



Regional Innovation Strategy for Smart Specialisation

RIS Thuringia



Table of Contents

1. Initial Situation	3
2. A highly developed Regional Innovation Strategy	6
2.1. Further development of the strategy in the context of the European structural policy	6
2.2. Goals of RIS Thuringia 2021	8
2.3. Innovation policy challenges	9
2.4. Shaping the regional specialisation between 2021-2027	13
3. Developments and Prospects of the Fields of Specialisation	17
3.1. Field of Specialisation: Industrial Production and Systems	17
3.2. Field of Specialisation: Sustainable and smart Mobility and Logistics	20
3.3. Field of Specialisation: Healthy Living and the Healthcare Sector	23
3.4. Field of Specialisation: Sustainable Energy supply and Resource Management	26
3.5. Field of Specialisation: ICT, innovative and production-related Services	29
4. Operational Implementation from 2021 to 2027	31
4.1. Further development of governance	31
4.2. Instrumental implementation using ERDF funding instruments	34
4.3. Continuous performance measurement and further development of the innovation strategy	37
5. Classification in the Economic Policy of Thuringia	39
5.1. Harnessing the potential of digitalisation in science and industry	39
5.2. Using industrial change, including decarbonisation, as an opportunity for companies and skilled workers	42
5.3. Supporting the growth of Thuringian companies	47

1. Initial Situation

Since 1990, Thuringia has made remarkable progress towards becoming a modern centre for business and science. This is reflected in an efficient science system, competitive economic structures, modern production facilities, attractive industrial and commercial sites, a well-developed transport infrastructure and liveable cities and communities that offer a high quality of life. Economy and science are therefore the two key fields of action crucial for Thuringia's future. It is here that the ideas, knowledge, products, jobs and the technologies of tomorrow are created, laying foundations for growth, prosperity, quality of life and, ultimately, the basis for a functioning community.

In the face of tough national and international competition, Thuringia has an overall good reputation as an up-and-coming innovation hub. With its ten universities, the free state has an efficient higher education system. The universities are of the utmost importance as a source of impetus for the development of Thuringia and its regions. As training centres for academic professionals, they attract young people from Germany and abroad and stand for a cosmopolitan Thuringia. They carry out high-level basic and applied research and are partners of industry in the initiation and implementation of innovation processes. A strong non-university research landscape and industry-oriented research institutions, which are geared to the R&D needs of the regional economy, round off the scientific profile.

At the same time, an innovative, competitive industry, including production-related services, plays a prominent role in Thuringia's economic development. Thuringia has a broadly diversified, medium-sized industry with hidden champions who are leaders in their fields. Sectors such as optics, photonics, sensor technology, medical technology,

automotive/automotive supply industry, mechanical engineering, logistics, metal processing, the food industry and the plastics industry have developed well. Enterprises, especially those in the manufacturing sector, have a high share of gross value added in Thuringia compared to the rest of Germany (22.4% in 2019, compared to a national average of 21.2% and an average of 17.2% for the new federal states excluding Berlin), with around one third of industrial sales now generated abroad. With 83 industrial jobs per 1,000 inhabitants, Thuringia is now well above the national average of 77.¹ In addition, the importance of production-related services or service-oriented and less materially driven value creation, especially for industry, has grown in recent years. This is mainly due to the growing demand for system solutions and customised products, which include an ever-increasing share of services that complement industrial products and production processes and expand value creation. In this respect, an innovation policy aimed at innovative and intelligent economic change is an essential element of a sustainable, future-oriented economic policy for Thuringia.

Despite positive developments in many respects in recent years, Thuringia, like the other eastern German area states, continues to lag behind the western German average in terms of macroeconomic indicators such as per capita gross domestic product, gross domestic product per employed person or even the wage and salary levels. The following structural characteristics of the Thuringian economy can be regarded as the main reasons for the existing productivity gap: a small-scale business structure, below-average business R&D activities and a low presence in foreign markets. This is also due to specific features of the industry structure, such as a significantly lower value-addition share in business-related services than the German average, a high share of low value-add-

¹ TLS 2020, press release 222/2020 of August 31, 2020: Beschäftigtendichte in der Thüringer Industrie im Jahr 2019 (Employment density in the Thuringian industry in 2019).

ing production of intermediate goods in the total industrial production and a low share of planning activities that usually take place at the headquarters.

This gap has hardly been reduced in the past years. Increasing the value creation and productivity by strengthening endogenous economic performance is therefore of central importance for Thuringia's economic future and must remain the overarching goal of Thuringia's economic policy. Shaping the upcoming change innovatively and intelligently is a prerequisite for a further increase in the income level². It is also indispensable for Thuringian companies if they are to survive in the increasingly international competition for skilled workers.

At the same time, Thuringia, as a centre for business and science, is also facing four main overarching challenges: digitalisation, decarbonisation, demographic change and the consequences of the COVID 19 pandemic. Taken individually, but even more so in combination, these have a profound and diverse impact on many aspects of life.

- › Digitalisation will not only bring about technological disruption, it will also change job profiles, introduce new modes of working and traffic control possibilities and enable connectivity between cities and their surrounding areas. Apart from the associated risks, the opportunities associated with these changes at the workplace level also need to be discussed more intensively. In particular, it is important to exploit the potential of digitalisation to increase productivity and value creation and thus achieve a higher wage level.
- › The goals of the European Union to achieve greenhouse gas neutrality by 2050 and to decouple economic growth from resource use (European Green Deal) go hand in hand with an energy and mobility transformation in the society as a whole. As a result, the economic sectors are faced with the immense challenge of making their production processes CO₂-neutral and more resource-efficient in the long term, while at the same time developing new, sustainable, recycling-oriented and more climate-friendly products and technologies. Here, the industry is in demand as a manufacturer of products, a provider of services and a user of technologies.
- › According to available projections, the ageing of society will lead to a decline in the working population in Thuringia by 24.5% in 2040 as compared to 2018, and in some districts - including industrial centres - even by more than 30%.³ Against this background, meeting the demand for skilled workers remains a key challenge for successful economic development in Thuringia.

² With a per capita GDP measured in purchasing power standards of EUR 27,400 (2019), Thuringia is still significantly below the national average (EUR 37,000) and also below the EU-27 average (EUR 30,200). [Source: Working Group on "National Accounting by the German States" 2020].

³ TLS 2019, Anschlussrechnung auf Basis der 2. regionalisierten Bevölkerungsvorausberechnung (Follow-up calculation based on the 2nd regionalised population projection).

› Not least the pandemic means that the above need for action and transformation in the economy and society will become even more apparent and, in some cases, will be accelerated. The asynchronous course of the Corona pandemic globally will not only delay unrestricted resumption of business in all sectors but also the smooth movement of goods and people and frictionless production for a long time to come. In addition - also against the backdrop of ongoing trade conflicts - there is an intensified discussion about increasing the sovereignty of certain key technologies and industries at the national level. It is therefore important to mitigate the disruptions caused by the pandemic as best as possible and to exploit the potential of transformation processes that are already underway to enable the economy in Thuringia to make a rapid and successful new start.

The European Cohesion Policy makes an important contribution to the economic, social and ecological development of the Free State of Thuringia. Between 2021 and 2027, it will also be necessary to use the European Regional Development Fund (ERDF) to reduce regional disparities and support Thuringia in its efforts to catch up with the more developed regions of Germany and the EU. The Regional Innovation Strategy for Smart Specialisation and Economic Change in Thuringia (RIS Thuringia) specifically addresses the ERDF Policy Objective 1 "A more competitive and smarter Europe by promoting innovative and smart economic change and regional ICT connectivity".⁴ In this context, good governance of RIS Thuringia is a fundamental prerequisite for Thuringia to use the ERDF support for developing and expanding research and innovation capacities and introducing advanced technologies under the umbrella of Policy Objective 1.⁵

⁴ Regulation (EU) 2021/1058 of the European Parliament and of the Council of 24 June 2021 on the European Regional Development Fund and on the Cohesion Fund.

⁵ Pursuant to Regulation (EU) 2021/1060 of the European Parliament and of the Council of June 24, 2021 laying down common provisions on the ERDF, ESF+, the Cohesion Fund (...), in conjunction with Annex IV of the same Regulation.

2. A highly developed Regional Innovation Strategy

Innovation policy is increasingly focussed on using innovative solutions at different levels to help address pressing societal and social challenges such as public services and participation, decarbonisation and climate change, demography and ageing. On the one hand, innovations originate in the scientific sphere, where innovations in applied research can flourish on the basis of basic research. On the other hand, the entrepreneurial and social environment also generates impulses for technological innovations, innovative adaptations and improvements of products and processes as well as new, innovative business models, organisational forms and services.

The key to overcoming the challenges ahead lies in combining Thuringia's efficient scientific landscape with the innovative strength of the local economy, especially industry and production-related services. In this context, science acts as a driver of technological progress in the economy. This means, among other things, increased productivity and qualitative, endogenous growth. It thus contributes to a strong, resilient and competitive economy for the future.

Harnessing the potential for innovation in the sense of smart change and with regard to the challenges ahead will be a major task, especially for small and medium-sized enterprises in Thuringia, which often have low R&D capacities. Given the lack of large domestic companies, the impulse-giving role of the scientific landscape is therefore of particular relevance.

2.1. Further development of the strategy in the context of the European structural policy

The conceptual basis for the present further development is the Regional Research and Innovation Strategy for Smart Specialisation in Thuringia for the 2014-2020 Structural Funds funding period, which is being updated, optimised and supplemented by a concept for strengthening innovation-based value creation networks. The goal is to create a strategic framework that identifies the cornerstones for the coming years and the framework conditions that need to be further improved for developing Thuringia as a centre of innovation and business.

RIS Thuringia and the corresponding ERDF measures have demonstrably made a positive contribution to increasing innovation in the Thuringian economy during the 2014-2020 funding period.⁶ The measures co-financed by the ERDF to strengthen research, technological development and innovation have also had a demonstrable impact on the innovative behaviour of companies. For example, R&D activities in companies have been sustainably increased and companies have been motivated to engage in long-term R&D projects.⁷ The monitoring system introduced by the Thuringian ClusterManagement (ThCM) as the coordinating body of the implementation process also shows that considerable federal funding has already been obtained for large-scale R&D projects within the framework of federal programmes, e.g., Growth Cores of the Federal Ministry of Education and Research (BMBF) with a total volume of EUR 75 million for R&D projects, of which EUR 52 million have been funded since 2014.⁸

⁶ Evaluation of the measures to strengthen research, technological development and innovation under the ERDF Operational Programme for Thuringia 2014-2020, Ramboll.

⁷ Evaluation of the measures to strengthen research, technological development and innovation under the ERDF Operational Programme for Thuringia 2014-2020, Ramboll.

⁸ Data from the Thuringian ClusterManagement.

In the new Structural Funds funding period, this progress will be built upon and structures and processes will be selectively improved and strengthened. Important starting points are the strengthening of the location's endogenous development potential, especially in industrial research and development, R&D infrastructures, cluster development and supraregional networking, the meeting of the demand for skilled workers, the establishment of future technologies - e.g., digital technologies, artificial intelligence (AI), hydrogen technology - and the support of transformation processes and innovation-based value creation networks⁹.

The innovation policy focuses on the five fields of the previous RIS Thuringia for the 2014-2020 funding period and, in particular, on those sectors, topics and growth areas that are particularly important for the future of the state and in which Thuringia has comparative specialisation advantages (see Chapter 2.4). The innovation system is seen as a process embedded in a broader framework. Original research and technological development through to market maturity as well as framework conditions conducive to innovation must be taken into account. The underlying broad innovation concept goes beyond technological, research-driven innovation and also includes innovative products and process-related, organisational and social innovations.

Political Objective 1 of the ERDF Regulation for the 2021-2027 programme period is the basis for the instrumental implementation of the strategy through funding instruments. Within this framework, Article 2 Number 1 Letter a¹⁰ allows the ERDF Operational Programme to support measures in the areas of research and innovation, increasing sustainable growth and competitiveness,

digitalisation of society, improving ICT connectivity and measures to strengthen skills for industrial change. The further developed RIS Thuringia focuses on the specific objective of "expansion of research and innovation capacities and the introduction of advanced technologies" within Policy Objective 1.

Funds from the European Regional Development Fund as well as from various other sources of financing, e.g., from open-topic and topic-specific state, federal and EU programmes, will be used to finance the economic and innovation policy measures. A mix of these sources, together with support for the innovation strategy through instruments from other economic policy areas of the state (in the sense of Chapter 5) such as the digital and fibre optic strategy and investment and start-up support, should ensure that all target dimensions of a modern innovation policy are taken into account. Alternative forms of financing and the combination of different funding strategies will be crucial, especially when supporting transformative processes and industry resilience.

Continued efforts are necessary, among other things, to further optimise the participation processes and the funding instruments in terms of orientation, funding conditions and funding procedures, so that an economic boost can be better achieved with innovation funding, especially in rural areas.¹¹ The examination and selective further development of the structures in process implementation are necessary with regard to the changed conditions for receiving ERDF funding for the 2021-2027¹² Structural Funds funding period.

⁹ Value creation networks not only involve the classic cooperation of companies along the horizontal value creation chain, but companies also cooperate through horizontal and vertical networking in dynamic value creation groups.

¹⁰ Regulation (EU) 2021/1058 of the European Parliament and of the Council of 24 June 2021 on the European Regional Development Fund and on the Cohesion Fund.

¹¹ Evaluation of the measures to strengthen research, technological development and innovation under the ERDF Operational Programme for Thuringia 2014-2020, Ramboll.

¹² In terms of the basic requirement "good governance of the regional strategy for smart specialisation" for Policy Objective 1 in ERDF 2021-2027.

2.2. Goals of RIS Thuringia 2021 to 2027

Thuringia has a broad network of economic agents, universities, non-university and industry-oriented research institutions, innovation centres and many different cluster and network organisations and multipliers, which have grown over decades and which mutually strengthen each other's innovation activities. The aim is to maintain and expand this basis for economic value creation in Thuringia together with the efficient scientific structures for the long term and to develop new value creation potential for Thuringia through a stable, future-oriented innovation strategy. The approximately 7,300 companies in the manufacturing sector¹³, including those in the fields of mechanical engineering, automotive/automotive supply industry, sensor technology, optics, photonics, medical technology and life sciences, metalworking and processing, the food and plastics industries, as well as numerous production-related service companies, such as logistics and IT services, play a special role here. The expansion of research and innovation capacities and the introduction of advanced technologies in these sectors could have significant positive effects on the economy as a whole.

The goal must be to develop new scientific knowledge and technologies at universities and research institutions and to rapidly translate suitable approaches into concrete, marketable applications, processes and products and thus into innovations by businesses. By using innovative technologies, production processes and services and through their own R&D and innovation activities, Thuringian companies can further increase their productivity, offer competitive business models and thus gain advantages for Thuringia as an internationally desired location. The transfer of innovative approaches to

other economic agents, e.g., by imitating the processes, also increases the innovative capacity of these actors. Ongoing R&D and innovation work and the exploitation of R&D results therefore make a significant contribution to the competitiveness of Thuringian companies and thus also to the attractiveness of Thuringia as a business location. On the other hand, industry provides the impetus for new research topics and technological developments in science and thus forms an indispensable part of the innovation chain. The relevance of this goal is heightened by the COVID 19 pandemic. The global economic downturn caused by the pandemic is significantly accelerating the transformation processes in the industry and society that are driven by decarbonisation, digitalisation and demographic change.

In the coming years, it will be even more important to strengthen the existing scientific and economic core competencies in the state by setting thematic priorities (strengths-based approach) and to systematically establish and expand growth and future oriented value creation networks across sectors and technologies. For a prospering economy, it is particularly important to establish these networks at nodes that are central to the supply and service chains and that are characterised by a high degree of value creation. Building on the existing competencies, specialisation can offer particularly high endogenous development potential here.

