PROCESSES

- Development of ethical principles for the development and use of key digital technologies on the basis of broad public consultation processes (in the form of the Montreal Declaration).
- Montreal Declaration as the as the basis for a transatlantic discourse regarding the principles-based development of AI.


サロンパス
シバトラ
もんじゃ
三千里薬品
西村
B1F
B2F
Matsumoto KiYoshi
大盛堂商事ビル
歩きタバ

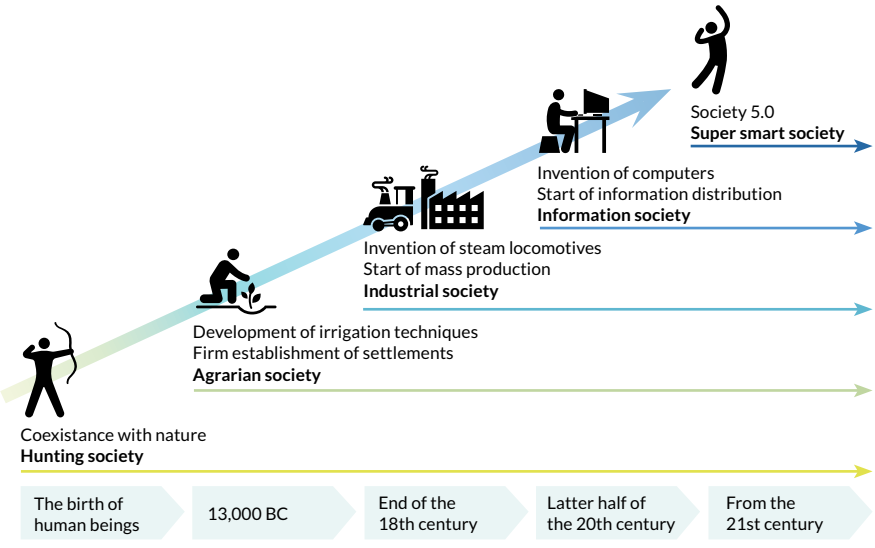
3.2.5 JAPAN

A high-tech path to a new society

Japan is facing enormous economic and societal challenges – and wants to meet them with an ambitious transformation agenda that is grounded in high-tech innovation. The frame of reference for this is the vision of a "Society 5.0," a fully digitally networked society in which world-class Japanese technologies foster societal progress. First used in 2016 in the Fifth Master Plan for Science and Technology, the term serves to a certain extent as an umbrella for a variety of innovation initiatives driven by Prime Minister Shinzo Abe's office; the Cabinet Office; the Ministry of Economy, Trade and Industry (METI); and the Japanese Business Federation (Keidanren), the country's most important trade association (Council for Science, Technology and Innovation). These initiatives have one goal in common: to make Japan's society sustainable through the targeted support and use of advanced technologies – especially in terms of digital transformation and networking – and thereby reach an entirely new stage of development.

A new era can be imagined as following the stages of hunters and gatherers, agriculture, industrialization, and the information society; it is this perspective that makes clear the comprehensive and transformational aspiration of Japan's development and innovation strategy (see Figure 19). The vision of Society 5.0 can also be interpreted as a reaction to Germany's "Industry 4.0" and the "Made in China 2025" initiative, but is explicitly extended to include the dimension of further societal development (Keidanren 2018).

FIGURE 19
SOCIETAL DEVELOPMENT THROUGH SOCIETY 5.0



Source: Prepared based on materials from the Japan Business Federation (Keidanren 2018)

In addition to the master plan mentioned above, the vision's substantive building-blocks include the 2017 Growth Strategy (released by the cabinet), the "Future Vision towards 2030s" document (METI), and a specific Society 5.0 action plan (Keidanren) (Konrad-Adenauer-Stiftung 2018). Underlying all of these initiatives is the clear intention to solve infrastructural, economic and societal problems through the development of new technologies or the repurposed use of existing technologies. The driving force for these efforts can be located in the urgent problems facing Japan as an economy and a society: the depopulation of rural regions, strongly declining birth rates paired with the aging of the population, and the consequentially shrinking potential labor supply (Floridi and Cowls 2019; Floridi et al. 2018).

The latter points in particular are quite comparable to the problems currently facing Germany. In addition, Japan's economy is strongly dominated by large enterprises, which makes it more difficult for start-ups to pursue potential innovation activities. Moreover, there is also a question in Japan as to how future energy needs will be securely provided for, and how the transition can be made to a resource-efficient, sustainable economy.

