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CONTEXT: ECONOMIC PROFILE OF NORTH RHINE-WESTPHALIA

The state of North Rhine-Westphalia is located in Western Germany and shares borders with Belgium and the Netherlands, allowing the state to trade with its western neighbours, who are the main trading partners for imports and exports of the state. The state's population of 18.1 millionⁱ as of September 2023, accounts for 21% of Germany's total population of 84 millionⁱⁱ, positioning it as the most populous state within the nation and inhabits the largest labour force in Germany with a workforce of 9.7 millionⁱⁱⁱ. The state can be further divided into five administrative districts at the NUTS2 level, namely Düsseldorf (DEA1), Cologne (DEA2), Münster (DEA3), Detmold (DEA4) and Arnsberg (DEA5).

MACROECONOMIC PROFILE OF NORTH RHINE-WESTPHALIA

As of 2021, the region's economy boasted a per-capita GDP of €37,100, which placed the country above the EU average of €32,400 but below the German average of €39,000.^{iv} It accumulated in 2021 a GDP of roughly €729 billion, which accounts for roughly 20% of the German GDP (€3.617 billion).^v During the years 2011-2021, the average economic growth was around 2.5%. Overall, North Rhine-Westphalia's sustained economic growth over the years is a testament to its resilience and adaptability in the face of global challenges.

The state exported €233 billion in 2022, making it the second-largest exporter in Germany while the imports were €314 billion^{vi}, making it the largest German importer. The neighbouring countries of Netherlands and Belgium were among the top 3 trading partners in 2023.^{vii}

NORTH RHINE-WESTPHALIA SECTOR SPECIALISATIONS AND EMPLOYMENT LEVELS

The state's economic landscape is characterized by its diverse industry composition. According to Eurostat data^{viii}, North Rhine-Westphalia features a noteworthy employment structure, with the highest share of its workforce employed in the services sector, accounting for 39.8% of employment. This is slightly higher than the national level in Germany, which stands at 38.8%, and is in line with the EU-27 average of 40.63%. In contrast, the industrial sector (excluding construction) plays a substantial role in North Rhine-Westphalia's economy, with 19.3% of the workforce engaged in this sector. The construction sector in North Rhine-Westphalia employs 5.7% of the workforce. Furthermore, the public administration sector plays a significant role in North Rhine-Westphalia, employing 34.4% of the workforce.

As part of its Industrial Strategy (March 2020), the European Commission has selected 14 industrial ecosystems that are particularly relevant in Europe and encompass all players operating in a value chain. The retail ecosystem comprises the largest employment share across all ecosystems in North Rhine-Westphalia, with 17.9%. The relative importance of this ecosystem is shown by its higher share compared to the EU-27 (16.2%) and national average (15.3%). This is followed by the health ecosystem at 16.0% across all ecosystems (compared to 13.3% at the EU-27 level and 15.8% at the national level) and Proximity, Social Economy, and Civil Security at 13.5%. Other ecosystems that demonstrate a higher concentration of employment compared to the EU-27 average include Energy Intensive Industries, Digital, Aerospace & Defence, Electronics, and Energy – Renewables.

To analyse specialisation in North Rhine-Westphalia, this paper examines the country's regionally relevant sectoral and ecosystem nodes. There is a total of six regionally relevant sectoral nodes. Four of the six nodes are in sectors pertaining to manufacture. The specialisation in those sectors indicates that NRW has a distinct advantage and competency in manufacturing-related activities. The analysis also shows that North Rhine-Westphalia possesses a diversified ecosystem landscape.

REGIONAL INNOVATION PERFORMANCE OF NORTH RHINE-WESTPHALIA

To provide a comprehensive overview of North Rhine-Westphalia's innovation landscape and assess its level of innovativeness, data from the Regional Innovation Scoreboard (RIS) is analysed. The RIS framework is structured into the following four categories "Framework Conditions", "Investments", "Innovation Activities" and "Impacts".