The aim is also to make Thuringia's scientific and economic core competencies even better known beyond the state's borders, to network the players more closely across regions and thus to strengthen the innovation hub as a whole. At the same time, developing a clear profile should enable Thuringia's innovation players to participate successfully in EU and federal programmes.

¹³ TLS, 2019: Rechtliche Einheiten nach Kreisen und ausgewählten Wirtschaftsabschnitten in Thüringen (Legal entities by districts and selected economic sections in Thuringia).

Improving the competitiveness of the region is also an important goal of the implementation of RIS Thuringia. To this end, small and medium-sized enterprises in particular should be more closely integrated into the innovation processes and their in-house R&D activities should be stepped up. In particular, the measures and the development within the field of specialisation and topics must be more strongly oriented towards the needs of the companies - even in rural areas, where the highest proportions of industrial employees per 1,000 inhabitants can be found in Thuringia, e.g., 143 employees in the Sonneberg district, Saale-Orla district (131), Wartburg district (124), Ilm district (110) and Sömmerda district (108)¹⁴. In addition to direct contact between policymakers and companies, multipliers, especially the efficient cluster and network organisations in Thuringia, play an important role here.

Forward-looking analyses and forecasts (foresight) should be used to identify the potential of new topics and trends for the economy and the entire Thuringian innovation system at an early stage, to make them accessible to as many players as possible and thus to stimulate innovation. It is also crucial that the already existing competencies of the innovation players match the concrete needs of the economy.

A key cross-sectoral objective of the RIS Thuringia in the 2021-2027 Structural Funds funding period is greenhouse gas neutrality. According to the Federal Climate Change Act, greenhouse gas emissions are to be reduced to such an extent by 2045 that greenhouse gas neutrality is achieved. This will have an impact on all sectors and areas of the economy. Given the sometimes long investment cycles, the course must be set accordingly in the coming years. The topic of greenhouse gas reduction is

therefore relevant - albeit to varying degrees - to all fields of specialisation, to research, technology and innovation policy and to economic policy as a whole.

2.3. Innovation policy challenges

Strengthening innovation activities and innovative, agile transfer structures

Thuringia has developed into a strong innovation region in recent years. The European Union's current Regional Innovation Scoreboard 2019 confirms that Thuringia is making progress as a centre for innovation and research, but also that it still has some catching up to do. According to the scoreboard, Thuringia stands out as a "strong innovator", but is already losing some ground again against other regions (-3.6% compared to 2011).¹⁵

The most recent successes of the free state - e.g., in the context of the excellence strategy of the federal and state governments - show the positive development in the area of state research funding that the state has undertaken in recent years. In contrast, a look at the overall financial flows of joint federal and state research funding underpins the continuing need for structural action. The current report of the Joint Science Conference (GWK) indicates that Thuringia's annual net fund inflow of EUR 87 per inhabitant is significantly below the national average (EUR 117).

This puts Thuringia in third last place in a nationwide comparison. In comparison, Saxony receives EUR 155 per inhabitant and Baden Württemberg receives EUR 140 per inhabitant; the amounts are even higher in the city states of Hamburg (EUR 284 per inhabitant) and Berlin (EUR 267 per inhabitant). The main reason for the significantly lower inflow of funds to Thuringia is a persistent gap in large

¹⁴ TLS 2020, press release 222/2020 of August 31, 2020: Beschäftigtendichte in der Thüringer Industrie im Jahr 2019 (Employment density in the Thuringian industry in 2019).

¹⁵ European Commission (2019): Regional Innovation Scoreboard. Retrieved from: <https://ec.europa.eu/docsroom/documents/35927>.

research infrastructures with a high federal funding share, such as the Helmholtz Centres.¹⁶

Due to low national research funding, the free state has to fund broad basic research with a significantly higher contribution of its own, since the funding gap that has become apparent is only partially filled by the newly established federal supplementary allocation for research. The impact of Thuringia's handicap in research funding is two-fold. As a result of persistent gaps in the research landscape, there is a lack of additional research impetus on the one hand and key regional partners for innovative companies on the other.

In addition to basic and applied research at predominantly publicly funded research institutions, experimental development, the implementation of marketable innovations and the diffusion of new products and technologies in Germany are largely driven by private actors.

There is also a clear need for companies in Thuringia to catch up. The innovation activity of Thuringian companies still lags significantly behind that of competitors from structurally strong regions. The share of corporate spending on R&D in GDP was only 1.15% in Thuringia in 2018. This puts the free state well below the national average of 2.15%. A similar picture emerges when we look at research and development personnel. Here too, the share in the Thuringian corporate sector is significantly lower in comparison with other German states and in the EU-28 states. In 2017, only 0.7% of employees in Thuringia worked in research and development in companies. For Germany, this value was 1.2% and for the EU-28 states it was 1.1%.

The main reasons for the structural weakness of private R&D activities in the Free State of Thuringia are: the

small-scale, SME-dominated corporate structure of the Thuringian economy, a high proportion of companies at the back end of the value creation chain without their own R&D department and the virtual absence of large companies¹⁷ that have their headquarters or management functions in Thuringia¹⁸. Statistics show that the majority of internal R&D expenditure in the business sector in Germany (2017: 91.68% compared to 59.68% in Thuringia) is carried out by large companies¹⁹ - with an increasing tendency, as stated in the 2021/22 annual report of the German Council of Economic Experts.²⁰ Overall, the business sector, which is the most important driver of innovation on average in Germany (around 70% of total R&D expenditure), accounts for only 50% of total R&D expenditure in Thuringia.²¹

Strengthening the entire innovation chain

The strengthening of research, technological development and innovation, the expansion of research and innovation capacities and the optimisation of knowledge and technology transfer to the economy are still needed to overcome Thuringia's existing structural weakness. There is a need for intervention along the entire innovation chain - from basic research to the market launch of innovative products or the implementation of process innovations. In the years to come, the focus will continue to be on using strategic target planning to set state R&D impulses in such a way that they can optimally and quickly result in economic application. The integration of the different interests of actors along the innovation chain appears to be indispensable.

¹⁶ Joint Science Conference, GWK Issue 71, Gemeinsame Förderung von Wissenschaft und Forschung durch Bund und Länder – Finanzströme im Jahr 2018 (Joint Funding of Science and Research by the Federal Government and the States - Financial Flows in 2018), p. 19 ff. Tab. 11.

¹⁷ In 2018, 328 of the total of 80,450 Thuringian enterprises (0.4%) were among those with more than 250 employees [TIS Rechtliche Einheiten nach Beschäftigungsgrößenklassen und Kreis in Thüringen (Legal entities by employment size group and district in Thuringia) (May 11, 2020)]

¹⁸ The latter also leads to individual regions being under-represented in the R&D statistics because reporting procedures and systems often allocate R&D expenditures of individual locations to the headquarters. Locations with headquarters are therefore often over-represented. See ZUSE-Gemeinschaft, ZUSE Transfer News Issue 01/2021: "Starke regionale Unterschiede bei FuE in Deutschlands Regionen" (Strong regional differences in R&D in Germany's regions).

The strategic development and expansion of the research infrastructure forms the starting point for a working innovation chain and remains a priority task of Thuringia's innovation policy. Both the building and equipment infrastructure contribute to the sustainable strengthening of universities, non-university research institutions, industry-oriented research institutions and innovation centres, as well as to the further sustainable increase in their competitiveness.

The knowledge available in Thuringia from scientific institutions must be made available to Thuringian companies in a cooperative manner and the absorption of know-how or the adaptation of technological developments must be facilitated in order to accelerate the diffusion of advanced technologies. Incentives for innovation must be strengthened in a targeted manner. In addition, the networking of business enterprises, among themselves and with universities, non-university and business-related research institutions and multipliers, continues to show potential for development that specifically addresses the existing structural deficits in order to overcome them.

SMEs can usually carry out only a few projects at a time, if at all (indivisibility of R&D projects). At the same time, R&D activity reduces their financial scope for innovation activities related to downstream R&D and market launch. For the continuous increase of economic innovation activities, application-oriented cooperation between companies and scientific institutions, such as universities, innovation centres, non-university and industry-oriented research institutions, is therefore an important and already successfully established instrument in Thuringia. R&D cooperation between companies (especially SMEs) and scientific institutions and the associated transfer of R&D results, ideas and rationalisation approaches to new products, processes and services can be specifically

promoted in this way.

The resulting potentials for SMEs are:

- › Strengthening of innovative capacity and competitiveness,
- › Use of cooperation advantages to accelerate the maturity of results and market approach in complete value creation or innovation chains,
- › Use of cooperation as an entry point into supraregional/transnational R&D alliances (federal, EU),
- › Use of a positive "bonding effect" for highly qualified people among the project partners involved.

Based on the experiences of the current funding period, there will be an even stronger focus in future on the marketability of new products and synergy effects in the course of combining them with other funding instruments. Sustainable products, services and business models should become the norm in the EU to meet the objectives of the European Green Deal and the initiatives outlined in the Circular Economy Action Plan. In addition to marketability, greater attention must therefore be paid to assessing the sustainability of the innovative products (circularity, recyclability, reparability).

19 ,ɑ:rən'di: Zahlenwerk 2019 - Forschung und Entwicklung in der Wirtschaft 2017 (Figures 2019 - Research and Development in Business 2017), Table 5.1, Stifterverband für Deutsche Wissenschaft e. V.

20 Annual Report 2021/22 of the German Council of Economic Experts, p. 294.

21 Joint Science Conference, GWK issue 67, Steigerung des Anteils der FuE-Ausgaben am nationalen Bruttoinlandsprodukt (BIP) als Teilziel der Strategie Europa 2020 (Increasing the share of R&D expenditure in the national gross domestic product (GDP) as a sub-goal of Strategy Europe 2020), p. 23. ,ɑ:rən'di: Zahlenwerk 2019 - Forschung und Entwicklung in der Wirtschaft 2017 (Figures 2019 - Research and Development in Business 2017), Table 2.4, Stifterverband für Deutsche Wissenschaft e. V.

To accelerate technology transfer and innovation processes, regulatory experimentation spaces should also be created or used where possible, and work should be done to further develop a legal framework that is open to innovation. Companies are increasingly innovating in smaller innovation steps. This is because innovation projects that are driven forward in small innovation steps and tested in the market at an early stage allow companies to adjust more quickly and thus reduce the overall risk of innovation activity. The aim is to promote an agile environment and agile forms of knowledge transfer (e.g., real labs, test labs, innovation hubs, etc.) that allow SMEs in particular to explore and test new technologies, products and business models under real conditions in a flexible, unbureaucratic and time-limited manner.

Supraregional and international cooperation

Supraregional partnerships and joint research and application projects by various supraregional and international partners offer great potential for strengthening the research and innovation activities of universities, research institutions and companies. The EU Framework Programmes for Research and Innovation and the "Medical Technology" and "Photonics" partnerships of the Smart Specialisation Platform for Industrial Modernisation (S3P-Industry) are examples of European cooperation with active participation of companies, scientific institutions and clusters from Thuringia.

Thuringia's geographical location in the centre of Germany and Europe offers advantageous conditions, especially for European cooperation projects, which should be exploited even more in the 2021-2027 funding period. The Thuringian Ministry for Economic Affairs, Science and Digital Society and the ThCM continue to support the supraregional networking activities of Thuringia's innovation players within the framework of the available possibilities. In order to increase Thuringia's international visibility and to further develop its own processes

through the exchange of best practices and experience, the state government and the ThCM, as the head office, use supraregional exchange formats, including those of the federal government and the EU, and cross-border synergy potentials.

Thuringia has also established important support structures for Europe-wide cooperation with the Enterprise Europe Network Thuringia and the EU Network of Advisors of universities and research institutions to support territorial cooperation. Expressed in concrete figures, more than 100 cross-border project and business collaborations have been successfully supported since 2015. During this time, more than 1,800 companies and research institutions were supported, among other things, in tapping into foreign markets, finding business and project partners and submitting applications under European funding programmes, especially in the field of research and innovation.

The plan is to continue the promotion of these support structures that assist the measures of the operational programme. The measures such as expansion of transfer infrastructures, R&D joint funding, individual company R&D and transfer funding as well as equipment for research projects can contribute to supporting Thuringian players in preparing project proposals for EU formats. Funding is also provided for equipment for research projects with the intention of supporting planned projects of Thuringia's universities and research institutions under the EU funding programmes that involve cooperation with partners from other EU countries.

At the same time, cooperation with partners from various regions is intended to serve further internationalisation within the framework of the Thuringia innovation strategy. The rules of participation for the relevant funding lines of the R&I framework programme of the EU, Horizon Europe, require participants from at least three different countries. In most cases, however, the number of partner institutions in successful project applications in these formats is far greater than this minimum requirement, and hence the participation in EU projects that the above-mentioned ERDF measures aim at usually results in accompanying cross-border networking.

2.4. Shaping the regional specialisation between 2021-2027

With the Regional Research and Innovation Strategy for Smart Specialisation in Thuringia for the 2014-2020 funding period, the Thuringian state government has created a cooperation and coordination platform for the various players of Thuringia as a centre for innovation. The basis for achieving the strategic goals is the focus on the following fields of specialisation: "Industrial production and systems", "Sustainable and smart mobility and logistics", "Healthy living and the healthcare sector",

"sustainable energy supply and resource management" and the cross-sectoral field "ICT, innovative and production-related services", in which Thuringia has developed strengths and which have a high potential for the future (see Fig. 1). These were identified by the players in a broad participation process in 2014.

Over the past six years, a large number of companies, universities, non-university and industry-oriented research institutions, clusters and networks as well as innovation centres and other multipliers have been involved in the strategic and operational processes of strategy implementation through the working groups of the fields of specialisation and the cross-sectoral field, which consist of representatives from business and science as well as intermediaries, and through topic-specific forums. With their thematic input in terms of content for the targeted development of the fields, a feedback loop between strategy and application could be achieved in the sense of the entrepreneurial discovery process. At the same time, it was possible to foster a trusting partnership between a wide range of players and initiate a large number of research, innovation and transfer projects.



Figure 1: Five fields of specialisation of the Regional Innovation Strategy for smart Specialisation and Economic Change in Thuringia, 2021 to 2027

The approach of the four fields of specialisation was narrow enough to focus on the most important issues and broad enough to allow flexibility for new developments. In order to ensure the content-related continuity of what has been achieved so far, this approach will be continued in the 2021-2027 Structural Funds funding period.

The evaluation of the measures to strengthen research, technological development and innovation under the ERDF Operational Programme for Thuringia 2014-2020 confirms that the thematic focus of RIS Thuringia is still appropriate because overarching trends and developments can also be addressed with the RIS fields. Due to the increased importance of the cross-sectoral field "ICT, innovative and production-related services" for Thuringia as a business location - which was also emphasised in the evaluation - efforts are being made to categorise it as an independent field of specialisation.

As the head office, the Thuringian ClusterManagement has continuously accompanied the development of the fields since the start of the Regional Innovation Strategy Thuringia. Within the framework of an intensive participation process involving competent committees as well as forums and dialogue formats from industry, science and multipliers, it was possible to develop specialisation profiles and action plans for the respective fields. In 2018, the committees agreed on a greater prioritisation and differentiation of the aspects covered by the fields. In an intensive dialogue process, the ThCM, in cooperation with the RIS working groups, has sharpened the specialisation profiles in the RIS fields on the basis of actual-state analyses. The specialisation profiles of the individual fields, which can be seen in Figures 2 to 6, provide an overview of the overall thematic structure of the respective field of specialisation.

