Management Summary

The effects of digital transformation on entire national economies are now well documented. The Draghi Report demonstrates that the strong productivity growth recorded in the United States in recent years has been driven to a significant degree by American tech corporations and their innovative capacity. Without these firms, productivity growth would have developed similarly to that observed in Germany (Draghi 2024). The backbone of this digital transformation is data centres. While the average data volume per broadband connection amounted to 26.6 gigabytes per month ten years ago, it currently stands at 321 gigabytes—roughly twelve times as much (DIALOG CONSULT / VATM 2023). This rapid growth is also attributable to the fact that almost half of all companies in Germany now use data centres; two years ago, this share was only 37.5 per cent. Access to data centres and thus to cloud infrastructures will enable German businesses to generate additional value creation of at least EUR 250 billion by 2030 (IW Consult 2024c).

Nearly all large German enterprises make use of data centres—and hence cloud services—to scale processes and foster innovation through data analytics. Some 5.9 million employees in Germany work in companies whose business model would not be feasible without cloud infrastructure. As a result, firms using data centres exhibit significantly higher levels of innovation and productivity than non-digital companies. In 2023, data-centre users generated approximately 18 per cent of their turnover with new products or services that had not previously existed, whereas among companies without data-centre infrastructure this share was only around 8 per cent (IW Consult 2024c; DIALOG CONSULT / VATM 2023). Without cloud services, the innovative capacity of German enterprises would be substantially below current levels.

Artificial intelligence (AI) will amplify these effects further. Widespread adoption of AI could increase value creation in Germany by EUR 330 billion by 2035 (IW Consult 2023a). This, in turn, leads to high demand for additional data-centre space and to new requirements regarding site selection. Energy demand is expected to rise significantly in the years ahead, and the utilisation of waste heat from data centres is already enshrined in the Energy Efficiency Act (EnEfG).

The current draft coalition agreement of the expected CDU-SPD federal government proposes strengthening Germany as a leading European location for data centres by supporting clusters and both regional and decentralised development. It also seeks to facilitate the use of waste heat in district heating networks.

While data centres are essential for safeguarding the competitiveness of German businesses and national prosperity, the question of their direct local and regional economic relevance is debated. Data-centre sites are often linked to expectations of attracting further companies seeking proximity to such facilities—leading to potential spillover effects, for example through the settlement of digital-affine businesses and start-ups. At the same time, concerns are raised regarding comparatively high land use per employee, high energy consumption, possible land-use competition, and the often limited architectural appeal of data-centre buildings.

Frankfurt am Main stands out as Germany’s most significant data-centre cluster. As of October 2024, the city hosts 55 data-centre sites—around 30 per cent of all German data centres (DCM 2024). In the FrankfurtRheinMain metropolitan region (hereafter FRM), new data-centre developments have accelerated in recent years. By 2030, a further 25 sites are expected to be added in the Frankfurt area alone. These data centres not only serve the local economy but play a key infrastructural role for all of Germany and international markets. As Germany faces the challenge of mastering digital transformation, these facilities are becoming a critical enabler for the development of digital products, processes and business models.

At the same time, Frankfurt's 2021–2026 coalition agreement places strict limits on new data-centre developments. New data centres are to be permitted primarily within pre-defined clusters, while commercial and industrial zones within the city are largely closed to further projects. Local energy providers Mainova and Syna note that, due to grid constraints, no new data centres with a capacity exceeding 10 MW can be connected before 2030. Already today, up to 30 per cent of Frankfurt's available peak electricity load is consumed by data centres.

Research Questions

Against this background—data centres as drivers of digital transformation in Hesse and Germany, yet with ambivalent local impacts—this study investigates the spatial and regional-economic implications of data-centre development in the Hessian part of the FRM region. The following spatially relevant questions guide the analysis:

1. What is the economic significance of the data-centre industry in FRM?
2. How important is proximity to data centres for businesses?
3. Do cities and regions benefit economically from hosting data centres?
4. To what extent do answers differ between Frankfurt and other FRM sub-regions?

Methods

A broad methodological framework was applied to capture the complexity of the research questions and the limited availability of structured data:

- Literature analysis
- 20 expert interviews with data-centre operators, users and consultants
- Company survey in the Hessian part of the FrankfurtRheinMain metropolitan region (n = 320)
- Analyses within the framework of national accounts to determine the economic impact of data centres
- Analyses of secondary statistics, particularly regarding the strengths and weaknesses of the FRM location compared with other metropolitan regions
- Data analyses of industrial land purchase prices for data-centre use in Frankfurt am Main

The present study adopts a broad interpretation of the guiding research question. Accordingly, it examines how a regional innovation ecosystem in FRM—of which data centres constitute one component—is embedded and functions. Innovation ecosystems are characterised by the interlinking of diverse actors at the levels of businesses, research institutions and regional stakeholders. These interconnections generate knowledge spillover effects, which enhance the overall effectiveness of the innovation ecosystem compared with unconnected, individual elements (IW Consult 2024d; Expert Commission for Research and Innovation 2025).