With three out of five sub-regions (Düsseldorf, Detmold, Arnsberg) being classified as "Strong Innovator", one sub-region (Münster) being classified as "Moderate Innovator" and one sub-region (Cologne) being classified as "Innovation Leader", North Rhine-Westphalia can overall be classified as a "Strong Innovator".^{ix} Relative to the EU-27 average, the State of North Rhine-Westphalia demonstrates relatively high scores in the innovators "product innovators", "business process innovators", as well as "employment innovative enterprises", underscoring its strengths in institutional setup and R&D landscape. The state also exhibits high levels of "international scientific co-publication" and "public-private co-publications", highlighting active participation in international research collaborations.^x

Given the availability of the RIS at the NUTS2 level, it allows shedding light onto the innovation performance of the different regions of North Rhine-Westphalia and examining for disparities

across regions. The administrative district of Cologne emerges as the strongest innovator within the region and is ranked as an “Innovation Leader”. Düsseldorf, Detmold, and Arnsberg, on the other hand, are classified as “Strong Innovators”, while Münster is the only region classified as a “Moderate Innovator”. The administrative districts exhibit a favourable positioning. Nevertheless, regional disparities persist, notably concerning research and development expenditures in the public sector, the number of international scientific publications, and collaborative innovation indicators, where the district of Cologne exhibits high scores relative to the other districts.^{xi}

REGIONAL COMPETITIVENESS LEVEL OF NORTH RHINE-WESTPHALIA

The regional competitiveness of North Rhine-Westphalia is examined based on the Regional Competitiveness Index, which measures key aspects of competitiveness among regions across the EU in three dimensions: the Basic Sub-Index, the Efficiency Sub-Index, and the Innovation Sub-Index. It is worth noting that, akin to the Regional Innovation Scoreboard, the Regional Competitiveness Index is computed exclusively at the NUTS2 regional level. Therefore, there isn't an overarching index value for North Rhine-Westphalia. Instead, the values are scrutinized within the five administrative districts.^{xii}

The overall regional competitiveness score of the five NUTS2 regions in North Rhine-Westphalia spans a range from 111.2 to 128.6 relative to the EU average, signalling that all regions outperform the EU average and can be classified as more developed regions. Notably, the regions of Cologne and Düsseldorf stand out with index values of 128.3 and 128.6, respectively, thus being ranked 17 and 16 in the EU, respectively.^{xiii}

CLUSTERS IN NORTH RHINE-WESTPHALIA AND THEIR IMPORTANCE FOR REGIONAL ECONOMIC DEVELOPMENT

This chapter provides an overview of the cluster landscape in North Rhine-Westphalia and the policy framework under which cluster organisations are operating in the region.

CLUSTER ORGANISATIONS IN NORTH RHINE-WESTPHALIA

The European Cluster Collaboration Platform serves as a one-stop-shop for cluster organisations at the European level. Out of the total 1,149 registered EU-27 cluster organisations on the ECCP, there are 115 cluster organisations from Germany as a whole and 10 cluster organisations from North Rhine-Westphalia. Looking at their geographical distribution within North Rhine-Westphalia, the Ruhr area shows the highest concentration of

cluster organisations (4), followed by Aachen and East Westphalia (Ostwestfalen-Lippe) with 3 each.^{xiv}

There are two national-level cluster programmes supporting flagship clusters throughout Germany. One of these programmes is the Spitzencluster programme, established by the Federal Ministry of Economy and Climate, with two Spitzencluster in North Rhine-Westphalia. SPIN (Spitzencluster for Industrial Innovation) concentrates on developing technologies, processes, and products for CO₂-neutral industrial and energy systems, using insights from the energy sector, energy-intensive industry, and science.^{xv} The second Spitzencluster, it's OWL, is a technological network located in the eastern area of North Rhine-Westphalia. It links businesses, research institutions and organisations to devise solutions for SMEs' digital and ecological transformation.^{xvi}

There are also two Future Clusters in North Rhine-Westphalia, and a second flagship cluster programme at the national level, administered by the Federal Ministry of Education and Research. NeuroSys, headquartered in Aachen, aims to create innovative hardware for artificial intelligence (AI) applications and position the Aachen region as a leading global player in this field. The initiative leverages the foremost research institutions of RWTH Aachen University, the Research Centre Jülich, and the NRW State Institute AMO (Institute for Nanotechnology).^{xvii} The second comprises the Zukunftscluster Wasserstoff (Hydrogen), whose aim is to consolidate existing expertise in hydrogen technology from diverse stakeholders in and around Aachen, to develop solutions for the complete hydrogen lifecycle – from production to storage, distribution, and utilization.^{xviii}

Additionally, at the regional level, cluster networking is executed via the competence centre NRW.innovativ. An interactive map provided by NRW.innovativ offers further insights into the innovation ecosystem overall, including 60 cluster organisations, 5 digital hubs, 67 research institutes, and 71 higher education institutions at the regional and sub-regional level.^{xix}