The action plans, which have been merged into an overall action plan for the RIS, have identified thematic priorities and needs for action in the individual fields of specialisation. The implementation of a large number of measures contained in the overall action plan on the basis of key objectives, combined with a largely competition-oriented, technology-open funding of research, technological development and innovation, has served to advance the key objectives in the fields and strengthen their economic development (see Chapter 3). The fact that large R&D consortia have been accompanied and supported by suprarregional funding programmes (e.g., Growth Cores of the Federal Ministry of Education and Research, programme families "Entrepreneurial Regions" and "Innovation & Structural Change", Horizon 2020, INTERREG), has made a major contribution to building Thuringia's profile and positioning it in international competition in recent years.

According to the evaluation report, the optimisation potential of the strategic orientation of RIS Thuringia lies in the expansion of the cross-field "cross-over" approach, in stronger interdisciplinary cooperation between different sectors, industry and science, and in a cross-field strengthening of cross-sectoral tasks such as digitalisation and sustainability in the industrial context.²² These potentials have been addressed while further developing the strategy, among other things in the following concept for strengthening innovation-based value creation networks.

Specialisation and differentiation in the further developed innovation strategy

As in the previous funding period, the Regional Innovation Strategy for the 2021-2027 funding period aims to drive the development of the five fields of specialisation on the basis of their specialisation profiles and through a multi-stakeholder approach. In addition to innovation drivers such as universities, non-university research institutions and business enterprises, the following

²² Evaluation of the measures to strengthen research, technological development and innovation under the ERDF Operational Programme for Thuringia 2014-2020, Ramboll 2020.

players also contribute to the development of the fields of specialisation: cluster and network organisations, industry-oriented research institutions and innovation centres as well as other multipliers such as business and industry associations. These players act as links between research and application and between innovation players and political institutions such as the state government.

Within value creation chains, partners are increasingly interdependent when working and need to be effectively linked (vertical networking). At the same time, cross-sectoral and cross-technology issues are becoming increasingly important for innovation activity, which means that cooperation between different sectors and disciplines is growing (horizontal networking). Overall, these developments mean that value creation chains are increasingly seen as dynamic, cross-sectoral and cross-technology value creation groups or networks in which internal and external research, development and production partners, and increasingly also customers, are involved in product creation.

Vertical and horizontal networking and cooperation (cross-cluster approach) are to be strengthened in the sense of a sustainable and comprehensive cluster policy. Therefore, in addition to the five fields of specialisation, the further developed strategy places great emphasis on targeted differentiation within the fields. Highlights that can be developed and built up into innovation-based value creation networks in the sense of the cluster policy²³ should be crystallised from the multitude of topics and activities and on the basis of the specialisation profiles in the fields of specialisation.

The focus here is on those nodes of the supply and service chains that promise high value creation potential and that are of particular strategic importance for Thuringia in the sense that

- › they help identify comparative specialisation advantages for Thuringia,
- › there is a scientific and/or economic critical mass (both quantitative and qualitative) of players who have built up competencies over the years,
- › there is high applicability in innovative solutions for future challenges and
- › there is high future and growth potential.

Networking and transfer activities between universities, research institutions, business enterprises, intermediaries and supraregional/international partners in the innovation-based value creation networks are supported with the aim of providing targeted impetus for cooperation and collaboration. The aim is to exploit competitive advantages in these highlights through closer cooperation, improved regional division of labour and increased exchange of knowledge and experience between the companies and scientific institutions of one technology and innovation field in one region and with supraregional partners. The aim is also to increase the supraregional visibility of the value creation networks to the outside world ("shop window") and networking through more setting and storytelling.

Any gaps that may exist in the value creation networks are to be reduced through targeted accompanying activities. Possible measures include, for example, the acquisition of locations that complement the network portfolio, the targeted expansion of the research infrastructure and the support of R&D projects, e.g., through state funding instruments or through third parties (federal government, EU, etc.), or influencing regulatory framework conditions. The aim is to strengthen the competitiveness and resilience of this part of the value creation chain that is important for Thuringia and to increase the innovative strength of the players.

²³ In line with the competence networks according to Meier zu Köcker and Buhl (BMW 2008; Kompetenznetze initiieren und weiterentwickeln: Netzwerke als Instrument der Innovationsförderung, des Wirtschaftswachstums und Standortmarketings (Initiating and further developing competence networks: networks as instruments of innovation funding, economic growth and location marketing).

The targeted strengthening of innovation-based value creation networks is particularly important for a competitive, innovative economy. This is because the progressive use of cross-sectoral and cross-technology innovations that emerge in these networks goes hand in hand with positive employment and location effects and endogenous growth.²⁴ Exploiting the competitive advantages of clusters and networks is particularly relevant for industries that are highly integrated in international supply and sales relationships and value creation chains.

Steps towards establishing innovation-based value creation networks

As a basis for identifying potential value creation networks, the ThCM and the members of the working group have compiled, based on actual-state analyses, an initial portfolio of topics, which, in the view of the players, offer sustainable and promising approaches for future-oriented, innovation-based value creation networks. These potential topics are highlighted in Chapters 3.1 to 3.5. The aforementioned topics are at the intersection of industries, technologies and future issues and offer innovative solutions in response to current socio-economic and ecological challenges. They mostly cover several of the criteria mentioned for innovation-based value creation networks.

Based on the SWOT analyses for each of the above topics, the next step will be to identify and prioritise needs for action and bottlenecks in the development of the topics. By involving external experts, such as the strategy

advisory boards and the RIS Thuringia steering committee, the ThCM will examine the areas in which concrete approaches for innovation-based value creation networks in the sense of the cluster policy can be developed on the basis of the topics, and prepare roadmaps for these as the next steps. These roadmaps are intended to enable the consistent derivation of fields of action for the respective value creation network and the identification of concrete measures for the players involved.

The concept of strengthening innovation-based value creation networks is agile and dynamic. By anticipating and taking into account the current market developments (foresight process), new topics can be adopted and addressed over time. At the same time, priorities are set for implementing the roadmaps. Topics that prove to be more relevant for Thuringia as an innovation hub over time will be implemented on a higher priority than those that are less relevant.

²⁴ In line with the competence networks according to Meier zu Köcker and Buhl (BMW 2008; Kompetenznetze initiieren und weiterentwickeln: Netzwerke als Instrument der Innovationsförderung, des Wirtschaftswachstums und Standortmarketings (Initiating and further developing competence networks: networks as instruments of innovation funding, economic growth and location marketing)).

3. Developments and Prospects of the Fields of Specialisation

3.1. Field of specialisation: industrial production and systems

Specialisation profile and significance for Thuringia

The field of specialisation "industrial production and systems" is the backbone of Thuringia's economy. With growing markets, a broad technology spectrum and numerous activities in different industries, this field contributes to almost half of the turnover in the manufacturing sector. Thuringia has a strong entrepreneurial base, especially in the fields of plastics and metal processing, mechanical engineering, plant engineering and toolmaking, micro- and nano systems technology and optics/photonics.

Almost 4,000 companies generate a turnover of over EUR 15 billion per year.²⁵ In particular, the high localisation coefficients²⁶ of over 6 in terms of employees and 8.31 in terms of turnover illustrate the remarkably high concentration by national comparison and thus the high economic importance of optics/photonics for Thuringia. In the manufacture of glass and ceramic products, the high localisation coefficients of over 4 and 3 respectively in terms of employees shows a very high degree of specialisation in this sector compared to the rest of Germany.

In addition, at over 1.5, the localisation coefficients in terms of employees for the higher-turnover sectors of metal and plastics processing are also above the national average. The field of "industrial production and systems" also demonstrates its strategic importance through its innovative spirit - almost half of all patent applications from Thuringia from 2014 to 2018 can be attributed to this field.²⁷

In the specialisation profile, the close interaction with the former cross-sectoral field of "information and communication technology and innovative and production-related services" is immediately clear through the "digitalisation" interface. In addition, there are numerous other synergistic interrelationships with the other innovation fields in Thuringia, such as photonic sensors for medical applications and autonomous driving or materials for energy systems or hybrid materials for automotive engineering. Figure 2 shows the current specialisation profile.

²⁵ ThCM calculation as part of RIS3 monitoring based on data from the TLS, data status: 2018 (figures rounded)

²⁶ The localisation coefficient is the employee or turnover share of an industry in Thuringia out of all employees/turnover of the industry in Germany in relation to the employee or turnover share of all industries in Thuringia out of the total employment/total turnover in Germany. The localisation coefficient is one if the specialisation in Thuringia corresponds to that in Germany. If its value is greater than one, Thuringia has a higher degree of specialisation than the German average.

²⁷ ThCM calculations based on data from PATON | Patent Center Thuringia, applications between 2014-2018 (in Germany and worldwide).

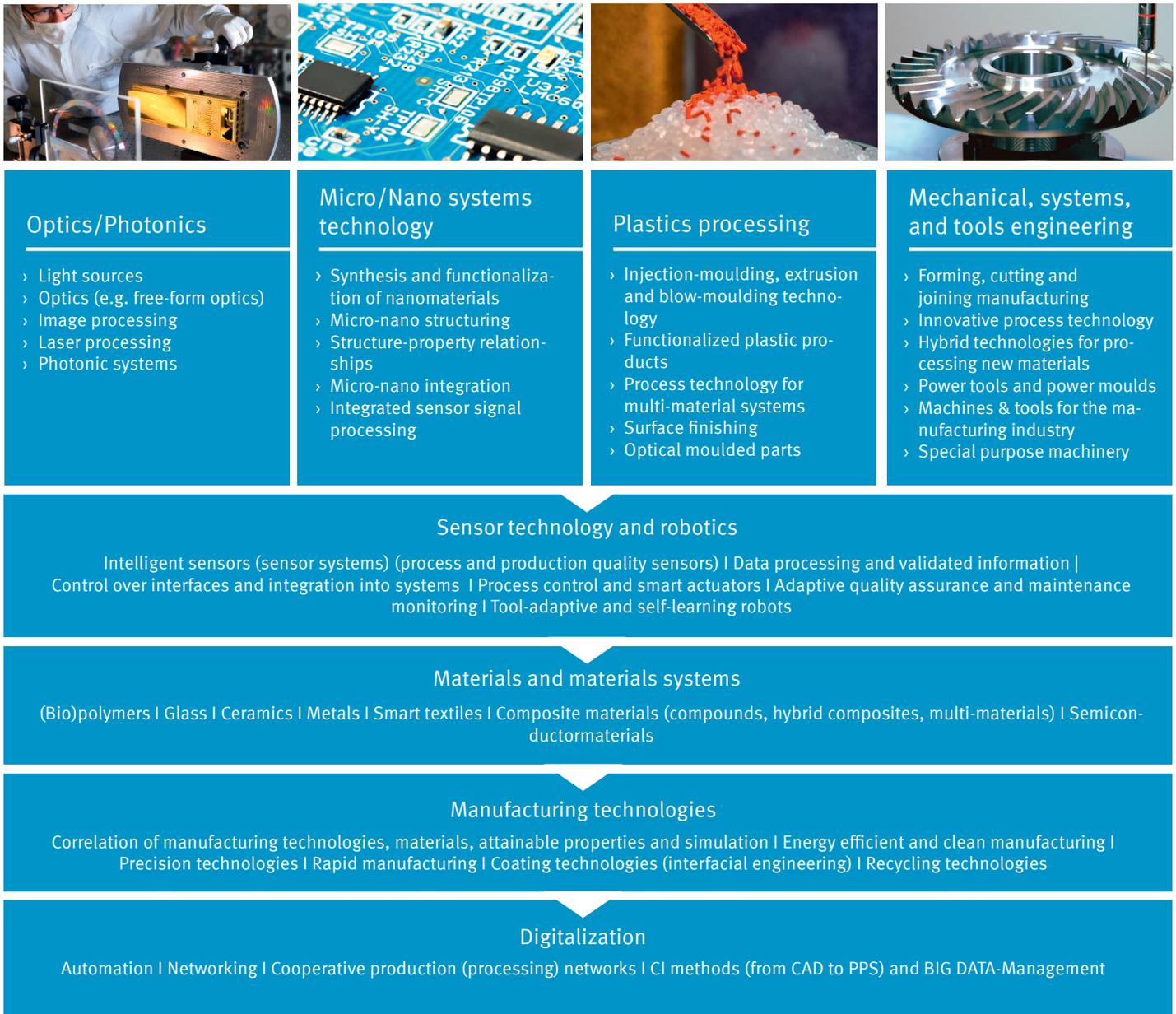


Figure 2: Specialisation profile "industrial production and systems" (Data status: 2018)

Field development and important milestones

Scientific expertise is also very strong in the seven Thuringian universities, 15 research institutions and two innovation centres that are active in the field of specialisation of industrial production and systems. The optics and photonics sectors in Thuringia enjoy an excellent reputation worldwide. As a "key enabling technology", they, like sensor technology, play a crucial role in driving innovation in the free state. Through application-oriented developments, manufacturing companies in particular can make their production processes more efficient and flexible. Smart manufacturing processes are used to ensure near flawless production and to guarantee the sustainability of the local economy. Further disruptive innovations are expected, particularly in the field of quantum optics. Significant federal and EU funding for further development has been secured for this field, especially in 2019 and 2020. For example, the Fraunhofer IOF is leading the research association for QuNet - secure quantum communication, which has received EUR 165 million in funding, but other DFG and ESA projects on quantum sensor technology are also being implemented. In addition, optics has been one of the top technology fields for patent applications in Thuringia for years.

Materials and material systems also play a prominent role in sustainable economic development. New materials or material combinations lead to new properties and additional functionalities of innovative products. Individualised, competitive products can be produced when this is combined with modern production technologies and adaptive design. Last but not least, the over 130 patent applications in this field from Thuringia (in the years 2014 to 2018) show the innovative strength and importance of the field.²⁸

In addition to digital twins for products, digital shadows for production processes are also implemented to optimise processes and reduce material consumption. The growth core "VIPO - Virtual Product and Process Development and Optimisation" is developing a very promising technology platform for this in Thuringia. The Twenty20 consortium 3Dsensation has laid a solid foundation for innovation and the establishment of optical 3D data acquisition, processing and rendering. Furthermore, the SME 4.0 Center of Excellence Ilmenau provides hands-on experience of digitalization in production through practical demonstration and implementation projects.

Long-established cluster structures and network initiatives such as Elektronische Mess- und Gerätetechnik Thüringen (ELMUG) eG, Mikro-Nanotechnologie Thüringen e. V. (MNT), OptoNet e. V. and SpectroNet for the topic of "photonics and sensor technology" as well as the initiatives Fertigungstechnik Metallbearbeitung Thüringen (FerMeTh), Material innovativ Thüringen (MiT), PolymerMat e. V. - Kunststoffcluster Thüringen, SmartTex-Netzwerk for the topics of "function integration" and "smart manufacturing systems" play an eminent role. In addition to the knowledge transfer of research results, they transfer technological solutions to the manufacturing sector through company-driven projects. Furthermore, the innovation centres, such as the Thüringer Zentrum für Maschinenbau and the Thuringian Innovation Centre for Quantum Optics and Sensors, are very important players in Thuringia's innovation system. The increasing overarching cooperation between the individual network initiatives, e.g., through the Cross-Cluster-Initiative Thüringen, has also initiated cross-sectoral linkages in recent years.

²⁸ ThCM calculations based on data from PATON | Patent Center Thuringia, applications between 2014–2018 (in Germany and worldwide).

Profiling

The "factory of the future" is becoming more flexible, more efficient, faster and more sustainable. The adaptability of factories and their manufacturing processes will be a decisive factor for future competitiveness. Manufacturing processes will become flexibly configurable, allowing small local sites to develop correspondingly in-depth manufacturing know-how. In this context, increasing digitalisation will make it possible to link processes across factories even more closely, thus optimising supply chains. This will give rise to many local and smart value creation networks. Sensors, analytics and artificial intelligence will increase productivity and minimise downtime and maintenance.