Ambitious goals and a holistic conception of development

The basis for the solution of these problems is seen as lying in the connection between the physical and digital worlds. That is, in a Society 5.0 geared toward efficiency and inclusiveness, humans and machines will work hand in hand. Processes will be automated, robots capable of learning will take over daily tasks, and intelligent systems will optimize value chains. Just as some cultural traditions are considered to be the causes of many of the country's problems, Japan's long record of emphasizing technological solutions comes into play in this context. The country has the second-largest IT sector of any OECD country (OECD 2015), and has traditionally seen innovation as a driver of increased competitiveness, productivity increases and even societal transformation (Atkinson and Ezell 2012). The areas of application for the new technologies in Society 5.0 are broadly defined. The government identifies in its Five Year Plan the following challenges as examples (Government of Japan 2016):

1. Managing the impact of natural catastrophes
2. Ensuring a secure food supply and healthy workplaces
3. Ensuring the security of digital networks
4. Dealing with issues of national security

Additional areas of application include energy-production processes, transportation and mobility, data-driven urban management, robotics used to improve care for the elderly and data-driven agriculture – the list goes on and on, testifying to the Japanese strategy's holistic approach. This comprehensiveness, and especially the societal thrust of the approach, is also reflected in the overall goals. Keidanren outlines these goals without any reference to specific technologies:

- Liberation from focus on efficiency: A society where value is created.
- Liberation from suppression of individuality: A society in which anyone can exercise diverse abilities.
- Liberation from disparity: A society in which anyone can get opportunities anytime, anywhere.
- Liberation from anxiety: A society in which everyone can live and pursue challenges with peace of mind.
- Liberation from resource and environmental constraints: A society where people can live in harmony with nature.

In addition, all 17 Sustainable Development Goals (SDGs) are explicitly cited as guiding principles, further underscoring the comprehensive character of Society 5.0.

Overall, one can speak of a high level of intentionality and directionality in Japan's innovation strategy, as it aims at nothing less than a societal transformation, while explicitly defining the areas of activity to be involved in this process. However, the path to this goal is not clearly specified. Rather, as the Japanese Business Federation notes:

"Society 5.0 is not something to come, but something to co-create. Main player of that society is not technology but human being. It is a society realized by people who pursue diverse values with diverse imagination and creativity." (Keidanren 2018)

Multiple actors driving the innovation process

In practice, the innovation activities associated with Society 5.0 are shared across a number of participants, and to a large extent are being carried out in coordination between the government and large industrial companies. Among its various actions, the government is directly supporting the development of key technologies, for example through the "Strategic Innovation Promotion Program" overseen by the Japan Science and Technology Agency, a state funding organization. These projects are also intended to strengthen cooperation between private and public actors. For example, large companies such as Toyota can participate by making a financial contribution or by conducting their own research. Another important state instrument is the ImPACT (Impulsing Paradigm Change through Disruptive Technologies) program, which aims to produce disruptive innovations in technology through ambitious R&D expenditures, in turn generating economic and societal change (see also Results Paper 3 in this series).

Similarly, the Moonshot program aims at inducing disruptive innovation by funding unconventional ideas with the potential for positive economic and social impact. The ideas are selected by a government commission on the basis of a public consultation process. The projects are highly experimental, and the program is thus constituted to allow for failure (Cabinet Office Japan 2020). The innovation activities carried out by the private sector are often brought together by trade associations such as Keidanren, and organized in industry consortia founded expressly for this purpose such as the Robot Revolution Initiative or the Industrial Value Chain Initiative.

These examples show that there is a lively exchange between the various relevant actors that takes place across portfolios and disciplines. However, the innovation activities do fall into the tradition of a coordinated market economy, in which the state, in agreement with (large) corporations, creates an environment favorable to technological innovation (Witt and Redding 2014). A certain top-down and centralistic character is thus evident. In this context, it must again be noted that the startup scene, which could in theory hold the potential to disrupt old structures, is

In a Society 5.0 geared toward efficiency and inclusiveness, humans and machines will work hand in hand.

too weak to do so here. At the same time, in the conversations conducted for this research, interviewees indicated that integrating the public more strongly into innovation processes, for example in the context of the Strategic Innovation Promotion Program, is being considered.

Lessons learned with relevance for Germany

As yet, it is too early to be able to fully assess the success of the transformation toward a Society 5.0. In particular, it remains to be seen whether and to what extent the rather loose connections between the individual initiatives might produce obstacles, particularly from the organizational perspective. Nevertheless, despite all the cultural and structural differences, Japan's example provides some valuable inspiration for the German context. This is the case particularly because of the generally quite comparable contextual environments and the associated pressure to act. Both countries feature aging populations and, as industrialized, high-tech nations that have in some ways grown complacent, have yet to find their way in the new age of digital transformation.