The analytical focus on the actors and framework conditions of a digital innovation ecosystem is based on the concept of related variety, applied in line with the subject of this study. The high concentration of data centres and their geographic proximity to DE-CIX, the world's largest internet exchange, have given rise to a distinctive competence profile in digital technologies. In the context of related variety, different yet related industries within a region draw on similar knowledge bases, skills and technologies. This diversity likewise promotes knowledge spillovers and enables companies to learn from existing technologies and adapt them, thereby increasing their innovative capacity. Studies show that regions with a high degree of related variety tend to exhibit higher innovation rates, as the proximity of industries facilitates collaboration and the exchange of knowledge and technologies, while also opening up opportunities for exploration at technological frontiers—leading to new business models. Regions that rely on related variety are therefore better positioned to achieve technological breakthroughs and secure long-term growth (Broekel et al. 2017). Conversely, low related variety—the co-existence of industries without a shared knowledge or technological base—can hamper productivity (Aarstad et al. 2016).

In this study, the strengths and weaknesses of FRM as a digital location are assessed, and the interrelationships between local data centres and the elements of a regional digital innovation ecosystem are analysed.

Economic Significance of the Data-Centre Sector in FRM

The economic significance of the data-centre industry for FRM is defined in this study as the economic impact in terms of direct, indirect and induced value-added and employment effects, as well as spillover effects—that is, external effects arising, for example, from the establishment of a digital innovation ecosystem. In such an ecosystem, firms in related sectors both cooperate and compete, generating knowledge transfers between companies, start-ups, universities and research institutions. These pull factors attract additional digital businesses that likewise seek to benefit from spatial proximity.

To address the guiding research questions, the data-centre industry in FRM was first mapped and its economic impact calculated based on employment and GDP shares. In 2023, the sector employed around 2,900 workers (0.1 per cent of total employment in FRM), with a further 1,100 employees arising from data-centre suppliers. The industry's contribution to GDP is somewhat higher at 0.5 per cent, equivalent to EUR 1.25 billion. Compared with key FRM industries such as financial services (9.2 per cent), pharmaceuticals (2.6 per cent) or chemicals (2.3 per cent), the GDP share of the data-centre industry is also below average. These calculations show that the immediate economic effect of data centres is relatively small, as only around 4,000 jobs are associated with the sector—whereas the financial services sector in Frankfurt alone employs roughly 80,000 people.

However, the economic contribution of the industry is expected to grow in future—both in Frankfurt and in FRM as a whole. Since 2019, the data-centre sector has grown substantially faster than the overall economy and is expected to continue outpacing it until at least 2029. Over the past five years, the sector's GDP in FRM has doubled, and in Frankfurt its growth was nearly 90 per cent—in contrast to just 16 per cent growth in the overall city and regional economies.

The discrepancy between the employment share and the GDP share indicates very high productivity (i.e., GDP per worker). The sector generates around EUR 430,000 in GDP per employee, compared with an FRM average of around EUR 95,000. In an industry comparison, the data-centre sector ranks at the top—surpassing even the most productive branches in finance, insurance and manufacturing. This is attributable to its capital-intensive nature and relatively low labour requirements. Because most data centres in FRM are located within the city of Frankfurt am Main, the highest GDP contribution is also realised there: EUR 937 million, or 75 per cent of the sector's GDP in FRM, is generated in Frankfurt, with a further 16 per cent in the independent cities of the region and 9 per cent in the surrounding districts.

Data centres require a large land area per employee. In both the city of Frankfurt and FRM, the industry employs significantly fewer workers per hectare than other industrial and service sectors. Across the entire industrial and service economy, there are more than seven times as many employees per hectare as in the data-centre industry in Frankfurt. The sector generates EUR 17 million in GDP per hectare of industrial/commercial land in Frankfurt—only about half the economic output per hectare of the rest of the economy (EUR 35.4 million). In the wider region, however, the data-centre industry is significantly more productive than other industrial and service sectors. This is because the sector exhibits similar land productivity to other businesses in both Frankfurt and FRM, whereas industries outside Frankfurt typically generate only around EUR 10 million per hectare, far below the city average.