The digitalisation of production and the systemic networking of value creation chains into value creation networks in the sense of "Industry 4.0" are of key importance for Thuringia as an innovation hub. The production world of tomorrow will be accompanied by a further linking of the real and the digital world. On the one hand, intelligent information, communication and management systems are used to link processes and resources more closely within the company, and on the other, entire value creation chains are networked from the supplier to other producers and all the way to the customer. New automation solutions, intelligent robotics and autonomous systems will specifically assist skilled workers with routine tasks. Nevertheless, humans will play the key role to a large extent. Safe and ergonomic human-machine interaction will enable skilled workers to concentrate on their core competencies and develop freely. The image of a factory floor will transform into an interactive, digitalised place, not least because of the European "Green Deal". For this reason, the following four topics are being promoted in a

sustainable manner:

- › Assistance systems for safe and ergonomic human-machine interaction,
- › Functional integration of innovative products,
- › Photonics and sensor technology for the world of tomorrow and
- › Smart manufacturing systems for efficient, flexible and precise production.

Quick responses to market changes and technological developments are crucial. Existing Thuringian competencies in various technology segments can be used, continuously expanded and efficiently interlinked for this. With its innovative companies, differentiated research and education landscape, excellent R&D expertise and strong networks and cluster structures, Thuringia is ideally positioned for a digitally networked future.

3.2. Field of specialisation: sustainable and smart mobility and logistics

Specialisation profile and significance for Thuringia

The mobility of the future will be resource-conserving and climate-neutral, networked, multimodal and characterised by a high degree of user-friendliness. Digitalisation will drive the development of innovative mobility carriers on the one hand and new mobility models on the other. Driving tasks are increasingly being taken over by machines and algorithms. As a result, the role of humans in the "mobility system" is changing.

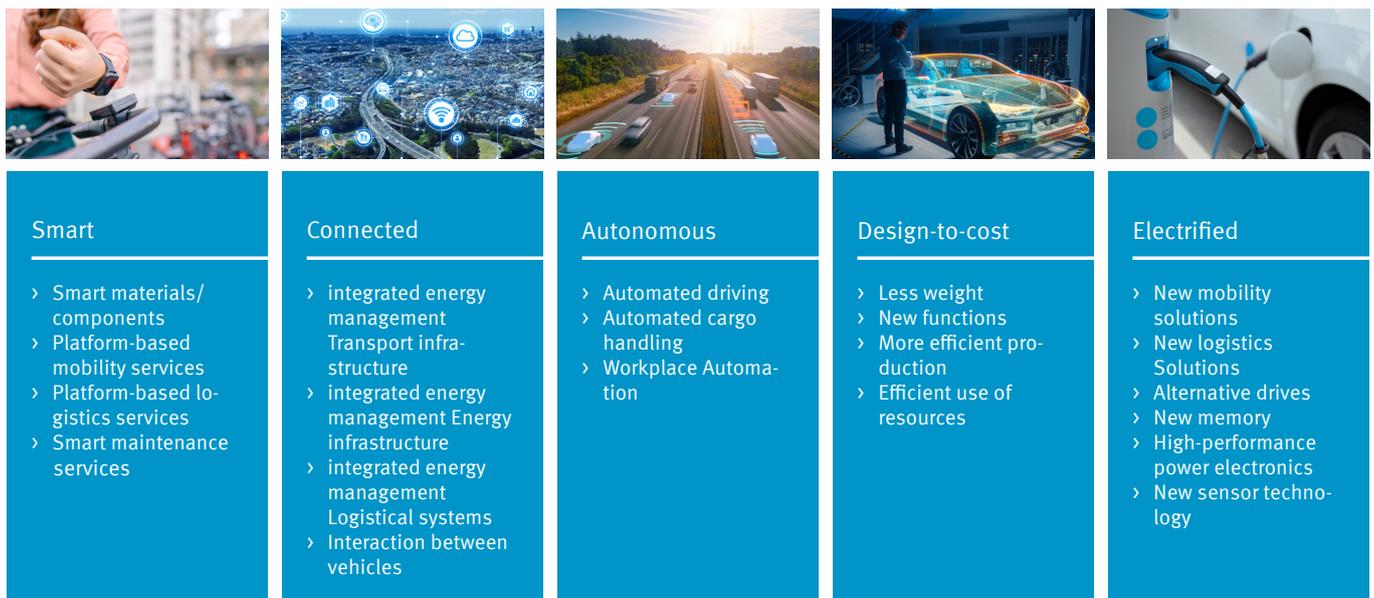


Figure 3: Specialization profile "sustainable and smart mobility and logistics" (Data status: 2018)

The field of "sustainable and smart mobility and logistics" includes the area of mobility and transport concepts in the narrower sense, the logistics sector with its large number of employees, and the automotive and supplier segment, which, seen as an industry, had the highest industrial turnover in the whole of Thuringia in the pre-pandemic year 2019. In total, more than 3,000 companies with around 50,000 employees and a turnover of about EUR 7.4 billion operate in the field of "sustainable and smart mobility and logistics".³⁰ The specialisation profile reflects the cross-references between these three areas and the future trends mentioned at the beginning. Resource conservation approaches (e.g., less weight, efficient use of resources, alternative drives) can be seen

along with topics related to networking (e.g., sector coupling, interaction between vehicles) and aspects of multi-modality (e.g., platform-based mobility services, new mobility carriers). The trend towards more user-friendliness is also taken into account (e.g., platform-based logistics services and new functions).

Field development and important milestones

Thuringia's central location in the heart of Germany and Europe, coupled with a modern road and rail infrastructure, has attracted numerous well-known logistics and trading companies in the recent past. Intelligent mobility and transport concepts "made in Thuringia", in turn, ensure that people and goods get from A to B

²⁹ TLS 2020, press release 038/2020 of 17 February 2020: Manufacture of motor vehicles and motor vehicle parts - again the most successful industry in Thuringia in 2019.
³⁰ ThCM calculation as part of RIS3 monitoring based on data from the TLS, data status: 2018 (figures rounded).

quickly, efficiently and with low emissions not only within Thuringia but also worldwide, and that urban and rural areas are closely linked. The automotive industry is also benefiting from this, with suppliers now accounting for well over 70% of value creation. These same suppliers make up the majority of Thuringia's automotive industry, whose product range today includes, for example, high-tech sensors, state-of-the-art lighting technology and high-quality interior components and body parts. Experts in optimised combustion engines, manufacturers of components for hydrogen mobility and one of the largest production plants for battery cells for e-vehicles in Europe all make use of Thuringia's locational advantages.

In order to be able to speak with one strong voice and use synergies despite their diversity, the players in this field of specialisation organise and network in clusters such as automotive thüringen or the Thuringia Logistics Network. At the same time, they take advantage of the spatial and professional proximity to the photonics cluster in the Jena region and to the Thuringian sensor industry.

Thuringia's business enterprises are largely supported by the efficient science and research landscape in the free state. In addition to the Thuringian Center of Innovation in Mobility, several industry-oriented research institutions and universities in Thuringia are researching and developing and, together with their industrial partners, transferring new products and services for the mobility of the future into application. Regular successes of regional and supraregional research consortia, such as the projects "Bauhaus.MobilityLab", "Smart Distribution Logistics" and "H2-Well", are proof of the productive

transfer of knowledge and technology between the players in this field of specialisation.

Profiling

Based on the specialisation profile, four topics have currently emerged as having potential for this field:

Low-emission mobility for mobility transformation: in the future, reduction in mobility-related emissions will be of great importance for every vehicle model and for the transport system as a whole. Depending on the intended use, different drive types - including various hybrid forms - will continue to sustain for years to come: the battery-powered e-vehicle, e.g., for urban cars, the internal combustion engine powered vehicle, e.g., generally for long-distance driving or in regions with poor infrastructure, and the hydrogen drive, e.g., for cargo and long-distance transport (air, sea, rail, road). Value creation chains, vertical integration and the range of parts vary depending on the drive type. At the same time, there is new potential to develop additional business areas.

Smart logistics for advanced delivery solutions: shipment volumes and customer expectations for speed of delivery are increasing, while the size of shipments is decreasing. At the same time, ecological demands are also increasing. E-commerce and online trade are forcing established market participants to make radical changes; new business models and alternative mobility concepts are constantly placing high demands on the entire industry. While Industry 4.0 and the use of big data increase the already high customer demands, they also create new technical possibilities. What is needed are concepts that enable

flexible and low-emission on-demand delivery, taking into account and intelligently linking urban and rural flows of goods.

Interior-of-the-future for future-oriented vehicle interiors: in perspective, the interior of a vehicle is one of its largest growth areas. All major product innovations on the way to future individual mobility leave their mark on the interior: new drives (especially electromobility) create new design freedom in the vehicle interior, the networking of vehicles leads to increasing digitalisation of the interior and the development steps towards autonomous driving change user behaviour and thus also the requirements for functionalities in the interior. All of this offers opportunities for Thuringia's automotive and supplier companies.

Cognitive car for mobility of the future: autonomous driving with all its facets will significantly change mobility in general as well as the mobility value creation chain. Traditional production of vehicles will continue to get challenged by the rapidly growing area of data and mobility services. Intelligence of vehicle parts and components as well as communication within the vehicle, between vehicles and with the vehicle environment will continue to increase. Here, additional opportunities for new business fields will compensate for the increasing risks for the traditional automotive supply business.

3.3. Field of specialisation: healthy living and the health-care sector

Specialisation profile and significance for Thuringia

The field of specialisation "healthy living and the health-care sector" is an important part of Thuringia's economy with its activities in the fields of medical devices, diagnostics/analytics, biotechnology, pharmaceuticals and healthy living/nutrition (see Figure 4). The high importance of this field of specialisation is particularly evident from the localisation coefficient of 1.11 in terms

of employees and 1.64 in terms of turnover. The further development of field-specific areas is driven by a number of cross-sectoral themes such as digitalisation, research, internationalisation and translation/utilisation.

The field comprises 8,389 companies in the manufacturing and service sectors, which generate a turnover of just under EUR 6.9 billion with 161,889 employees subject to social insurance contributions.³¹ With more than 180 companies with over 20 employees, a turnover of over EUR 4 billion and a total of about 20,000 employees, the food industry is the third largest economic force in the manufacturing sector in Thuringia. The value creation of the Thuringian food industry is based on traditional business models. Their economic importance is particularly evident in rural areas away from conurbations.

The "medical devices" and "diagnostics/analytics" fields draw on the competencies and closed value creation chains in optics and photonics that have developed historically at the location. Since 2015, the field of "in vitro diagnostics" (IVD) has developed a strong development dynamic, especially in combination with the field of "infection research", and now stands as a profile-forming topic in its own right. Companies in Thuringia research and develop innovative products and applications to prevent infections (prevention) or detect them (infection diagnostics) in order to be able to treat them specifically. Competencies from the fields of photonics and diagnostics provide the basis for these activities as well.

³¹ Calculation as part of RIS3 monitoring based on data from the TLS, data status: 2018 (figures rounded).



Figure 4: Specialisation profile “healthy living and the healthcare sector” (Data status: 2018)

The high innovative strength of these fields is evident from the total of 453 patent applications³² (from 2014 to 2018). It is also reflected in the success of Thuringian players in competing for funding from federal programmes in the field of technology/innovation, which have raised a total of around €128 million between 2015 and 2018. “Pharmaceutical manufacturing” is a dominant theme among the pharmaceutical companies based in

Thuringia. In addition to pharmaceutical manufacturing, drug development activities are becoming increasingly established.

Field development and important milestones

Traditional strengths in the field of optics make Thuringia an international innovation leader in the fields of microscopy, laser technology and ophthalmology. In recent

³² ThCM calculations based on data from PATON | Patent Center Thuringia, applications between 2014–2018 (in Germany and worldwide)

years, new thematic fields such as infection research and “healthy ageing” have been established and have continuously attract international attention.

The entire field is characterised by a particular strength of Thuringia's research institutions. Here, it has been possible to attract further structure-building R&D initiatives to Thuringia in highly endowed and prestigious tenders in competition with other German regions. These include the Cluster of Excellence "Balance of the Microverse" (approx. EUR 47 million; infection research) and the "Leibniz Center for Photonics in Infection Research (LPI)" with a funding volume of EUR 150 million.

Other structure-building successes in major federal programmes include the second funding phases of the “InfectoGnostics” research campus programme and of the “nutriCARD” nutrition competence centre programme. These initiatives are now firmly established in the actors' landscape and have the power to significantly shape the further development of the field's topics (diagnostics and nutrition).

The clusters medways e. V. and the "Thüringer Ernährungsnetzwerk e.V." have established powerful network structures that accelerate the development of value creation networks and support companies in bringing products successfully to the market more quickly. In the field of medical technology, the "ThIMEDOP" innovation centre supports SMEs in product development.

Over the past few decades, a network of innovative companies has developed around the field of diagnostics. As a sub-sector of medical technology, the field of diagnostics covers everything ranging from imaging to laboratory diagnostics.

At the "Center for Translational Medicine" (CeTraMed) of the University Hospital of Jena, research into age-associated diseases (gerontology) and medical photonics combines two focal areas of research in Thuringia.

Thuringia has a large number of innovative IT entrepreneurs and IT service providers who already have experience in developing digital health services. Companies in the field of "digital health" are characterised in part by rapid employment growth.

In the food sector, regional sourcing, production, processing and marketing structures that draw on both regional tradition and regional innovation potential create identity.

Profiling

Demographic change in large parts of the developed world is the societal driver for the expansion and optimisation of health systems and for the ever-increasing demand for services and solutions across the health sector. The main technological drivers are digitalisation, the use of artificial intelligence, personalisation of medicine and developments in sensor technology. The current pandemic situation will also have a significant impact on further developments in prevention, diagnostics and treatment as well as in the organisation of healthcare. From these trends, five themes emerge as having potential along the Thuringian competencies:

“Biophotonics/Bioinstruments” builds on the existing know-how in the area of photonics as the key enabling technology (KET). New biophotonic technologies when combined with innovative image analysis have a high potential to make a significant contribution to the personalisation of medicine. This sector shows above average growth rates in turnover and employment. Increased participation in international platforms should further

increase the international visibility of the activities in this field.

The topic of "Infections/diagnostics" is an international beacon in Thuringia. There are established value creation networks especially in the field of infection diagnostics. The increasing miniaturisation and interconnectedness of new technologies enables them to be used directly near patients or outside healthcare facilities, thus giving rise to completely new business models.

Digital health is a comparatively young subject area that is developing at a fast pace. The development and implementation of digital health applications have the potential to enable new types of business models. In particular, the small and medium-sized IT company landscape in Thuringia allows new business models to be developed along the value chain on the basis of valid health data.

With the trend towards healthier food, innovative approaches to developing health-promoting and disease-preventing foods are being encouraged. Current developments in the field of nutrition are working towards establishing a national centre for nutrition research, which will build on the expertise established in Thuringia in the field of age-related diseases (gerontology). Well-founded scientific expertise for initiating R&D activities is available in the food industry.

The topic of "healthy ageing" has developed dynamically in Thuringia over the last 15 years and will be an area of application for new market opportunities in the future. The topic includes medical devices for orthopaedics and surgery among other things, offers for "healthy working" for instance and the digital transformation of working environments as well as the field of pharmaceuticals. Among other things, the establishment of research centres focusing on diseases that are typical of old age will boost the

profile in the coming years.

3.4. Field of specialisation: sustainable energy supply and resource management

Specialisation profile and significance for Thuringia

The field of specialisation "sustainable energy supply and resource management", with sector activities in areas such as renewable energies, energy storage, energy systems as well as resource management and reuse, comprises about 6,600 companies with about 42,600 employees. An annual turnover of around EUR 9.13 billion is generated from special products, plants and services, thus contributing to the gradual expansion of a resource-conserving and climate-neutral circular economy.³³ The following figure shows the specialisation profile.