With regard to the aspects of directionality and intentionality, the scale of Japan's ambitions must be emphasized. Society 5.0 is intended as a reinvention of the country, entailing a comprehensive transformation of the economy and society. The highly developed technology sector is to serve as the foundation for this transformation – an ambitious approach that could also be embraced more fully by Germany, which as an engineering nation has tended to be more hesitant and pursued innovation more incrementally.

Moreover, while Japan's innovation strategy certainly addresses the economic and technological dimensions, it also emphatically includes a societal dimension. Technology is not an end in itself or simply an engine of growth but is rather a key lever of future societal development. This holistic approach is translated into practice through the support of new technologies in many different fields of application. It is striking that there are no strict substantive specifications for the support and development programs and that disruptive innovations are given a high priority. The prerequisites for such activity include openness and a willingness to take risks – two characteristics that German innovation policy often lacks. The cross-sectoral nature of the application areas in Japan also testifies to the presence of a lively exchange across commonly encountered technical and disciplinary boundaries.

From an organizational perspective, the Japanese model's top-down orientation may not appear as an aspect to be emulated. In addition, international (innovation) exchanges are significantly less common than is typical in Europe. Nevertheless, the formulation and implementation of Society 5.0 shows that a strategic bracketing of this kind can certainly be of use in bringing a number of actors and interests together under the same roof. Especially given the complex federal characteristics and diversity of interests in Germany, such an approach appears worth considering in order to bundle local innovation efforts within an ambitious, cross-sectoral and integrated framework.

FIGURE 20

LESSONS LEARNED

from the Japanese innovation system with relevance for Germany

DIRECTIONALITY AND INTENTIONALITY

- Comprehensive, ambitious transformation of the economy and society, with the goal of a new stage of societal development.
- Unites actors and interests under the shared Society 5.0 vision.
- Consciously builds on the country's high-tech traditions as a basis for progress.
- Formulation of societally preferred fields of application for new technologies.
- Initiation of high-risk innovation programs to promote potentially groundbreaking innovations.

COORDINATION ACROSS DISCIPLINES, SECTORS AND MINISTERIAL PORTFOLIOS

- Promotion of new technologies across commonly encountered technical and disciplinary boundaries.
- Close exchange between government and industry for the coordination of innovation projects.

BOTTOM-UP NEGOTIATION, DECISION-MAKING AND SOLUTION PROCESSES

- Broad-based consultation processes as a basis for the disruptive Moonshot program.

4.

Addressing societal challenges through innovation – the coronavirus crisis as a window of opportunity

Germany and Europe face enormous societal and economic challenges. Climate change, shifting demographics, the overexploitation of natural resources, the coronavirus pandemic and the need to improve crisis resilience – to cite just a few examples – are imposing urgent pressures to act within economic and political systems, with governments' legitimacy hanging in the balance. Given the fundamental nature of these problems, seeking to remedy them through small-scale solutions or by making isolated adaptations to existing structures seems doomed to fail. Instead, the situation calls for deep system-level transitions that entail a range of complementary societal, economic and technological developments.

Innovation is the only way forward if we are to achieve a sustainable, resource-efficient and climate-neutral economy. New solutions and approaches to policy will be needed in order to make sociopolitical objectives of this magnitude a reality. In this regard, a modern innovation policy must place itself in the service of a holistic, sustainable development strategy in which economic and societal concerns are effectively and strategically linked. An innovation policy of this nature can also help ensure that the paradigms of "strengthening technological and economic competitiveness" and "solving societal problems through innovation" mutually reinforce each other in facilitating positive outcomes. Formulating ambitious goals aimed at solving challenges facing society as a whole can serve as an especially effective lever with regard to promoting new technologies, driving innovation forward, increasing competitiveness and improving future crisis resilience.