Of the 60 cluster organisations, 26 operate on a state-level. Most of them are located in the state capital Düsseldorf (7), followed by Cologne and Bochum (2 each). The other state-level organisations are mostly concentrated in the central to southern part of North Rhine-Westphalia, with different cities hosting one organisation each. On the other hand, most of the 34 regional-level organisations are in Aachen (6), followed by Düsseldorf and Essen (2 each). They are less concentrated in the central and southern part, but more evenly distributed in

cities throughout North Rhine-Westphalia.^{xx} The state clusters can be linked to the seven innovation fields outlined in North Rhine-Westphalia's Regional Innovation Strategy^{xxi}:

1. Innovative materials and intelligent production (10 cluster organisations)
2. Networked mobility and logistics (6 cluster organisations)
3. Environmental and circular economy (4 cluster organisations)
4. Energy and innovative construction (3 cluster organisations)
5. Innovative medicine, health, and life science (3 cluster organisations)
6. Culture, media and creative industries and innovative services (1 cluster organisation)
7. Key technologies of the future, ICT (16 cluster organisations)

The cluster organisations in North Rhine-Westphalia can be related to ten out of 14 EU industrial ecosystems^{xxii}. The most prevalent industrial ecosystem is Digital with 13 cluster organisations, followed by Energy Intensive Industries with eight cluster organisations. The cluster landscape in NRW presents significant potential for the "twin transition".^{xxiii} With 13 clusters included in the digital industrial ecosystem. The green transition is also very prominent in the cluster ecosystem. In particular, the competence network Green Economy.NRW acts as a hub for decarbonisation and environmental protection across sectors and ecosystems.

Furthermore, North Rhine-Westphalian cluster organisations registered on the ECCP have significantly higher numbers of staff than average. Two golden and four silver Cluster Excellence Labels have been awarded to ECCP registered cluster organisations in North Rhine-Westphalia. The Cluster Panorama NRW 2022 indicates that from 2012 to 2022, a total of 23 Cluster Excellence Labels were awarded to all clusters throughout the state.^{xxiv}

THE IMPORTANCE OF CLUSTERS FOR REGIONAL ECONOMIC COMPETITIVENESS

The European Cluster Panorama Report (2021) examines the relationship between clusters and regional competitiveness. The stand-out findings of this report showcase how the presence of cluster organisations is positively correlated with economic indicators such as GDP per capita, labour productivity, as well as business R&D expenditure. While public R&D expenditure is merely positively correlated with industry-relevant nodes^{xxv}, it does indicate how regions could earn greater public support, when certain industries have a local significance. The industries in North Rhine-Westphalia form an average number of regionally relevant sectoral specialisation nodes and an average number of cluster organisations, in comparison to other European regions. The ECCP is considering a region is specialised in the sector if the

employment share of that sector is relevant for the region (regional employment share > 1%).^{xxvi}

In addition to the enabling and facilitating effect of clusters on economic performance and growth, other studies have provided additional information on the impact clusters can have. Ketels & Protsiv delineate how “cluster strength” has a unique impact on “wages and prosperity”.^{xxvii}

POLICIES AND PROGRAMMES SUPPORTING CLUSTER DEVELOPMENT

On the national level, the two main cluster policy programs in Germany are the “go-cluster programme” and the “Zukunftscluster-Initiative” (Clusters4Future). Go-cluster focuses on cluster excellence and supports cluster management organisations in further developing their innovation clusters through consultation, networking, labelling and project funding.^{xxviii} “Zukunftscluster-Initiative”, has a specific focus on German regions with strong research activities and aims to develop regional innovation networks based on outstanding foundational research that later become “Future Clusters”.^{xxix}

On the regional and local level, cluster policies are well-established in North Rhine-Westphalia. In the past, cluster support was already part of the “Ziel-2 Programm” from 2000 to 2006 and from 2007 to 2013.^{xxx} Currently, the main policy instrument that builds the policy framework for cluster support in NRW is the S3 strategy (“Regionale Innovationsstrategie 2021-2027”), successor to the previous version “Regionale Innovationsstrategie 2014-2020”, which highlights the importance of technology transfers from the public sector (universities, research institutes) to the private sector (especially SMEs).^{xxxi}