The sub-sector of energy systems, components and materials focuses on the development and design of sustainable energy systems as well as storage technologies and storage materials. The sub-sector of resource-efficient material cycles and bioeconomy includes aspects such as circular economy and material efficiency. The individual sub-topics of the specialisation profile have direct cross-relationships with other fields of specialisation: energy system automation, for example, is related with the field of "ICT, innovative and production-related services", material- and energy-efficient processes and circular economy are related with the field of "industrial production and systems" and mobile energy storage is related with the field of "sustainable and smart mobility and logistics".

Field development and important milestones

Significant research and innovation activities in the individual sub-sectors characterise the field. This is reflected, among other things, in the 185 patent applications³⁴ (from 2014 to 2018) and the numerous Thuringian R&D projects on innovative topics at the EU, federal and state

³³ Calculation as part of RIS3 monitoring based on data from the TLS, data status: 2018 (figures rounded).

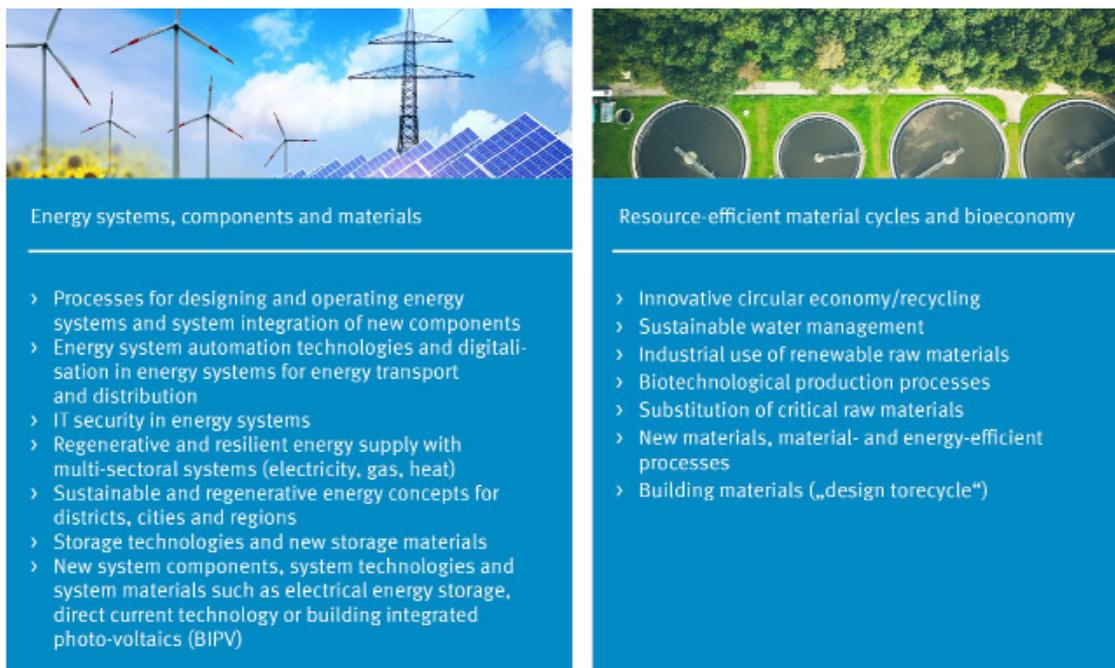


Figure 5: Specialisation profile "sustainable energy supply and resource management" (Data status: 2018)

levels. In the competition for federal funding alone, approximately EUR 57 million were raised in 195 projects between 2015 and 2018. Players from universities, research institutions and research centres as well as companies are developing technology platforms and marketable solutions in larger project networks, for example in the BMBF growth core project "smood - smart neighbourhood", in the BMBF project "H2-Well" or in the BMWi joint project "ZO.RRO - Zero Carbon Cross Energy System". Once these platforms and solutions are put into practice, the field will start creating value for Thuringia and increase the productivity of SMEs. The two Thuringian innovation centres are a special feature of field development: Center for Energy and Environmental Chemistry Jena (CEEC) and Thüringer Innovationszentrum für Wertstoffe (ThiWert - Thuringian

Innovation Center for Recyclables), which address concrete market needs through application-oriented research. In addition, the Battery Innovation and Technology Centre (BITC) is a state-funded centre that focuses on networked and digitally supported production and quality assurance of battery cells and modules. R&D developments in this field are increasingly characterised by digitalisation approaches, for example in the development of AI-based energy systems or the energy conversion of residential quarters. In addition to already existing cross-field potentials, this will open up new value creation approaches. Players are networked in a targeted fashion through long-established network structures such as the Thuringian Renewable Energies Network (ThEEN e. V.) as an industry association and SolarInput e. V.

34 ThCM calculations based on data from PATON | Patent Center Thuringia, applications between 2014–2018 (in Germany and worldwide)

Profiling

Climate and resource protection, energy transition and decarbonisation of the economy are key challenges for the future. In the context of the European Green Deal and the New Circular Economy Action Plan for a cleaner and more competitive Europe, future tasks pertaining to the field - including sub-topics such as material efficiency, raw material substitution, avoidance of greenhouse gas emissions, expansion of renewable energies, integrated energy management and IT security - are addressed and safe, sustainable and economically viable solutions are designed. By bundling Thuringian economic and scientific competencies from this field of specialisation, three current topics have emerged as having the potential to contribute to the creation and strengthening of regional and supraregional value creation networks in the sense of the circular economy:

The topic of "energy storage for energy transition" is dedicated to the development of the innovative storage technologies that are necessary for successful energy system transformation. It focuses on approaches to materials research for energy storage technologies and on the development, testing and establishment of market-ready products. The interplay between scientific and economic players, including from the fields of sensor technology and plant engineering, creates a holistic value creation network. Thuringia can therefore participate in the growing global market for energy storage. With the establishment of the Chinese lithium-ion battery manufacturer Contemporary Amperex Technology Thuringia GmbH (CATL), Thuringia is gaining global recognition for battery production for automotive applications. In addition to modern batteries, green hydrogen is also an important storage medium and is used in the field of sustainable mobility as well as in emission-free industrial processes.

The successful shaping of the energy transition through

cross-sectoral approaches is addressed by the topic of "cognitive energy systems for secure and sustainable energy supply of the future" by addressing the need to make the electricity system more flexible. The focus is on grid and system stabilisation measures using software-controlled and AI-based methods along the voltage levels. The bundling of outstanding scientific expertise in energy system research with competencies from the regional energy, IT and control technology industries creates application-oriented solutions and regional value creating relationships for a globally growing digital electricity market.

The focus of the topic "resource-efficient material cycles and raw material use for sustainable business" is on closing material cycles by developing efficient and recycling-oriented manufacturing processes, high-quality recycling processes as well as innovative and sustainable product designs. Thuringian players are working on forward-looking solutions through application-oriented R&D approaches in science and industry. Thuringia's expertise in mechanical and plant engineering and the digital economy increases the potential for building a value creation network. This will contribute to the development of future market potential.



Figure 6: Specialisation profile "ICT, innovative and production-related services" (Data status: 2018)

3.5. Field of specialisation: ICT, innovative and production-related services

Specialisation profile and significance for Thuringia

Information and communication technology (ICT) is the driver and pioneer of digitalisation in all areas of life. This is also reflected in the innovations in the individual fields of specialisation, many of which are now based on developments in ICT. With the structural change, the rapid and mobile exchange of data and the intelligent evaluation of data have established themselves as significant growth factors. More and more creative service providers are contributing to innovation, for example with new product features or new business models. The field of "ICT, innovative and production-related services" has a cross-sectoral character in Thuringia with its numerous links to the other four fields of specialisation.

The field comprises about 5,630 companies that generate a turnover of about EUR 3 billion with a total of almost

24,000 employees.³⁵ Looking at ICT as an overall system, the players can be grouped into the main areas of IT infrastructure and systems, software and production-related services and digital media/media for people. The detailed specialisation profile is shown in Figure 6.

Field development and important milestones

Although this field of specialisation is smaller in Thuringia than the national average, it recorded significant growth (around 30%, compared to an average of around 16% for the other fields) in terms of turnover development in the period 2013 to 2018.³⁶ Numerous Thuringian companies, especially in the field of ICT service provision, have been able to distinguish themselves, which is reflected, for example, in successful company developments, investments, innovation projects, internationalisation activities and awards. Supraregionally and internationally operating companies have successfully settled here.

The development and establishment of the annual industry day "Thüringer IT-Leistungsschau" as a platform for

³⁵ ThCM calculation as part of RIS3 monitoring based on data from the TLS, data status: 2018 (figures rounded).

³⁶ ThCM calculation as part of RIS3 monitoring based on data from the TLS, data status: 2018 (figures rounded).

exchange between the players in the field and the users has proved extremely successful. It has developed into one of the largest events of its kind in central Germany and is also an expression of the steady expansion of the industry network ITnet Thüringen e. V. and the cooperation with other networks, institutions and partners.

The work of the centres "Thüringer Kompetenzzentrum Wirtschaft 4.0" and "Mittelstand 4.0-Kompetenzzentrum Ilmenau", which have been established in recent years, is particularly important for the further development of the field and its interrelationship with the other fields of specialisation. They introduce Thuringian companies to the digitalisation of their products, processes and business models as well as to R&D projects by raising awareness, providing information and through concrete demonstration projects³⁷. The conceptual cooperation between Thuringian universities, combining outstanding scientific expertise in the fields of big data, visualisation and IT security, was a crucial basis for the successful establishment of the DLR Institute of Data Science in Jena. A contact point with and interface to the industry in the field of AI was also established in 2020 with the Thuringian Center for Learning Systems and Robotics (TZLR) established by Thuringia's universities and research institutions.

Profiling

Based on current challenges such as digitalisation including artificial intelligence (AI), structural change (especially in the automotive and supplier industry) and demographic change, four promising topics have been identified within the specialisation profile, taking into account current IT trends and the competencies of Thuringian players.

The topic of "learning systems" can rewrite the accomplishments with the technologies and methods of "weak" AI. The topic of "learning systems - basis for efficient digitalisation" addresses one of the most important megatrends with high potential. It can be assumed that, in the future, almost all IT systems will be developed as learning sys-

tems by implementing AI methods. It is primarily through these technologies that further value can be added in the context of digitisation in the fields of specialisation.

One aspect of the human-centred use of AI is the visualisation of the results of AI methods, relevant information in large data volumes or complex processes. The topic of "augmented and virtual reality - audio-visual assistance for people" offers solutions for this and allows the combination of digital objects and the real world or even complete virtual realities in image or sound. Other outstanding applications are primarily in the didactic field (use for training and qualification) or in supporting manual processes. In just a few years, these applications will significantly influence and change social life.

The topic of "Service robotics enhancing everyday life" focuses on service and assistance robotics for special applications that provide services and relief for people in everyday environments. Autonomous and mobile robotics are some of the main application areas of "weak" AI. For more than 15 years, Thuringia has made its mark internationally with robot-assisted systems as well as with products, research results and developments on autonomous robotic platforms for indoor, outdoor and underwater use. Service robotics itself can benefit greatly from further innovations in the areas of digitalisation and AI, especially machine learning, as well as from further developments in standardisation.

The topic of "digital platforms and services for business and administration" focuses on technologies and services that digitally map relationships and value chains in and between companies and institutions and link the increasingly inhomogeneous software structures. The growth potential for this cross-cutting topic can be considered very high in view of the further digitalisation of the economy, the use of AI applications, the creation and expansion of value creation networks and the compensation of size-related disadvantages of SMEs. Among other things, the topic builds on outstanding eCommerce expertise and successful projects.

³⁷ Demonstration projects are only offered by the Mittelstand 4.0-Kompetenzzentrum.

4. Operational Implementation from 2021 to 2027

4.1. Further development of governance

After six years of successful implementation of the Regional Research and Innovation Strategy for Smart Specialisation in Thuringia for the 2014-2020 funding period, it is time to take stock and put processes and structures to the test. In close cooperation with the RIS working groups, which are made up of more than 100 representatives from science, industry, clusters and networks as well as intermediaries, it has been possible, in retrospect, to strengthen trust and the willingness to cooperate to significantly intensify the cooperation between players and thus to initiate cooperative innovative projects. At the same time, other forums and dialogue formats were created along with a broad discussion platform that continuously provides impetus to the development of Thuringia's innovation system. A wide range of communication measures were developed and established to inform the public about the successes of RIS implementation and the focus of the work. These measures include the RIS annual event "InnoCON Thüringen" as a flagship event for the innovation policy and a digital platform in www.cluster-thueringen.de for knowledge exchange and information material.

Overall, the regional research and innovation strategy for the 2014-2020 funding period was characterised by a strong bottom-up approach. Various channels were used to strengthen the networking between science, industry and intermediaries and to enable their participation in the RIS process. Building on this, targeted strategic impulses will now be provided in the sense of specialisation and differentiation of the innovation policy priorities as part of further development. To this end, long-term, strategic considerations will be more closely linked to the bottom-up approach pursued so far.

Participation formats

The evaluation of RIS processes in the 2014-2020 funding period has shown that it has not yet been possible to adequately involve all interested innovation players from Thuringia and the industrial base, especially companies in rural areas, in the implementation processes.³⁸ The aim is therefore to achieve an even stronger macroeconomic view with a strong voice for the industry through even more application-oriented participation formats and an equal involvement of the players. The departments responsible for other specific areas of innovation should also be more closely involved in the participation formats and given a more active role in the strategy advisory boards, so that better networking between the departments as well as the exchange for the promotion of innovation in the free state and the exchange among each other are strengthened.

In order to tap additional innovation potentials, companies from rural districts with the highest proportion of industrial employees per 1,000 inhabitants³⁹ should primarily be integrated even more strongly into innovation processes. In this context, clusters and networks play an important dual role: as a link between the industry and policymakers and representatives of business interests, especially SMEs, and as a multiplier in their own networks.

In order to involve universities, non-university and industry-oriented research institutions, innovation centres, business enterprises, clusters/networks and other intermediaries, the ThCM continues to use forums as a key participation instrument with a broad impact. In the new funding period, these forums will be the main platforms for dialogue and cooperation, used on a topic-related or situational basis and enabling agile, target group specific and topic-specific cooperation. They will

38 Evaluation of the measures to strengthen research, technological development and innovation under the ERDF Operational Programme for Thuringia 2014-2020, Ramboll.
39 TLS 2020, press release 222/2020 of August 31, 2020: Beschäftigtendichte in der Thüringer Industrie im Jahr 2019 (Employment density in the Thuringian industry in 2019).

serve as a format for networking, exchanging experiences, initiating concrete projects and discussing development steps in the various fields and the overall strategy. At the same time, they will serve as a broad participation process (bottom-up approach) in the sense of an entrepreneurial discovery process for the further development of the content of the fields of specialisation. Through an agile and low-threshold design, i.e., a design that is easily accessible and that focuses on system solutions, they are intended to give the wide range of innovation players in Thuringia the opportunity to discuss and participate in the implementation process, while at the same time enabling the establishment of new collaborations or the initiation of new R&D projects.

Thuringia's innovation strategy also aims to strengthen open innovation processes⁴⁰ in companies and institutions. An agile environment also aims to attract unconventional, creative minds, who can bring new ideas and out-of-the-box thinking and broaden the horizons of everyone involved and thus generate ideas for new products, business models and R&D projects.

Executive bodies

Evaluation of the RIS processes in the 2014-2020 funding period has confirmed that the ThCM plays an important role in networking and building trust among innovation stakeholders in Thuringia and that it has made a significant contribution to the successful implementation of RIS Thuringia in the 2014-2020 funding period.⁴¹ In the study on smart specialisation in Germany conducted by Prognos AG on behalf of the EU Commission, the ThCM was highlighted as a best-practice example of a governance structure for RIS in Germany.⁴² It will continue to play an important supporting and complementary role for the Thuringian Ministry for Economic Affairs, Science and Digital Society in the 2021-2027 Structural Funds funding

period as well. Here, the ThCM will primarily take on the process and participation oriented work for implementing the Regional Innovation Strategy for Smart Specialisation and Economic Change in Thuringia.