Drawing on selected "good practices" from other countries, the present study shows how this can be achieved in practical terms, and what we can learn from such examples in the German and European context. In reviewing these findings, it is always important to keep in mind the great economic and societal opportunities that can result from an approach of this kind. To be sure, this study makes repeated

Innovation is the only means of achieving the transformative goal of a sustainable economy.

reference to specific innovation weaknesses – reflected, for example, in the degree to which the rollout of key digital technologies has fallen behind, or in the present lack of disruptive innovations. Nonetheless, Germany and Europe without question continue to show enormous potential that could be exploited and even expanded during the course of fundamental transformative change. Germany continues to benefit from considerable advantages, including highly developed technological capacities, exceptional basic-research institutions, a comparatively high standard of education, stable democratic systems and a vibrant civil society. Taken together, these factors give us a good foundation for formulating and realizing ambitious future-oriented transformation goals. But to unlock this potential effectively, and to promote innovation as a lever of societal transformation, an ambitious mission-oriented strategy is needed, along with effective instruments and progressive institutions that can further such an approach and enable the achievement of these goals.

Times of crisis deliver opportunities to re-prioritize societal and economic needs.

Against this background, this study analyzes selected strategies and institutional practices with the goal of transferring knowledge and sparking the desire for further learning in Germany and Europe. The goal in this regard is not the wholesale adoption of complete policies – which is in any case impractical – but rather to generate a discussion of promising elements and inspiring approaches that could be applied in the local context. The present moment is ripe for such a discussion, and for possible adaptations of existing innovation-policy instruments. Periods of crisis in particular offer the opportunity to reprioritize societal and economic needs, and to revise potentially outdated policies and approaches. Moreover, such eras generally entail a widespread increase in the acceptance of transformative change. So why wait? Now is the time to increase our innovative capacity and unlock the potential inherent in our societies in order to solve the great problems of our time.

Directing innovation policy toward ambitious goals

The coronavirus crisis is not the only factor providing a window of opportunity to adapt innovation policy to the needs of our time. As the review of innovation-policy developmental steps has shown, the thinking regarding this area of policy and its objectives has significantly evolved. In the initial decades following World War II, innovation policy was primarily oriented toward purely economic goals. However, a different approach developed gradually over time, featuring the use of appropriate, targeted measures to combat market or system failures and to solve societal problems, which led to a shift in focus. In addition to growth and competitiveness objectives, politically motivated and societally relevant goals (“missions”) emerged as new guiding principles for innovation-policy activity. This paradigm shift is prominently ex-

pressed in the United Nations' Sustainable Development Goal 9 (industry, innovation and infrastructure), which explicitly emphasizes innovation as a starting point for inclusive and sustainable economic and societal development.

This new way of thinking about innovation policy can also be linked to the transformative change called for here. Missions (such as the development of an emissions-free economy by a clear deadline) contribute to holistic transformative change, thus having an impact well beyond their specific area of activity (such as the development of new engine technologies). An innovation policy that works toward such missions is inherently cross-sectoral and multidisciplinary; thus, it encompasses not only the stage of pure knowledge generation, but also the phases in which ambitious strategies are formulated, measures are implemented, all relevant actors are involved, and the resulting ideas or products are disseminated within the market. Needless to say, a process of this kind is more challenging and requires more preparation than a traditional innovation-policy approach. The task of defining missions requires democratic legitimation and a widely shared understanding of the problem. This kind of consensus, in turn, requires complex processes of coordination and inclusion that can, at times, overwhelm conventional coordination mechanisms. Finally, during the implementation stage, a very broad spectrum of actors must be networked together, behavioral changes must be initiated, and infrastructures must be adapted to support the policy's needs. In short, a modern innovation policy demands innovative strategy-development processes, and new configurations of actors, institutions and practices.

Meeting these challenges requires a specific set of governance structures. Although their precise form will necessarily reflect the particularities of the specific (national) innovation landscape, a number of promising elements useful in an "innovation for transformation" approach can be derived from the good-practices examples discussed here and in the other results papers published as part of this project:

- An independent, agile "change agent" can bundle innovation expertise, prioritize and orchestrate innovation processes, and serve a liaison function between the various (top-down and bottom-up) levels and sectors.

- Disruptive innovation must be given active and venturesome support, , and it must be directed toward the solution of societal problems. This can be accomplished, for example, through the use of specialized institutions or with appropriately designed programs and incentive systems.