In terms of evaluation, one can refer to the annual innovation report, the “Innovationsbericht Nordrhein-Westfalen”^{xxxii}. The 2022 edition of this report shows that there are many well-functioning clusters in North Rhine-Westphalia for many different industries that work on a broad basis of businesses and institutes, but also highlights areas for improvement, particularly in terms of enhancing ecosystem coordination and cost-effectiveness. Additionally, a 2020 evaluation study of the cluster “NanoMicroMaterialsPhotonics.NRW” conducted by Hansmeier and Stahlecker from the Fraunhofer Institute ISI found that the cluster has been successful in the continuation of its work since 2015 and “contributes directly to the technology, innovation, and economic policy agenda of North Rhine-Westphalia.”^{xxxiii}

CROSS-BORDER COOPERATION AND THE INVOLVEMENT OF NORTH RHINE-WESTPHALIAN CLUSTERS IN EUROPEAN NETWORKS AND SUPPORT INITIATIVES

Findings from the Evaluation Study of and Potential Follow-Up to Cluster Initiatives under COSME, H2020 and FPI of the European Commission (2021) show that cross-border cooperation is perceived by innovation stakeholders as a highly relevant activity for clusters to support sustainable growth and resilience-building of their SME members.^{xxxiv}

INVOLVEMENT OF NORTH RHINE-WESTPHALIAN CLUSTER ORGANISATIONS IN THE EUROPEAN STRATEGIC CLUSTER PARTNERSHIPS (ESCP)

The ESCP initiative established partnerships of European clusters and intermediary organisations from the different EU Member States or associated countries. Those partnerships focused on three different thematic areas, which were internationalisation (ESCP for Going International), cluster excellence (ESCP for Excellence) and smart specialisation (ESCP for Smart Specialisation).^{xxxv} Only one cluster organisation from North Rhine-Westphalia, namely Food-Processing Initiative e.V., participated in the ESCP initiatives.

INVOLVEMENT OF NORTH RHINE-WESTPHALIAN CLUSTER ORGANISATIONS IN THE INNOSUP-1 INITIATIVE

Apart from the ESCPs, the INNOSUP-1 initiative focused on developing new cross-sectoral industrial value chains in the EU. "Clusters facilitated projects for new value chains" funded under the EU programme Horizon 2020 was a relevant EU support initiative that addressed the challenge to develop new cross-sectoral industrial value chains through European cooperation of cluster organisations and other relevant intermediaries.^{xxxvi}

The INNOSUP-1 initiative aimed at boosting the cross-sectoral and cross-border cooperation in consortia of European cluster organisations and other relevant innovation intermediaries.^{xxxvii} The same cluster organisation that participated in the ESCP initiatives, namely Food Processing Initiative e.V., participated in the INNOSUP-1 initiative under the project Value-added Innovation in Food Chains (VIDA).

INVOLVEMENT OF NORTH RHINE-WESTPHALIAN CLUSTER ORGANISATIONS IN INTERREG PROJECTS

Another important programme of interregional cooperation is INTERREG. It is the EU's flagship scheme for cooperation across borders and assists local, regional, and national governments in policymaking for regional development issues.^{xxxviii}

Several North Rhine-Westphalian clusters have been participating in different editions of the INTERREG programme. The FPI – Food Processing Initiative e.V. was part of the project FOOD2020, which was split in two phases: phase I ran from July 2015 to December 2018 while phase II ran from July 2018 to June 2022. Phase II had a budget of €4.5 million and a total of 8 partner organisations from Germany and the Netherlands.^{xxxix}

A project of the current 2021-2027 INTERREG VI programme is the Realise-Bio project, led by the North Rhine-Westphalian cluster organisation CLIB, which is focused on biotechnology and circular economy. The project started in 2023 as a successor to the Circular-Bio project and will run until 2025 with a budget of €3.4 million.^{xi}

Another 2021-2027 INTERREG VI project under North Rhine-Westphalian leadership is H2-Enabler. NMWP Management GmbH, who manages the cluster organisation NMWP.NRW (NanoMicroMaterialsPhotonic.NRW), acts as the lead partner for the German-Dutch project which focuses on hydrogen and fuel cells for converting hydrogen into electrical energy.^{xii}