For the future, the evaluation report recommends that the function of the ThCM as a cross-field networker of innovation stakeholders and initiatives be strengthened within the framework of the strategy's implementation structures in order to exploit the transfer potential between scientific institutions and companies. In future, the ThCM, as the Head office and an important agency for strategy implementation, will be given greater responsibility in the conceptualisation of field development. In concrete terms this means that by integrating the results from the forums and dialogue formats, through a structured, ongoing monitoring of the achievement of objectives and a long-term, strategic analysis of future trends and developments, the ThCM will strategically develop the fields of specialisation and innovation-based value creation networks in a targeted manner and implement the associated measures. As in the previous funding period, this will be achieved by using action plans or roadmaps to identify the key planning steps for implementation and milestones in the development of the field and topics. The above-mentioned study also shows that transformation roadmaps are a particularly useful tool for effective strategy implementation.⁴³

The ThCM is advised by so-called strategy advisory boards, which are formed for each field of specialisation and consist of a nucleus of the previous working groups from industry and science. The purpose of forming field-specific strategy advisory boards is to provide an overarching, content-related strategic component from an application and development perspective. The aim is to reduce decision-making levels, simplify processes and thus speed up implementation.

⁴⁰ In the sense of a targeted opening of internal innovation processes to external know-how and ideas in order to generate innovations.

⁴¹ Evaluation of the measures to strengthen research, technological development and innovation under the ERDF Operational Programme for Thuringia 2014-2020, Ramboll.

⁴² Study on smart specialisation in Germany conducted by Prognos 2020 on behalf of the European Commission.

⁴³ Study on smart specialisation in Germany conducted by Prognos 2020 on behalf of the European Commission.

The ThCM is developing itself further to strengthen its advisory and supportive function for the Thuringian Ministry for Economic Affairs, Science and Digital Society. In this

context, the ThCM should, for example, identify needs and impulses for the development of the Thuringian innovation system and - in consultation with key strategy

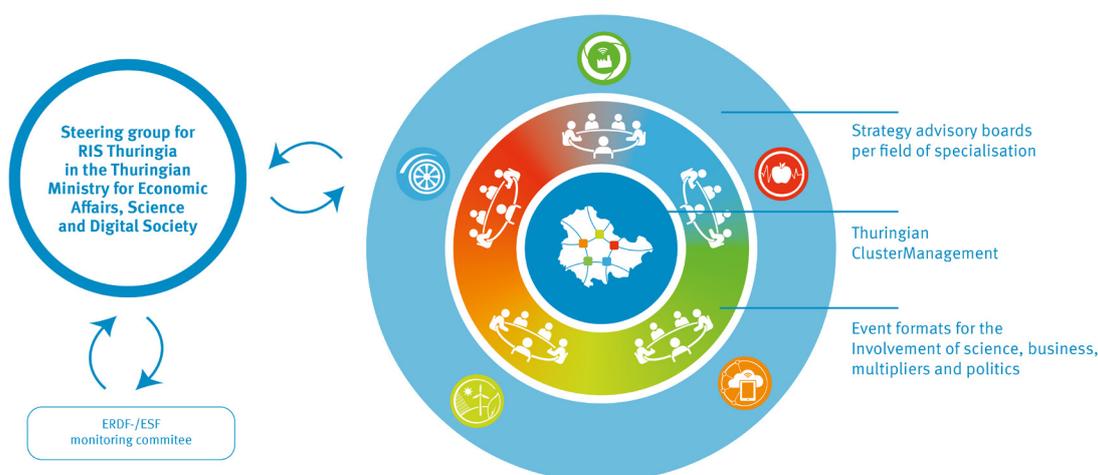


Figure 7: Future Governance on the Regional Innovation Strategy for Smart Specialisation and Economic Change in Thuringia

stakeholders (including strategy advisory boards) and taking into account the roadmaps - develop topic proposals for the funding instrument "Thüringer VERBUND".

The Thuringian Ministry for Economic Affairs, Science and Digital Society is developing the existing working group ("AG RIS3") into a steering group for RIS Thuringia, which will accompany and steer the implementation of the strategy and advise on the tasks of the ThCM. As a coordination and controlling committee, the steering group for RIS Thuringia will primarily assist in the final alignment of the development goals and processes (including roadmap processes) generated by the ThCM within the framework of the participation formats. It will consist of representatives of the RIS-relevant departments of the Thuringian Ministry for Economic Affairs, Science and Digital Society

as well as representatives of the ThCM and the "Thüringer Aufbaubank" (Thuringian Development Bank).

Other departments of the state government and the heads of the strategy advisory boards can also be consulted, if necessary. The steering group will ensure a transparent link with the departments and state institutions responsible for the other specific areas of innovation through active reporting and will meet regularly to monitor and coordinate the diverse RIS implementation processes. The steering group for RIS Thuringia will report regularly to the ERDF/ESF monitoring committee, where it will receive feedback from representatives of the industry and social partners on the use of the EU structural aid for the implementation of RIS Thuringia.

4.2. Instrumental implementation using ERDF funding instruments

In the 2021-2027 funding period, the aim is to achieve greater integration of research, innovation and general economic development by applying a broad concept of innovation. Supporting significant R&D projects or roadmap measures, for example, with instruments from other economic policy areas of the state as defined in Chapter 5, such as ‘digital and fibre optic strategy’ and ‘investment and start-up support’, can occasionally contribute to achieving the objectives of RIS Thuringia. For the successful implementation of RIS Thuringia, it will also be important to place significant research and innovation projects within the framework of topic-specific federal and EU programmes in addition to the stakeholders' own funds as well as state funds, municipal funds and the European Structural and Investment Funds. In the past, Thuringian innovation players have already succeeded in acquiring funding from programmes such as BMBF Growth Cores, BMBF Innovation Forums and from the EU Framework Programmes for Research. These additional sources of funding from the EU and the federal government will become increasingly important in Thuringia to support application-oriented and industrial innovation projects, also against the backdrop of the expected decline in state funding and funding from the European Structural and Investment Funds.

Integrated promotion of research, development and innovation

The funding instruments for research, technology and innovation are a key lever for the successful implementation of this strategy. In particular, they are intended to support further specialisation and differentiation in the fields of specialisation and thus to drive the development

of innovation-based value creation networks in the identified topics. A technology-open approach will continue to be pursued. At the same time, the funding instruments should be open for cross-cutting general topics that address fundamental challenges and thus provide an important basis and support for further specialisation and differentiation.

The state funding that is co-financed by the ERDF is very important for the implementation of the strategy. It must be placed in the overall context of state, federal and other EU funding because it cannot cover all funding needs and because it is also important to ensure supraregional integrability. In this respect, a broad approach to funding instruments will be pursued in the new Structural Funds funding period within the framework of the available budgetary funds, aiming at a coherent and synergetic use of the various funding options. The funding co-financed by ERDF should also be combined in the best possible way with the ESF co-financed funding instruments and the funding provided by the federal state in order to create synergies.

The existing funding instruments have proven their worth in the 2014-2020 EU Structural Funds funding period and in the implementation of RIS Thuringia. Their positive impact on the innovation system in Thuringia was convincingly demonstrated in the evaluation of the funding measures of the ERDF Operational Programme.⁴⁴ However, the targeted further development of the funding instruments is intended to respond even better to challenges and funding needs and, among other things, to implement the recommendations for action from the ERDF evaluation. The aim is to (further) develop strategic priorities more consistently on the one hand, and, on the other, to enable a simpler, steadier and more short-term

use of the funding instruments, especially with regard to SMEs. Lower-threshold funding approaches should reduce access barriers, especially for companies that are not active in the innovation system yet.

The intended basic structure of future funding instruments in the field of research, development and innovation in Thuringia comprises six funding areas, to which corresponding funding objects are assigned (see Table 1).

The already established competition-oriented funding approach should be used to align funding with the strategic

Integrated Thuringian Research, Technology and Innovation Funding (FTI-Thuringia)					
FTI-Thuringia RESEARCH Directive 1	FTI-Thuringia PERSONS Directive 2	FTI-Thuringia TECHNOLOGY Directive 3	FTI-Thuringia INVEST Directive 4	FTI-Thuringia TRANSFER Directive 5	FTI-Thuringia INFRASTRUCTURE
Equipment	Research groups	Thüringen VERBUND	WinaFo-Invest	get started 2gether	Building and basic equipment
Scientific research projects	Innovative staff	Thüringen VERBUND Dynamik	WinaFo-Digital	TGZ cold rent exemptions	
	Thuringia scholarship	Thüringen R&D INDIVIDUELL	Innovation centres		
		Innovation vouchers			

Table 1: Intended basic structure of the future instruments for promoting research, technological development and innovation in Thuringia

priorities. This is particularly suitable for large-volume R&D projects (e.g., Thüringen VERBUND). The associated thematic priorities should be developed within the framework of RIS governance and they can also be used to support the roadmaps. An important basis for this are the content proposals developed by the ThCM, taking into account the roadmaps and in consultation with the strategy stakeholders.

In addition to the competition-oriented funding approach, a continuous and, above all, low-threshold application process should be made possible for companies

so that they can respond quickly to new developments. This is particularly suitable for small-volume funding offers. The funding object "Thüringen VERBUND Dynamik" is a new offer that is designed to meet the need of Thuringian SMEs for simple and quick access to funding for cooperation projects and that is suitable for achieving results in the short term. Individual companies will continue to be able to apply for R&D funding at all times (Thüringen INDIVIDUELL).

The same applies, for example, to innovation vouchers, which also ensure a low-threshold accessibility of innova-

44 Evaluation of the measures to strengthen research, technological development and innovation under the ERDF Operational Programme for Thuringia 2014-2020, Ramboll.

tion funding and can be effective in the various phases of executing R&D projects.

The inclusion of the "get started 2gether" programme in the funding instruments will support innovative start-ups in the transfer of knowledge and technology to the market.

Planned investment funding is intended to specifically strengthen Thuringia's industry-oriented research institutions. With their market orientation within the innovation value chain, these institutions play a special role in the translation of research results to industrial implementation. In addition, innovation centres will be established and developed further in a targeted manner with the aim of setting specific thematic priorities and making them active providers of transfer structures.

Moreover, it will continue to be possible for Thuringian research institutions and companies to participate in consortia within the framework of EU joint undertakings (e.g., ECSEL JU, KDT JU).

Supporting sustainable growth and competitiveness, especially of Thuringian SMEs

The advisory and investment grant programmes under the ERDF OP for the 2021-2027 funding period, which can also provide innovation incentives to SMEs among others to convert production processes to resource-conserving and efficient methods, will be supported by the "Thüringen-Dynamik" loan programme that includes diverse content and by the two investment funds "Gründerfonds" and "Wachstumsfonds". The aim is to encourage the creation of start-ups, support SMEs in overcoming critical development stages, increase the innovation rate and improve business growth in Thuringia.

For it to overcome the critical growth processes in establishing itself on international markets, Thuringia's economy will be rigorously internationalised through a modified measure called "internationalisation of Thuringia's economy" that is adapted to the challenges facing Thuringia's economy today. Lessons learnt from the COVID 19 pandemic will be borne in mind and virtual formats will be added to the toolkit.

In addition to the instruments mentioned above, the ESF-funded advisory and networking projects of the Thüringer Zentrum für Existenzgründungen und Unternehmertum (English: Thuringian Center for Start-ups and Entrepreneurship), subsidised advisory services for start-ups and SMEs as well as start-up passes will continue to be available to raise awareness about and activate start-up potential.

4.3. Continuous performance measurement and further development of the innovation strategy

Monitoring the implementation of the strategy

The basic monitoring structure for the implementation of the Regional Research and Innovation Strategy for Smart Specialisation in Thuringia has proved to be successful in the 2014-2020 funding period and will be used in the 2021-2027 period as well. It consists of two parts; firstly, performance measurement using performance indicators to monitor activities related to the implementation of the strategy and secondly, impact indicators to measure the achievement of objectives.

In addition to the indicators, it also includes qualitative results, particularly in the monitoring of activities. In this context, activities should be understood in a broad sense: they include activities directly related to innovation (e.g., R&D projects, patent applications, etc.) as well as activities that indirectly drive innovation and economic development (e.g., networking activities, cross-regional cooperation, development of skilled labour, etc.). In addition to the direct activities of the state (including through corresponding funding programmes), monitoring also includes a wide variety of initiatives/projects by Thuringian players.

Monitoring reports and indicators have proven effective in measuring the performance and impacts of RIS Thuringia and will also continue to be used. The monitoring reports that are prepared annually bundle the various

performance and impact indicators and provide a comprehensive view of the development of the strategy and the fields of specialisation. For example, the following are linked together:

- › Evaluation of the use of Thuringia's R&D funding instruments by fields of specialisation and evaluation of output and performance indicators of ERDF monitoring,
- › Consideration of the participation of Thuringian players in federal/EU R&D funding programmes,
- › Sector, cluster and patent monitoring,
- › Qualitative consideration of activities and developments in the fields, including trend scouting, milestones and other supporting measures.

As in previous years, the report is flexible and can be supplemented with additional elements as needed in order to respond swiftly to new funding instruments and, if necessary, new objectives. The monitoring radius, especially with regard to activities, will be expanded in a targeted manner in the new funding period. For example, more qualitative results, such as the reflection of current trends and framework conditions, will be included and field-specific indicators will be supplemented with topic-related and roadmap-related monitoring.

As a steering committee, the steering group for RIS Thuringia will continuously draw conclusions on the implementation of the strategy on the basis of the expanded monitoring reports.

Evaluation as a basis for impact measurement and strategic development

Monitoring and evaluation are two separate processes, but there are many interactions between them. While a monitoring system for RIS is implemented internally by the ThCM (with recourse to funding agencies and their existing monitoring systems), evaluations are supposed to be carried out externally by independent experts. Monitoring provides some of the empirical basis for evaluation. Conversely, the evaluation concept justifies which indicators are relevant for monitoring.

The further development of the innovation strategy for the 2021-2027 period incorporates conclusions and recommendations from an ex-post evaluation of the measures to strengthen research, technological development and innovation under the ERDF Operational Programme for Thuringia 2014-2020.⁴⁵ In order to assess the effectiveness of the objectives of the regional innovation strategy in conjunction with the ERDF measures to strengthen research, technological development and innovation, an evaluation by an externally commissioned expert is also planned in the course of the 2021-2027 funding period. As in the previous funding period, evaluation will be part of the evaluation plan for the ERDF Operational Programme.

As a basis for evaluation, data will be systematically and comprehensibly documented throughout the funding

period, e.g., within the framework of the monitoring system, which can then be used for topic or region based evaluations. On the other hand, additional data can be methodically collected during the evaluation process, e.g., by interviewing key stakeholders and beneficiaries of funding and by analysing relevant studies, including those relating to the use of ERDF funding or the further development of funding approaches. In addition to the evaluation - as in the 2014-2020 funding period - the continuous further development of Thuringia's regional Innovation Strategy should also include impulses from strategy stakeholders. A continuous exchange between ThCM or Thuringian Ministry for Economic Affairs, Science and Digital Society and partners from science, business and industry as well as social partners and multipliers, especially through forums, dialogue formats and strategy advisory boards, provides valuable and regular feedback on strategic orientation and strategy implementation. This approach is of particular relevance because the strategy can be successful only if it is supported and co-designed by the RIS stakeholders.

⁴⁵ Evaluation of the measures to strengthen research, technological development and innovation under the ERDF Operational Programme for Thuringia 2014-2020, Ramboll 2020.