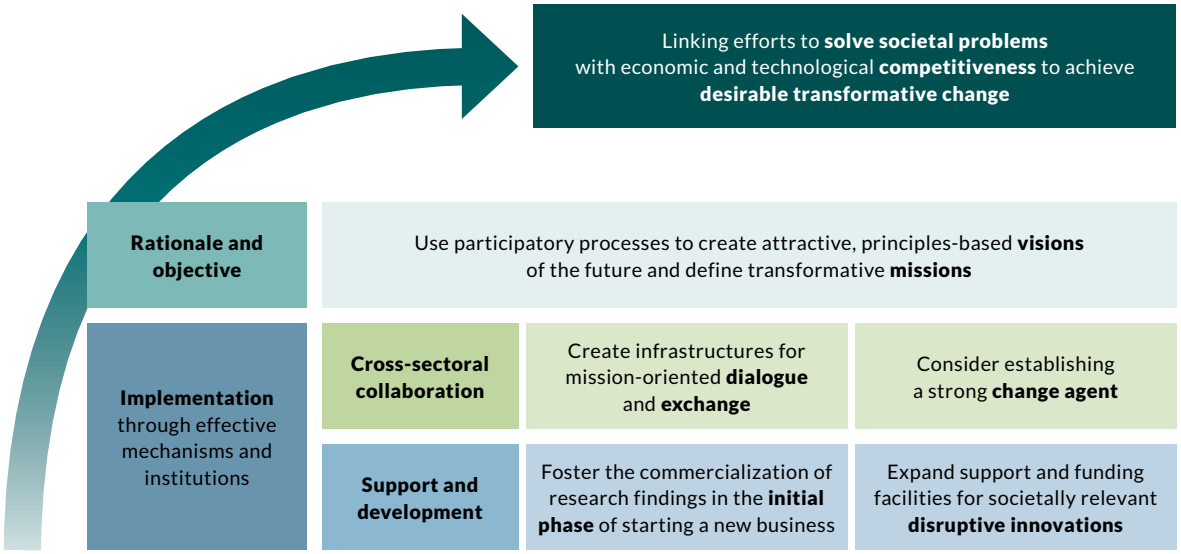
- Dialogue and strategic networking between different actors and spheres of activity (such as the business, policy, civil society and academic sectors) can be supported through open innovation processes, with the aim of orienting innovation toward societal needs and speeding the diffusion of innovative products and practices.

Ideally, a holistic set of institutions and structures of this kind would ensure that the factors fueling an innovation system (such as the availability of adequate financing for startups, the presence of skills relevant to innovation, the ability to retain talented international employees, etc.) are enhanced or at least scaled to an appropriate level – all with the objective of strengthening overall innovative capacity and thus enabling deep system-level transitions (see Figure 21. For more information on the various areas of activity, see the other papers in this series).

Mission-oriented innovation policy in practice: Ambitious strategies, new governance structures, broad-based participation

An analysis of Germany's High-Tech Strategy 2025, which constitutes the primary framework for the conception and implementation of the country's innovation policy, reveals a number of areas showing potential for improvement. With regard to the directionality and intentionality of the strategy, there is an evident lack of tried-and-tested processes for formulating and realizing missions. In particular, it is not clear that sufficient care is taken in the conception phase to ensure that missions have a cross-sectoral character. Moreover, the coordination across disciplines, sectors and ministerial portfolios does not always appear to function well on a practical level. This can be explained by a lack of clarity with regard to the strategic ownership of policy measures, an implausible distribution of responsibilities and a rather weakly developed culture of consensus between the ministries involved. Finally, there is a lack of bottom-up participatory processes for the negotiation of objectives, and for making decisions and identifying solutions collectively.

FIGURE 21
INNOVATION FOR TRANSFORMATION



Source: Bertelsmann Stiftung

Despite the country's undeniable successes, these findings indicate that Germany may have significant unexploited potential with regard to developing and implementing mission-oriented innovation policy. This impression is heightened by the findings derived from the good-practices research presented in this report, which clearly indicates that the countries studied often rely on strategies, institutional practices and instruments other than those employed in Germany. This study offers the following insights in particular:

1. **Directionality and intentionality**

Developing ambitious strategies: Like Germany, the countries examined here are subject to considerable pressure to act – and are meeting it with ambitious and bold innovation strategies. Innovation never appears as an end in itself, or as an isolated area of activity with a purely economic justification; rather, it is regarded as a key lever for societal and economic development. Japan, where the "Society 5.0" concept aims at comprehensive transformative change across society, offers a particularly striking example in this regard, but Canada too stands out with an AI strategy that features societal and ethical dimensions as well as ambitious goals.