INVOLVEMENT OF NORTH RHINE-WESTPHALIAN CLUSTER ORGANISATIONS IN I3 PROJECTS

The Interregional Innovation Investments (I3 partnerships) is a funding instrument under the European Regional Development Fund (ERDF) 2021-2027 programming period that provides advisory and financial support through the European Innovation Council and SMEs Executive Agency (EISMEA).^{xliii} HIGHFIVE (enHancing digital and Green growth in the Food processing industry via Interregional innoVation invEstments), one of the projects supported by the I3 instrument, includes two actors from North Rhine-Westphalia: FPI – Food Processing Initiative e.V. and rbk group. HIGHFIVE aims to foster, enable, and facilitate SME targeted and interregional investment actions to implement or bring to the market innovative digital solutions to concrete challenges of the food processing companies and thus contributing to the Farm-to-Fork strategy.^{xliiii} The two thematic priorities are sensors to monitor real time critical control parameters, as well as sensor integration and implementation.

SMART SPECIALISATION STRATEGIES IN NORTH RHINE-WESTPHALIA

Cluster organisations play an important role in the design and implementation of Smart Specialisation Strategies (S3) since in both concepts, the facilitation of economic growth and competitiveness through regional proximity, are key elements.^{xliv}

REGIONAL INNOVATION STRATEGY OF NORTH RHINE-WESTPHALIA

A key starting point for the analysis of Smart Specialisation in North Rhine-Westphalia is the Regional Innovation Strategy 2021-2027 of North Rhine-Westphalia, which was published in 2021.^{xlv} Cluster organisations and similar networks played a central role in the development of the Regional Innovation Strategy 2021-2027 of North Rhine-Westphalia. In addition, cluster organisations are actively included in the Entrepreneurial Discovery Process (EDP) to monitor the progress of the strategy and to make adaptations if necessary. This process is orchestrated by the meta-cluster organisation NRW.innovativ.^{xlvi}

The Regional Innovation Strategy 2021-2027 of North Rhine-Westphalia identifies seven priority areas: “Innovative materials & Intelligent production”, “Networked mobility & Logistics”, “Environmental economy & Circular economy”, “Energy & Innovative construction”, “Innovative medicine, health & Life science”, “Culture, media and creative industries & Innovative services” and “Future key technologies & ICT”.^{xlvii}

SMART SPECIALISATION ON THE REGIONAL AND LOCAL LEVEL

The Rhine-Ruhr region is characterised by energy-intensive industry, and further by the large consumption of raw materials. On the regional level, the S3 strategy of the metropolitan area Ruhr gives insight on how the state’s priority subjects are reflected on the local level to steer the economic development of the Ruhr area.^{xlviii} The Ruhr region identified six areas in which to focus their strategy: “Green Technology, Hydrogen & Circular Economy”, “Urban Transformation & Smart City”, “New Industry”, “IT Services – Cybersecurity & AI”, “Intelligent Logistics” and “Health Economy”. Except for the sector “Health Economy”, the City of Duisburg is listed as a pioneer in all the focus areas of the metropolitan area Ruhr.^{xlix}

The City of Duisburg is located in the western part of the Ruhr area and plays a central role in the state’s economy. The city is the third-largest city in the Ruhr area with 506.809 inhabitants. It accounts for roughly 10% of the workforce in the Ruhr area with 179,307 employees¹ (1,780,000 in total)^{li}. Besides the “Economic Compass”, Duisburg is driving the smart

specialisation of its industrial base towards a climate-neutral industry using green hydrogen and circular economy. The unique geographical location of the city, with direct logistical connections to the major European seaports in the Netherlands and Belgium via the river Rhine, made Duisburg the home of Europe's largest steel works and the largest hinterland harbour in the world^{lii}. Therefore, the logistics sector and steel production are the most important employment sectors for Duisburg, which face the pressure of decarbonisation.^{liii}

According to the strengths and industrial character of Duisburg, the city has successfully implemented four of the seven priority areas of the North Rhine-Westphalian Regional Innovation Strategy in its own strategy, the "Economic Compass" ("Wirtschaftskompass")^{liv}. The "Economic Compass" was adopted by the City Council in 2021 and is the guiding instrument for the city's economic development efforts^{lv}. It identifies four areas of specialisation for the city: "Smart Logistics", "Green Industry", "Smart Engineering" and "Urban Transition". The "Smart Logistics" specialisation includes the development of alternative propulsion and energy sources leading to an emission-free logistics process, in line with the "Networked Mobility & Logistics" priority area.^{lvi}