5. Classification in the Economic Policy of Thuringia

Alongside the regional structural policy geared towards the growth of Thuringian companies, the regional Innovation Strategy is an important pillar of the economic policy of the Free State of Thuringia. In addition to supporting innovative and smart change, measures to achieve the national convergence target remain an important aspect of Thuringia's economic development. The following section explains how RIS Thuringia fits into the economic policy activities of the state and illustrates how the projects and goals of the Specific Objective 1 are embedded in a broader context and economic policy strategy. In this respect, the measures described below support the objectives of the regional Innovation Strategy without being part of the processes described in Chapters 2 and 4, and illustrate that RIS Thuringia interfaces with the structural policy activities of the free state in a wide variety of aspects.

5.1. Harnessing the potential of digitalisation in science and industry

Digitalisation is bringing about far-reaching changes in politics, the economy, science and society. Last but not least, the economic and social restrictions caused by the pandemic illustrate the importance of digital networking and secure, interoperable data use for the German economy and science. This reinforces the already dynamic development of digitalisation and accelerates the pace of digital transformation.⁴⁶ In addition, the importance of functioning value creation and supply networks, which are also increasingly digital and knowledge-based, is growing, especially for SMEs.

The aim of the state government is to use the current digitalisation boost from the pandemic to provide targeted support for the transition to new digital technologies in companies, scientific and educational institutions and regions, and thus for the development of sustainable structures. The state government and the Thuringian Ministry for Economic Affairs, Science and Digital Society intend to build on the extensive expertise that has developed in the fields of business and science and on the many ongoing projects and initiatives in the areas of digitalisation and business/Industry 4.0 to specifically strengthen the diffusion/dissemination of digital technologies and their far-reaching integration into complex business processes as the basis for new business models. This requires, in particular, more investment in the digital infrastructure, complementary investment in skilled workers and the reduction of bureaucratic hurdles in its expansion.⁴⁷

At the same time, digitalisation is changing the way we research and develop. One example is the use of big data, which opens up immense possibilities for the simulation of highly complex processes. There is also great potential in research into revolutionary technologies such as artificial intelligence (AI) and quantum technologies, which will significantly drive the next stages of digitalisation. As elements of digitalisation, large data volumes (big data) and learning systems in particular are expected to change the global digital transformation process even more comprehensively and rapidly than before. In many areas of life, decisions are already based on algorithms and, increasingly, also on AI calculations. The ability of advanced cognitive systems to independently learn complex correlations from big data and to transfer them to new situations opens up a very large field of application for AI technologies in application-oriented research and development. In these key technologies in particular, the transfer of academic findings into industrial research and

⁴⁶ Benchmark study "Digitalisation Index for SMEs 2020/2021" by techconsult.

⁴⁷ Annual Report 2020/2021 of the German Council of Economic Experts, p. 313 ff.

development and into concrete applications that increase growth and efficiency, combined with an efficient data infrastructure and services, is of great importance for innovation and economic policy.

In recent years, companies in the Free State of Thuringia have taken important steps towards Business 4.0. Not least the demand for the "Digital Bonus Thuringia" funding instrument, which came into force in 2018, proves that companies in the manufacturing and trade sectors in Thuringia are increasingly using digitalisation for their business processes and business models.⁴⁸ According to a survey conducted by the Thuringian Ministry for Economic Affairs, Science and Digital Society in 2019, 75% of the surveyed Thuringian stakeholders from industry and science see a high strategic potential in the application of artificial intelligence and learning systems in their companies and institutions.⁴⁹

Across Germany, however, SMEs in particular are still finding it difficult to use digital technologies for themselves and to integrate them into their business processes in conjunction with supplementary investments, including investments in employee training.⁵⁰ Often, the cost-benefit ratio, which is difficult to calculate, still holds many entrepreneurs back from investing in digital solutions. Thuringian SMEs also often lack the expertise and resources to integrate AI methods into their production process and/or even to drive AI-related innovations on their own. Only a few SMEs have the volume of machine-generated data required to make AI and big data work. There is still a considerable need for networking, consulting and qualification to support Thuringian companies in the testing and introduction of AI technologies and the implementation of data science projects.

Dovetailing with the digital and fibre optic strategy of the Free State of Thuringia

Thanks to digitalisation, Thuringia also stands before historic opportunities to connect local SMEs with global markets, the state with its citizens, the urban with the rural, research with application, work with family, the patient or person in need of care with the doctor or caregiver. The innovation strategy, especially the field of specialisation "ICT, innovative and production-related services" (see Chapter 3.5), and the Thuringian Strategy for a Digital Society have been interlinked to create target-oriented impulses for the society as a whole. Taking advantage of these opportunities in all areas of life is a joint task of all players because the interdependencies are manifold and considerable. For example, infrastructural foundations need to be created, the legal framework needs to be adapted and data protection and security need to be guaranteed for facilitating participation in digitalisation. With the Thuringian Strategy for a Digital Society, which was published in 2018 and has since been updated, the state government has set the strategic framework for selected initiatives on digitalisation in important key topics and areas of life.

The aim is to build on the positive developments and to make as many stakeholders as possible aware of the many possible applications of digital solutions in processes, products and services and to provide impetus for further digital transformation in industrial SMEs through additional initiatives and measures. In this context, the Thuringian Strategy for a Digital Society serves as a platform: it supports the implementation of existing and new digital initiatives of the state government, raises awareness for relevant measures and provides impetus for a digital society in Thuringia. As part of the Thuringian Strategy for a Digital Society, the Thuringian Ministry for Economic Affairs, Science and Digital Society supports

⁴⁸ Under "Digital Bonus Thuringia", investment expenditures made by SMEs for acquiring ICT hardware and software, including expenditure for migrating and porting IT systems, are eligible for funding. From the start of the programme until December 31, 2020, a total of 554 digital bonuses have been approved with grants worth EUR 6.63 million and an investment expenditure of around EUR 14.5 million. Of these, about a third were granted to industrial enterprises and a third to the skilled trade sector. Source: the Thuringian Ministry for Economic Affairs, Science and Digital Society, TAB, January 20, 2021.

⁴⁹ Online survey by the Thuringian Ministry for Economic Affairs, Science and Digital Society following the 1st AI Forum on May 24, 2019 to gather opinions on AI in Thuringia. Survey of around 100 Thuringian AI stakeholders from science and business.

⁵⁰ Annual Report 2020/2021 of the German Council of Economic Experts, p. 313, 323 ff.

companies by creating the necessary framework conditions and concrete offers to make digitalisation accessible and tangible for companies in Thuringia. The focus is not only on Industry 4.0, but also on companies from all sectors in the sense of SME 4.0.

The measures anchored in the digital strategy form a comprehensive and modular support offer for Thuringia's SMEs, which they can use depending on the status of their own digitalisation progress (Digital Check, Digital Consulting, the Digital Bonus funding programme, Digital Test Environments and Digital Platforms Competition). The federal ministries also provide a comprehensive portfolio of funding programmes to support industry and science in their digitalisation efforts. The state is in regular contact with the federal government to place Thuringian projects in federal programmes and to work towards creating favourable framework conditions for Thuringian stakeholders.

The following publicly funded, state-level support structures for the business community are worth mentioning: the Thuringian Competence Center Economy 4.0 (awareness-raising and orientation advice for companies), the SME 4.0 Competence Center Ilmenau (demonstration and implementation projects as best practice) and the Thuringian Center for Learning Systems and Robotics (transfer coordination around AI and robotics between universities, non-university research institutions and industry).

Smart regions through a nationwide fibre optic and mobile network

Although demographic change poses major challenges for Thuringia, it also offers opportunities. The opportunities offered by digitalisation can make a significant contribution to securing the future provision of public services in both urban and rural areas and between the two living environments. Digitalisation can also help in remaining competitive in a shrinking population by making production processes more efficient. There is a need to reduce the structural disparities in the sense of equal living conditions between the regions and to prevent them from drifting apart and this can be achieved by a differentiated regional strategy with a vision that enables real smart regions.

The municipalities of tomorrow should remain liveable through smart and flexible transport projects, more collaboration and the use of technologies for self-determined living. Overall, the aim is to create a good network for comfortable living conditions across the board, especially for an ageing society. Learning systems, such as intelligent traffic control, autonomous vehicles, automatically navigating drones and cooperative robots, can also make a major contribution to this. In medical technology, great progress can be expected with the help of AI, especially in the areas of telemedicine and telemonitoring, e-health as well as the miniaturisation and molecularisation in the field of biotechnology.

In terms of their scope, it is important that smart city/ smart region approaches are not obscured by individual, unconnected solutions, but address the wide range of public services and also link the relevant applications together. In addition, municipalities need a concept for handling and linking data and, ideally, an open data policy. Since 2019, "Digitalagentur Thüringen" (Digital agency Thuringia) has been supporting the implementation of

Thuringia's digital strategy in the priority areas of digital infrastructure and digital society.

A high-performance broadband infrastructure is essential for citizens as well as businesses in Thuringia to participate in these developments. This way, profound and comprehensively networked digital applications and processes can be integrated in companies and public institutions, enabling more efficient and productive production processes and workflows. Such fundamental networking within organisations can create impulses for the development of further technological applications, such as a comprehensive integration of AI technologies.

In addition to high download speeds, the networks of the future must also guarantee high upload speeds, absolute connection stability and minimum response times. Future-proof networks must also be open to a wide range of devices and applications. Therefore, the upcoming network expansion is no longer about improving provision through broadband connections or mobile data networks. The primary goal of the fibre optic strategy for the Free State of Thuringia is to create a nationwide fibre optic infrastructure that brings fibre optic lines to buildings (so-called FTTB = fibre-to-the-building expansion) and on which all usage options and usage interests can build.

The expansion of fibre optic networks will also meet the requirements of future 5th generation (5G) mobile networks. This is because we already know that a high-performance fibre optic network will be a prerequisite for future nationwide mobile phone coverage since the upcoming fifth generation of mobile telephony will no longer function purely as a mobile network, but will be designed as a local and situational connection of data transmission paths and will thus be able to meet the requirements of companies much better than before.

5.2. Using industrial change, including decarbonisation, as an opportunity for companies and skilled workers

The Europe-wide conversion of energy systems from fossil to renewable energy sources and the associated energy and mobility transition are increasingly gaining momentum owing to the goal formulated in the European Green Deal of the European Union to achieve greenhouse gas neutrality by 2050. Ambitious climate targets have been adopted at the EU, federal and state levels in recent years. For example, Thuringia's climate act aims to reduce greenhouse gas emissions by 60-70% by 2030 compared to 1990 levels. Achieving the maximum emission reduction is the guiding principle for the state. The amended Federal Climate Protection Act brings forward the greenhouse gas neutrality target to 2045 and increases the reduction target for 2030 to at least 65% compared to 1990. The industry, among others, must achieve additional reductions by 2030. The permissible emission levels for the industry in 2030 are 118 million tonnes of CO₂ equivalents. This represents a reduction of more than a third compared to 2019 (187 million tonnes).

These decarbonisation goals are accompanied by strong pressure on the Thuringian economy to make structural changes. The transition to resource-efficient and circular production using climate-neutral technologies and sustainable products requires the industry to show a high level of willingness to adapt and is associated with high costs and effort. It can succeed only if the energy transition is managed in such a way that energy prices do not jeopardise the competitiveness of the industry and the security of supply is maintained at its current high level. Economic efficiency and security of energy supply will become even more important as the demand for electricity continues to grow due to digitalisation, artificial intelligence and the use of sector coupling technologies.

Discussions about the opportunities and challenges of economic and social transformation must take account of the need to preserve the industrial base from the outset, as many of the consequences of these change processes can only be overcome together with the industry. With its competencies and innovative potential, the industry can make a significant contribution to climate protection. The products manufactured by the industry are a prerequisite for the success of the energy and mobility transition.

Not least due to the economic downturn as a result of the COVID 19 pandemic, it is therefore of central importance to shape the location factors that can be influenced by the industry itself in such a way in the course of the transformation that sustainable value creation chains are fully maintained at the location in terms of both breadth and depth. In order to ensure the competitiveness and crisis resilience of the industry, public funds will be needed to deal with the consequences of these external influences.

Energy-intensive Thuringian companies, i.e., companies where energy costs account for more than 15% of total output or sales revenues, play a special role here. They accounted for 60.7% of energy consumption in 2018 in the entire manufacturing sector (around 65.2 gigajoules). According to the Thuringian State Office for Statistics, the 116 companies (with 20 employees or more) achieved a turnover of around EUR 4.6 billion in 2019 (14.2% of total turnover in the mining and manufacturing sectors) with an export ratio of 38%. Energy-intensive companies are also more capital-intensive than average and are predominantly located in structurally weaker regions. Transformation processes in these companies involve immense costs that the companies can hardly bear on their own in the short term. At the same time, the targeted conversion of processes to sustainable technologies, such as hydrogen and the implementation of a recycling system, offers a particularly high energy saving and energy efficiency

potential in the medium and long term in both energy-intensive and high-emission companies.

In order to meet the challenges posed by climate change, comprehensive efficiency, modernisation and digitalisation measures are required, which will not only create economic opportunities for the Thuringian industry based on its technological expertise, but will also mean that the Thuringian industry can play a significant role in the transformation process towards an economic system with lower greenhouse gas emissions. E-mobility in transport, digitalisation in industry and storage technologies in the power sector are the climate protection technologies, which, according to the Federation of German Industries (BDI), will have great market potential by 2030. Research and industry in Thuringia already have considerable expertise in these areas, which are aimed at resource-efficient, circular and/or low CO₂ economic activity, and this expertise should be jointly developed within the framework of RIS Thuringia and put into practice through concrete projects. Strong cross-field cooperation is of particular relevance because almost every field of specialisation can provide solutions using cross-sectoral technologies, application scenarios and process know-how (see description of the fields of specialisation in Chapters 3.1 to 3.5).

Businesses need to be further supported in implementing the necessary changes, as climate-related R&D efforts, modernisation investments and new business models require a high level of financial capacity on the part of companies, which is often not available to the extent required. Many companies are competing internationally and need to first generate the cash flow that will give them the financial flexibility to compete in the future. Add to this the negative impact of the COVID 19 pandemic.

In addition to the continuation of tried and tested investment and innovation promotion instruments, the state government is working at the state, federal and EU levels to create a suitable political framework to accompany and support companies in the necessary transformation processes and investments in low-CO₂ technologies. This includes, among other things, the development of a functioning hydrogen economy as the basis for more climate-friendly production on an industrial scale. To this end, the Thuringian state government adopted the interdepartmental Thuringian hydrogen strategy on 22 June 2021, which focuses on the entire value creation chain - technologies, production, storage, infrastructure and use, including logistics. The production, distribution and use of hydrogen in Thuringia can make an important contribution to regional value creation. If Thuringia succeeds in becoming a regenerative hydrogen economy, it will create attractive and new economic opportunities for the state and new and highly skilled jobs.

The Thuringian Ministry for Economic Affairs, Science and Digital Society is also committed to comprehensive programmes for supporting investments in sustainable and climate-neutral technologies. In principle, environmental and climate costs should be internalised as external costs in order to address climate-related challenges. This internalisation should ideally take place globally in order to create a level playing field worldwide. The aim is to prevent carbon leakage through measures that are preferably adopted across Europe. Carbon leakage refers to the situation that occurs if, for reasons of costs related to climate policies, companies relocate their production to other countries with laxer emission constraints. This could lead to an increase in their total emissions and would make neither ecological nor economic sense.

Resource efficiency and circular economy

Saving raw materials, materials and energy in the economic sector and consistently closing material cycles to achieve circular value creation can make a significant contribution to the transformation and to achieving the climate protection goals at the EU and national levels. It is estimated that 50% of global greenhouse gas emissions, 90% of biodiversity loss and water scarcity are caused by the extraction and processing of raw materials.⁵¹ By managing resources sustainably and sparingly through their efficient use, companies can improve their competitive position and become more resilient to raw material shortages, such as those caused by disruptions or restrictions in supply chains, and prevent default risks or significant cost increases.