Combining problem-solving with competitiveness for mutual benefit: At the level of innovation-policy umbrella strategies, all of the cases examined demonstrate that a government's economic and industrial-policy priorities need not be inconsistent with an orientation toward societal challenges. Indeed, these can represent thoroughly complementary, mutually reinforcing goals. In all the case examples, strategies effectively link the objectives of "strengthening competitiveness and innovative capacity" and of "solving societal problems through innovation," at least at an implicit level. The formulation of specific social-policy mission goals thus dovetails with the motivations of economic and industrial policymaking that target, for example, establishing a foothold in future global markets, developing future industries and achieving a global lead in innovation. Social-policy mission goals can also go hand-in-hand with economic- and industrial-policy aims to minimize the negative impacts of developments such as an aging labor force (e.g., Japan) on a country's future research and economic capacities. In the United Kingdom, there is even an explicit link between a "traditional"-seeming competition policy and a mission-oriented innovation policy.

Grounding missions in normative goals: Modern innovation policy by no means follows purely market-based preferences. Rather, it has the courage to pursue normative goals that target societal needs. This orientation may be based on generally recognized guiding principles such as the SDGs (as in Sweden), or an internally developed canon of values for artificial intelligence, as with Canada's Montreal Declaration. These general principles are then actively translated into corresponding policies. This kind of approach provides Europe with an opportunity to carve out its own values-based "third way" in the global innovation-policy competition between systems, and thus clearly distinguish itself from countries such as China or the United States.

Specify fields of activity and orient them toward future technologies: In formulating specific fields of activity, the challenge is to clearly define transformation goals without restricting innovation or prescribing the manner in which the goal is to be reached. Success factors include the specification of definite time frames, the allocation of strategic ownership and the provision of sufficient flexibility in the design of the innovation-related work. All of the example countries in this study – but most notably Canada, the United Kingdom and Japan – show a striking commitment to the promotion of key digital technologies with a cross-cutting nature. One key mechanism in this regard can be efforts to nurture technology development that offers clear societal opportunities (e.g., principles-based application of AI systems in Canada). Long-term strategic research programs with ambitious and societally relevant goals, in which companies actively participate with their own funds or research and development efforts, constitute another such instrument. Mission-oriented strategic

programs of this kind should also be subject to continuous review (for example, by national innovation agencies), with particular scrutiny of the degree of progress being made toward the mission's achievement. The case of Japan (the ImPACT program) clearly shows how such programs may require the assumption of considerable risk (with the eventuality of failure taken into account) in order to unlock the potential for disruptive innovation.

2. **Coordination across disciplines, sectors and ministerial portfolios**

Promoting dialogue and overcoming barriers: Innovation thrives on dialogue, and on the ability to establish networks across disciplinary, sectoral and cultural boundaries. This must be actively promoted at the local, regional, national and even international levels. The examples in this report show that dialogue grounded in a sense of partnership and oriented toward consensus – as in the case of the Swedish National Innovation Council – ultimately leads to a high level of commitment on the part of the participating actors. This in turn has a positive impact on the innovation-related activities. The Swedish example also illustrates that high-level government bodies such as the National Innovation Council can play an important role in trialing holistic innovation-policy concepts with new instruments, and in subsequently putting them into practice (e. g., national agencies' functional procurement policies, which are used to stimulate demand for and improve the diffusion of innovations).

Creating specialized institutions for implementation: In the United Kingdom and Sweden, specialized agencies such as UKRI and Vinnova constitute important pillars of the innovation system. Similar approaches can also be found in other countries such as Israel and Finland. Due to their high level of technical expertise and independence, these "change agents" have a high degree of credibility, and can relieve other institutions of otherwise burdensome tasks. They often take on responsibility for implementing missions, coordinating the negotiation and coordination of mission paths, creating spaces for experimentation, networking and orchestrating a broad range of actors with an eye toward the strategic innovation goals, and moderating cross-sectoral dialogue. By serving as liaisons between the different levels of activity, they help to further develop holistic innovation strategies, while averting any potential disruptions caused by parochial departmental interests. They also assume an important "strategic intelligence" role, identifying new technology trends and devising ways to measure the societal effects of innovation policy. Agility, independence, a highly qualified and diverse staff, and a strong political mandate are all prerequisites for their success.

3. **Bottom-up negotiation, decision-making and solution processes**

Negotiating priorities collectively: Although the approaches vary in detail, and are dependent upon individual cultural practices, the development of innovation-policy priorities in most of the countries examined here has been based on discursive, cross-sectoral and participatory processes of negotiation. This explicitly entails the bottom-up inclusion of civil society voices, as demonstrated particularly in the Netherlands (the Polder model) and in Sweden. One key success factor in this regard consists in involving representatives from the business, academic and civil society spheres alike in a consensus-based process of identifying societal challenges, defining missions and laying out transformation paths. This kind of negotiation process also serves as a well-targeted mechanism for identifying societal needs, and for increasing the acceptance of demand-oriented instruments (e. g.,

functional procurement), which can be conducive to pursuing and adhering to a transformation path. This helps in crafting innovation strategies that more closely fit their objectives and the society's needs. In addition, societal acceptance of interventions increases, and there is a greater sense of shared responsibility for change processes. Such negotiation processes may be organized by the national innovation agencies, for example.