The specialisation "Green Industry" focuses on green hydrogen and the use of hydrogen in the production process, which corresponds not only to the priority areas "Innovative Materials & Intelligent Production" and "Environmental Economy & Circular Economy". The "Smart Engineering" specialisation includes the promotion of automated production and artificial intelligence, which corresponds to the "Future Key Technologies & ICT" priority area. Finally, the specialisation area "Urban Transition" focuses on sustainable construction and the promotion of a smart city, which corresponds to the priority area "Energy & Innovative Construction".^{lvii}

The city has the best prerequisites for becoming the leading example in Europe for the successful transformation of a traditional industrial city into a sustainable, circular economy. Utilising a bottom-up approach, the business development agency of the City of Duisburg (DBI) has initialised two networks with local companies, that act as support and exchange platforms to facilitate and subject- and project-based discourse between its member companies.

The Hy.Region.Rhein.Ruhr e.V. is leveraging the potential of Duisburg by focusing on accelerating the market launch of hydrogen and fuel cell technologies and hydrogen-based industrial processes, and thus realising an industry fuelled by green hydrogen. Currently, the

association has 48 paying member companies, active along the hydrogen value chain in the Rhine-Ruhr region and is offering a portfolio of event formats ranging from dialogue formats with policy and decision makers on the state and national level to multi-day conference formats^{lviii}. Always with the goal of creating the framework to turn the Rhine-Ruhr region into a model region for the hydrogen economy.^{lix}

Following the model of Hy.Region.Rhein.Ruhr e.V., DBI has initialised a new association in cooperation with the “Wirtschaftsbetriebe Duisburg” – the municipal waste management company – in September 2023 with the goal of the promoting the application of the circular economy principles in the Rhine-Ruhr region. Circular Rhein.Ruhr^{lx} will develop an exchange and support platform for the circular economy in the Rhine-Ruhr region to provide a knowledge base for local companies that can profit from the transition to circular value creation. DBI has conducted a survey with local companies to assess the economic sectors with the most transformation potential for the application of circular business models. The focus sectors are metals, logistics, and construction.^{lxi}

COMPETENCIES AND INVOLVEMENT OF NRW CLUSTER ORGANISATIONS IN SMART SPECIALISATION

In the following, insights from an online survey conducted by NRW.innovativ with cluster organisations in North Rhine-Westphalia regarding their perception of the S3 priority areas are shown. The results of this survey show that the priority areas coincide with the thematic orientations of the cluster organisation in North Rhine-Westphalia. Depending on the priority area, cluster organisations in North Rhine-Westphalia allocate their competences to a certain innovation field to a greater or lesser extent. Most cluster organisations in North Rhine-Westphalia state that they have very good competences in the innovation field “Innovative Materials & Intelligent Production” followed by “Environmental & Circular Economy” and “Connected Mobility & Logistics”. The results of the survey further show that all priority will be of increasing or constant importance in the coming years. Moreover, it is shown that the cluster organisations are especially expecting an increasing relevance of topics related to the Green and Digital Transition.^{lxii}

CONCLUSION

This paper examined specialisation and cluster organisation in North Rhine-Westphalia. It was found that the state has a well-developed cluster structure to support the acceleration of the twin green and digital transformations. The green transformation is very prominent in the

cluster ecosystem. In particular, the competence network Green Economy.NRW acts as a hub for decarbonisation and environmental protection across sectors and ecosystems. The state also offers a comprehensive support environment for cluster organisations. At the state level, there are the top cluster programmes "SPIN" and "it's OWL" as well as the future cluster initiatives "NeuroSys" and "Future Cluster Hydrogen". There are also the "go-cluster" programme and the "Zukunftscluster" (Clusters4Future) initiative. At regional level, cluster networking in North Rhine-Westphalia is carried out by the NRW.innovativ competence centre. Further support for cluster organisations is also provided in the state's innovation strategy, as well as at sub-regional and local level (e.g., the S3 strategy of the Business Metropolis Ruhr and the "Economic Compass" of the City of Duisburg). The smart specialisation is pursued in Duisburg via the subject-orientated and issues-based associations Hy.Regions.Rhein.Ruhr e.V. and Circular Rhein.Ruhr, which provide new impulses for the transformation of Duisburg into a sustainable, circular industrial city. In summary, this paper has demonstrated that, the state of North Rhine-Westphalia is home to a highly developed landscape of cluster organisations, supported by a long-standing cluster development policy both on the national, state, and local level, which provides the right basis for accelerating the green and digital twin transformation.

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