The EU is also striving for a transition to a circular economy, which includes the sustainable and careful use of resources in companies. Due to the lack of internalisation of the environmental impacts and social overheads associated with the extraction of raw materials, the prices of the primary raw materials on offer are regularly lower than those of the recycled materials obtained in a circular economy. As a result, there are not enough incentives for companies to switch to resource-saving and resource-efficient production processes as yet. In addition, customers are only partially willing to bear the additional costs.

Aspects of the circular economy and resource efficiency will also become increasingly important in the development of innovative solutions in the various topics of the fields of specialisation, especially in the field of "sustainable energy supply and resource management" and the specialisation profile described there (see Chapter 3.4). Approaches towards a sustainable and circular economy in the R&D area of the industrial bioeconomy as

⁵¹ Communication from the Commission on "The European Green Deal" of 11 December 2019.

well as resource and material efficiency are in particular: research achievements on novel source materials and processes, the application and linking of new technologies (digitalisation, robotics, AI) as well as a stronger and intelligent use and further processing of renewable raw materials for the development and production of new or alternative (pre-)products. The most important goal in developing new methods and processes is to achieve economic efficiency, as the costs are often higher than for conventional manufacturing methods.

An example for this in Thuringia is the research association sustainable building and resource management, whose core topics include research into alternative building materials, the development of return concepts and recycling processes, and conservation (e.g., of gypsum) through new hybrid building products. The industrial bioeconomy has great potential for, among other things, developing naturally-sourced building, construction and composite materials based on wood, hemp or straw for instance, as well as for developing and evolving bio-based plastics. Due to the natural base and specific material properties, it is advisable to think about approaches for necessary recycling processes as early as during product design.

Within the framework of sustainable water management, there are approaches for R&D work, especially against the background of increasing contamination, e.g., due to microplastics and trace substances, into the design of future purification technologies and into new analysis and measurement systems which, for example, are sensitive to specific pathogens in wastewater. R&D approaches for the targeted and economical use of water in the face of seasonal, albeit temporary, droughts are also of great importance to sustainable water management. The development of new processes in the field of wastewater can

also lead to further possibilities for the use of residual materials and thus to the recovery of source materials in the sense of a material cycle.

Mobility transition in the context of Thuringia's automotive and supplier industry

The automotive and supplier industry in particular, and with it the companies of many other sectors involved in the complex value creation networks, are undergoing a profound structural change. This change is driven by alternative drive technologies (primarily electromobility, but increasingly also hydrogen-based mobility), the digitalisation of vehicles and infrastructure, new vehicle concepts, changing mobility needs and new business models. Conventional drives will also continue to play an important role, but their importance will decline in the long term. On the path to more climate-friendly mobility, the Thuringian Ministry for Economic Affairs, Science and Digital Society advocates a mix of different drive types (classic combustion engines, battery electrics, PHEV as a transition technology, hydrogen) because different applications require different solutions.

The structural change poses major challenges for Thuringia's automotive and supplier industry, which is dominated by small and medium-sized enterprises, especially in the drive/chassis product area, but can offer the industry good opportunities in other product areas. The Sector Dialogue Automotive Industry initiated a goal-oriented dialogue between the stakeholders of the sector, which led to the joint development of the "Automotive Agenda Thüringen" on the basis of an in-depth analysis. Ongoing measures are consistently implemented in the specific fields of action of the agenda. This includes sensitising Thuringian companies towards and informing them about transformation and skills marketing, strengthening cluster structures and promoting cooperation and net-

working. In a position paper⁵² of September 2020, the Thuringian Ministry for Economic Affairs, Science and Digital Society also outlined further approaches to advance the agenda (including the establishment of a cooperation centre Transformation in the automotive sector/automotive supply industry and the adaptation of the Thuringian GRW directive to the needs of the automotive supply industry in transformation).

The current structural change in the industry is characterised by the fact that all the influencing factors in the automotive value creation - market, product and process - are simultaneously undergoing an intensive change process. This has never happened before in such a big way. On the market side, new markets are developing, new competitors are emerging and the demand behaviour is changing due to new mobility patterns. On the product side, new materials, new drives, the networking of vehicles and the evolution from assisted to autonomous vehicles are increasingly shaping automotive development and production. At the interface between product and process, modular and platform strategies are becoming increasingly important. Like in other sectors, the possibilities of digitalisation and Internet use are permanently changing production and business processes.

However, several studies also show that, on balance, a slight increase in employment can be forecast for Thuringia despite the ongoing structural change because product segments such as "car body/exterior", "interior" and "electrics/electronics" will continue to grow. These are also high-potential topics within the framework of the innovation strategy and the main focus points of the field of specialisation "sustainable and smart mobility and logistics".

These developments will lead to a variety of changes in the nature of jobs, which means that skilled workers will need to adapt their qualifications and competencies more in the future. Significant efforts will be needed in the qualification and further training of employees in order to meet the changing demands of tomorrow's professional world. Professional qualification is in the interest of all stakeholders involved because well-trained skilled workers make an important contribution to maintaining the competitiveness of companies, so that competitive, high-quality jobs can continue to be offered in Thuringia in the future.

Mobilising skilled workers

The increasing difficulties in attracting urgently needed skilled workers - and also young people for vocational training - even under the conditions of the COVID 19 pandemic are already having a negative impact on the growth potential in some areas of the Thuringian economy. Since 2015, Thuringia's gross domestic product has already been growing more slowly than the German average.⁵³ Surveys conducted by Thuringia's Chambers of Industry and Commerce show that as of 2015, every second Thuringian company considers shortages of skilled workers to be a risk to further economic development. The existing bottlenecks are one of the reasons for the stagnating catching-up process of Thuringia's economic performance.

The already evident difficulties will intensify in the coming years given the decline in the labour force potential due to demographic trends (expected to decrease by 24.5% or 266,000 people from 1,085,000 in 2018 to 819,000 in 2040⁵⁴). Against this background, meeting the demand for skilled workers remains a key

⁵² Position paper for updating the "Automotive Agenda Thüringen": https://wirtschaft.thueringen.de/fileadmin/user_upload/Grundsatzpapier_zur_Fortschreibung_der_Automotive_Agenda_Thueringen.pdf.

challenge for successful economic development in Thuringia. The Thüringer Allianz für Berufsbildung und Fachkräfteentwicklung (Thuringian Alliance for Vocational Training and Skilled Manpower Development), which was formed in 2016 between the Free State of Thuringia and labour market players from the skilled trades, industry, commerce and the service sector as well as the social and healthcare sectors, will continue to pursue the goal of working together to secure Thuringia's skilled workforce base and thus ensure that the fundamentally good economic conditions in the Free State can be maintained and further expanded.

The transformation of industry through digitalisation, artificial intelligence, energy transition and e-mobility, and the associated profound changes in the nature of jobs and their requirement levels, will continue to be driven forward and accelerated in parallel with the developments already mentioned. For employees this means, among other things, that jobs or parts of jobs will get eliminated and, at the same time new, sometimes highly complex jobs will be created. Basically, the sphere of tasks and jobs of skilled workers will change fundamentally: controlling, supporting and steering tasks will replace original tasks. Entire job profiles are starting to change and need to be rethought, especially in a more cross-technological way.

With changing and increasing demands, further training will therefore become even more important as a tool to help employees develop their competencies on a continuous and lifelong basis. In this regard, there is also a need to interlink education, further training and higher education institutions more closely than before. Partners in the Thüringer Allianz für Berufsbildung und Fachkräfteentwicklung will work together to ensure that the imparting of digital skills and qualifications that meet the needs of the labour market is promoted at all levels of the

education and training system and that lifelong learning, especially in the workplace, is supported accordingly.

At the same time, the decline in the labour force potential makes productivity increases even more urgent. After all, labour-saving technological progress (e.g., through digitalisation) can also be an important tool to counteract the shortage of skilled labour. It is only through innovations and massive investments in new technologies as well as in the qualification and skill building of employees that we can succeed in shaping the irreversible transformation process that has already begun.

5.3. Supporting the growth of Thuringian companies

Important economic core indicators show that there has been positive development in Thuringia over the last 10 years. Thus, the gross domestic product has grown at an above-average rate. In 2019, the GDP was approximately EUR 63,865 million. Compared to 2012, this is an increase of almost 24%. The same applies to wages and salaries. Compared to the previous year, average income in Thuringia increased by around 4% in 2019. As in previous years, the wage gap between eastern and western Germany was reduced, partly because average income in western Germany remained constant.⁵³ Thuringia also had the highest increase in GDP per employed person between 2000 and 2018, after Bavaria, Baden-Württemberg and Brandenburg. The unemployment rate has fallen significantly and is now at par with the German average. Finally, the share of out-commuters (employees who live in Thuringia but work outside the state) has decreased, which speaks for the growing attractiveness of Thuringia as an employment location.

However, positive changes must not obscure the fact that these developments often take place at a level that is still below average. For example, the GDP per employed person

⁵³ Gross domestic product up to 2019 - adjusted for price, chain-linked - by federal state (economic growth), <https://www.statistikportal.de/de/vgrdl/ergebnisse-laenderebene/bruttoinlandsprodukt-bruttowertschoepfung/bip#9535>

⁵⁴ Labour force projection based on the 2nd regionalised population projection of February 2020.

in Thuringia in 2018 was EUR 60,830 compared to the national average of EUR 75,516. In terms of labour productivity (GDP per employed person), which reflects the economic output in relation to the labour input, the free state ranks last in a national comparison. The monthly gross average income in Thuringia for all sectors and company size classes was around EUR 2,780 per full-time employee in June 2019. The monthly gross average income in western Germany, on the other hand, was around EUR 3,340. In 2019, industrial enterprises in Thuringia achieved an average turnover of EUR 217,000 per employee. In contrast, the German average was EUR 319,000 and the average for industrial enterprises in the new states was EUR 272,000. The wage level in the manufacturing sector in Thuringia, measured by average gross annual income, was 76.5% of the national average in 2019.

The reasons for the lag in productivity as well as the wage and salary levels are manifold. One of the key aspects is the small average size of Thuringian companies, especially in the manufacturing sector. Large companies are on average more productive and can therefore also pay higher wages and salaries. In addition to production advantages due to higher unit numbers, larger companies tend to have more activities that require a higher qualification level and are therefore better paid, for example in the areas of management or research and development. A key goal of the state government is therefore to help Thuringian companies grow to an internationally competitive size.

The innovative strength of companies is also significantly influenced by the size of the company. Relevant scientific publications⁵⁵ show that in-house research capacities depend significantly on the company size. In this respect, the Thuringian Ministry for Economic Affairs, Science and Digital Society programmes outlined below, which are aimed at boosting the growth of Thuringian companies,

also help in building the innovative capacity of the Thuringian economy.

Companies receive state support through a coordinated set of funding instruments consisting of grant and loan programmes as well as public equity capital. The most important instrument of investment promotion available to commercial enterprises is the support provided by the joint programme “Improvement of the Regional Economic Structure” (GRW). This is because, between 2012 and 2017, the investment ratio was also consistently below that of the area states in eastern Germany. For 2017, it is evident that the gap between Thuringia and the area states in eastern Germany has widened compared to previous years. Thus, the decline compared to 2016 was greater in Thuringia than in other parts of eastern Germany. Nationwide, there was even a slight increase in the investment ratio between 2016 and 2017. Declining investment slows down the build-up of capital stock and thus also affects productivity growth.

Helping companies establish themselves in international markets continues to be an important aspect of the free state's economic development, which is geared towards the growth of companies. Thuringian companies have increasingly succeeded in benefiting from the dynamics of international markets in recent years. In particular, the positive turnover development of the manufacturing sector in Thuringia has been supported by an above-average development of export turnover for several years (e.g., turnover development in 2019: +0.6%; export development: +3.7%). Compared to 2014, export turnover has increased by 30.4% in 2019. At the same time, manufacturing companies in Thuringia still have structural deficits when it comes to internationalisation. While industrial companies with 50 or more employees earned every second euro abroad in 2019 (50.3%), in Thuringia this figure was only just over every third euro (36%). The structural

⁵⁵ IAB Establishment Panel, State Report for Thuringia (Länderbericht Thüringen), TMASGFF 2019.

⁵⁶ See for example Lee, CY and Sung, T. (2005), “Schumpeter's legacy: A new perspective on the relationship between firm size and R&D”, Research Policy, Vol. 34, Issue 6, pp. 914–931.

deficits become even more apparent when one compares the export orientation of SMEs.

Experience shows that SMEs in particular often have structural deficits in their management capacities. These companies often lack internal know-how and capacities to sustainably develop international market potential. The offers of Thuringia International aim to address these structural deficits.

Innovative start-ups and business succession

In addition to strengthening existing Thuringian companies, new start-ups and their business successions are indispensable for securing Thuringia's position as a business location in the long term. High-tech start-ups are particularly important for technological progress and for increasing the attractiveness and appeal of a location for highly skilled people and other innovative companies. Here, too, Thuringia lags behind the German average. Similarly, the start-up intensity in the high-tech sector has declined since 2011. In contrast, the slight increase between 2017 (1.04 start-ups per 10,000 employable persons) and 2018 (1.1) is a positive development that sets Thuringia apart from the development in the other eastern German states and Germany as a whole. Nevertheless, Thuringia is still in third last place when compared with other federal states. Only Mecklenburg-Western Pomerania and Saxony-Anhalt had an even lower start-up intensity in the high-tech sector than Thuringia in 2018. The recent positive development must be supported in the coming years in order to further reduce the gap.

The special feature of Thuringia's start-up landscape is the quality and not the quantity of start-ups. Thus, in Thuringia, start-ups with greater economic substance (i.e., especially corporations, partnerships and busi-

nesses that already employ staff when they are founded) account for a high and - compared to the rest of Germany - above-average share. It is precisely such start-ups that create sustainable jobs and are particularly important for the free state. The free state also has an above-average number of cutting-edge and high-tech start-ups, which is reflected by its 6th place in the national comparison of patents per 100,000 inhabitants.

Nevertheless, the free state faces specific challenges. On the one hand, according to an analysis by the Institute for SME Research Bonn (2018), there are around 620 transfer-worthy company successions per year in Thuringia⁵⁷, while the total number of pending company successions is estimated to be two to three times higher. On the other hand, the number of new businesses in Thuringia has decreased by 40.84% between 2009 and 2019. There are many reasons for this. Firstly, the persistently good economic situation up to the COVID 19 pandemic and the associated strong economic growth, combined with a high demand for skilled workers subject to social insurance contributions and the resulting falling unemployment rate, led to a decline in the number of start-ups. Secondly, demographic change in Thuringia is also having a negative impact on the number of start-ups.

According to the projections of the Thüringer Landesamt für Statistik (2020), the population in the 25 to 45 age group is expected to decline by approximately 85,000 persons by 2030 compared to the base year 2018. This reduces the number of people interested in starting a business by 17.43% in this age group, which has a particular affinity for start-ups and accounts for 62.7% of all start-ups according to the KfW Entrepreneurship Monitor 2020. At the same time, the Thuringian economy will need 344.000 skilled workers by 2030 (replacement and

expansion needs), so that the opportunity costs of starting a business will continue to rise compared to employment subject to social insurance contributions (despite the current below-average gross wages). Ultimately, the fear of failure, which is much greater than in other states, the lack of financial resources and therefore difficulties in obtaining start-up financing and the lack of security in the start-up phase make it more difficult for Thuringians to step into self-employment.

The development and qualification of new generations of entrepreneurs will therefore continue to require support services that motivate them to start a business and ensure its performance. This is why start-up support services must be available even if the number of start-ups declines. The European Structural Funds and synergies will be used for this purpose in the future as well.

⁵⁷ Only enterprises with an annual profit of at least EUR 58,400 (as a threshold for transfer worthiness from the point of view of successors) were considered.

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