Forging concrete agreements: Rather than being treated as an end in themselves, collaborative negotiation processes should produce results that are as concrete as possible. Canada offers an outstanding example in this regard with its use of a broad-based public consultation process to generate ethical principles for the development of key digital technologies, which were ultimately incorporated into the Montreal Declaration.

Building on traditions, breaking new ground

A modern innovation policy allows economic competitiveness, technological progress and societal development to be linked together in a complementary way. Although research on this topic remains in its infancy, the country examples cited illustrate what is important in practice. In this sense, the present study should be seen as providing inspiration for the pursuit of mission-oriented innovation policy.

Despite all the differences between the individual countries, it is quite clear that appropriately crafted strategies and governance structures are needed in order to develop and implement an innovation policy of this kind. To be sure, the examples also indicate that it is not necessary to start from scratch in every instance. Previous processes can be adapted, and existing strengths can be further developed; Germany, for example, has strong traditions of innovation that can be expanded upon for this purpose. However, given today's rapid technological developments and great societal challenges, traditional polices often prove to be unequal to this task.

What is needed is the determination to open up to new ideas and new approaches, in the form of new institutions or modes of dialogue, and of disruptive ideas and technologies. Doing so would also increase Germany's international appeal as a location for innovation. To this end, policymakers should not content themselves with small-scale solutions; rather, they should formulate far-sighted and courageous ambitions, so that innovation policy can truly become a lever for a fundamental, potential-realizing transformative change.

A modern innovation policy combines economic competitiveness with technological progress and societal development.

5. APPENDIX

5.1

Global research on good practices – our interview partners

INSTITUTION/ORGANIZATION	INTERVIEW PARTNER
1E9 (Munich)	Herbert Mangesius
acatech – National Academy of Science and Engineering (Munich)	Dr. Jan Henning Behrens
Bertelsmann Foundation (Washington)	Irene Braam
Briter Bridges (London)	Dario Giuliani
Bundesverband Deutsche Startups e. V. (Berlin)	Christoph J. Stresing
Business Finland (Helsinki)	Pekka Sivonen
Canadian Institute for Advances Research (CIFAR) (Toronto)	Rebecca Finlay
Center for Data Innovation (Brussels)	Eline Chivot
Centre for Social Innovation (Toronto)	Raissa Espiritu
Co-Lab Sweden / Förnyelselabbet (Stockholm)	Pia McAleenan
Digital Catapult (London)	Brian MacAulay Cordelia O'Connell Jessica Rushworth
Ecosia (Berlin)	Dr. Wolfgang Oels
European Commission – Directorate-General Research and Innovation (RTD) (Brussels)	Maximilian Steiert Renzo Tomellini Isabel Vogler
Federal Ministry for Economic Affairs and Energy (BMWi) (Berlin)	Thomas Jarzombek, MdB
Federal Ministry of Education and Research (BMBF) (Berlin)	Engelbert Beyer Dr. Gisela Philipsenburg

INSTITUTION/ORGANIZATION	INTERVIEW PARTNER
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Founders Foundation (Bielefeld)	Sebastian Borek
German Chamber of Commerce and Industry in Japan (AHK Japan) (Tokyo)	Dr. Lucas Witoslawski
German Consulate General Montreal	Dr. Markus Lang
German Institute for Japanese Studies (DIJ) (Tokyo)	Dr. Susanne Brucksch Prof. Dr. Franz Waldenberger
German Research Center for Artificial Intelligence (DFKI) (Berlin)	Julia Gundlach
Innosuisse (Bern)	Eliane Kersten Marc Pauchard
Innovate UK – UK Research and Innovation (UKRI) (London)	Dan Hodges
Innovation Policy Lab – Munk School of Global Affairs and Public Policy, University of Toronto	Travis Southin Prof. David Wolfe, PhD
Institute for Competitiveness (I-Com) (Brussels)	Mattia Ceracchi
Internet Economy Foundation (IE.F) (Berlin)	Amelie Drünkler Clark Parsons
Japan Science and Technology Agency (JST) (Kawaguchi)	Prof. Hiroshi Nagano Tomoko Sawada
Kienbaum Consultants International (Cologne)	Stephan Grabmeier
Laboratorio de Gobierno (Santiago de Chile)	Roman Yosif
LabX – Laboratório de Experimentação da Administração Pública (Lisbon)	Bruno Monteiro
Lindholmen Science Park (Göteborg)	Tord Hermansson

INSTITUTION/ORGANIZATION	INTERVIEW PARTNER
MaRS Discovery District (Toronto)	Matthias Oschinski, PhD Dwayne Simms
Max Planck Institute for Innovation and Competition (Munich)	Prof. Dietmar Harhoff, PhD
Ministère de l'Économie et de l'Innovation Québec (Montreal)	Inji Yaghmour
Ministry of Economic Affairs, Agriculture & Innovation (The Hague)	Luuk Klomp
Ministry of Economic Affairs and Climate Policy (The Hague)	Koen de Pater
Ministry of Economic Affairs and Employment of Finland (Helsinki)	Anita Silanterä Kirsti Vilén
Ministry of Economic Development, Job Creation and Trade Ontario (Toronto)	Vasu Daggupaty Alex Lee Ernst Lueger
Mitacs (Montreal)	Coryell Boffy
Montreal Institute for Learning Algorithms (Mila) (Montreal)	Stéphane Létourneau
Nesta (London)	Peter Baeck Albert Bravo-Biosca, PhD Marieke Goettsch Eva Grobbink
Ontario Digital Service (Toronto)	Waqas (Wes) Iqbal
Organisation for Economic Co-operation and Development (OECD) (Paris)	Caroline Paunov
PHINEO gAG (Berlin)	Dr. Andreas Rickert

INSTITUTION/ORGANIZATION	INTERVIEW PARTNER
Prototype Fund – Open Knowledge Foundation Deutschland e. V. (Berlin)	Adriana Groh
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Roland Berger GmbH (Berlin)	Dr. Julia Oppermann
RWTH Aachen, Center Smart Services (Aachen)	Benedikt Moser
SDGx (Berlin)	Christian Walter
Sitra (Helsinki)	Timo Hämäläinen, PhD Markus Kalliola Paula Laine
Staatslabor (Bern)	Alenka Bonnard
Startup Genome (Berlin)	Marc Penzel
Swedish Incubators & Science Parks (Stockholm)	Kajsa Hedberg
UnternehmerTUM (Munich)	Johannes von Borries
Vector Institute (Toronto)	Cameron Schuler
Vinnova (Stockholm)	Göran Marklund Judit Wefer, PhD
ZEW – Leibniz Centre for European Economic Research (Mannheim)	Dr. Georg Licht

5.2

List of figures

5.3

Glossary

AI	Artificial intelligence
AIS	Artificial intelligence systems
BMBF	Federal Ministry of Education and Research (Germany)
CIFAR	Canadian Institute for Advanced Research
Green Deal	A set of policy initiatives by the European Commission that aim to reduce net emissions of greenhouse gases to zero and make Europe climate-neutral by 2050
HTF	Hightech Forum (Germany)
HTS	High-Tech Strategy (Germany)
ImPACT	Impulsing Paradigm Change through Disruptive Technologies Program (Japan)
Keidanren	Japan Business Federation
Lund Declaration	Through this declaration issued in 2009, the EU calls for innovation policies at both the EU and individual member state levels to focus on meeting greater societal challenges (Lund Declaration 2009)
METI	Ministry of Economy, Trade and Industry (Japan)
Mila	Montreal Institute for Learning Algorithms
Missions	A specific package of activities designed to deliver a verifiable result within a planned timescale that contributes to solving a societal challenge. Missions can be expressed in three ways, through: – quantitative targets (e. g., reducing CO_2 emissions by a certain percentage by a certain date); – one-off projects or achievements (e. g., moon landing); or – a specific direction, without measurable targets (e. g., "clean water") (ESIR 2018).
Mission-oriented innovation policy	A mission-oriented innovation policy can potentially adopt any of the three aforementioned types of missions. Orienting policy toward a particular mission requires two additional elements: – Organizational accountability for mission management – Measurability of mission progress (ESIR 2018)
Nesta	National Endowment for Science, Technology and the Arts (United Kingdom)
OECD	Organisation for Economic Co-operation and Development
R&D	Research and development
RTI	Research, Technology, and Innovation Policy
SDG	Sustainable Development Goals of the United Nations
SMEs	Small-and-medium sized enterprises
UKRI	UK Research and Innovation
UN	United Nations
ZEW	Leibniz Centre for European Economic Research (Mannheim, Germany)

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