Using the economic indicators of the data-centre industry in FRM and its indirect effects, the study also estimates the level of tax revenues generated by the sector in the region. The data-centre industry is estimated to generate EUR 405 million in taxes, of which EUR 287 million stem directly from the sector itself (direct fiscal effect), while EUR 117 million arise from upstream supply-chain industries (indirect fiscal effect). This means that, relative to its employment and GDP contribution, the industry pays above-average levels of tax. Its directly attributable tax revenues account for 0.6 per cent of all tax revenue generated in FRM.

How Important Is Proximity to Data Centres for Companies?

The second question must be answered in two parts. Latency—the time delay within a system—together with the associated need for physical proximity, plays an important role in the relationship between data centre and data centre (also referred to as geo-redundancy). This is why data centres are concentrated in the greater Frankfurt area. The initial decision to construct a data centre creates a path dependency for subsequent facilities operated by the same provider. Frankfurt am Main represents the benchmark location in Germany, owing to its geographical proximity to DE-CIX, the world's largest internet exchange, and the substantial scaling opportunities this affords. Beyond latency, there are additional reasons for operators to establish data-centre clusters in urban areas, including access to a specialised pool of human capital and proximity to specialised service providers capable of carrying out repairs at short notice.

The high locational attractiveness is reflected in the willingness of data-centre operators to pay premium prices for commercial land in Frankfurt am Main. Compared with the average standard land values for commercially used plots, the prices paid by operators have in some cases significantly exceeded the reference values, according to the expert committee: between 2005 and 2014, the prices amounted to between one and 2.6 times the benchmark; between 2018 and 2024, they rose to between 3.9 and 6.7 times the benchmark. The districts particularly affected include Fechenheim (factor 6.2), as well as Ostend and Rödelheim (both factor 4.9).

In the data centre–to–company relationship, however, physical proximity is generally not required. Numerous experts from research institutions, businesses, start-ups and data centres note that only a vanishingly small proportion of companies need to be located within less than 30 kilometres of a data centre for latency reasons. Even in the future, business models requiring millisecond-level latency are considered highly unlikely for most companies. Examples of future models that may require minimal latency include digitally assisted surgery or autonomous driving (and autonomous mobility)—although such applications rely on high-performance mobile networks. Another example is smart manufacturing, i.e. real-time control of machinery and robots, where edge computing brings micro data centres closer to production processes; these in turn connect to high-performance data centres located further away. Accordingly, companies with ties to data centres are not expected to leave Frankfurt am Main if data centres increasingly locate in the surrounding region, or hypothetically were to relocate there. Around half of all companies using data centres still choose facilities located in Germany for reasons of data protection and data security. Data centres based in Germany therefore play an important role in digital transformation and data sovereignty.

Physical proximity to data centres can, however, become attractive to companies for reasons other than latency. Firms value the opportunity to maintain networks within the digital ecosystem (60.7 per cent agreement in the survey of around 320 FRM companies). In addition, Frankfurt am Main benefits from the digital reputation created by hosting DE-CIX, the world's largest internet exchange, which in turn attracts digital firms. While physical proximity plays only a secondary role, cultural and organisational proximity to data centres appears to be of latent importance. The combination of factors—difficult to measure quantitatively—such as the desire to be geographically close to one's data, or the ability to build networks with other digital companies that similarly seek proximity to data centres, can create location advantages. The company survey provides initial support for these hypotheses, though further research is needed for a comprehensive understanding of this phenomenon.

Do Cities and Regions Benefit from Hosting Data Centres?

With regard to the third question, this means that although FRM benefits only to a limited extent directly from the data-centre industry in regional-economic terms, measurable indirect effects can nevertheless be observed. This is also evident from the company survey conducted in FRM, which examined two types of firms in greater detail: first, around 20 per cent of companies in FRM report that the existing digital innovation ecosystem and the agglomeration advantages of Frankfurt are important for their own business development ("ecosystem type"). Second, around 12 per cent of companies state that the presence of data centres in close proximity constitutes a location factor relevant to their success ("data-centre-affinity type"). Both groups achieve higher levels of innovation performance in terms of product, service and process innovations. They also attribute a direct effect to cooperation with data centres: 48 per cent of data-centre-affine companies state that cooperation with data centres has a strong influence on service innovations, and 29 per cent say that it strongly influences process innovations. Across all companies, these shares amount to roughly 27 per cent (service innovations) and 20 per cent (process innovations).

The stronger performance of these firms is also reflected in developments in employment, turnover and productivity: for example, in the past two years, nearly 35 per cent of data-centre-affine companies increased their turnover and 41 per cent increased their productivity. Across all FRM companies, the respective shares are only 24 per cent and 35 per cent.

These effects are similarly reflected in the economic structure of FRM. Frankfurt am Main ranks second nationwide—behind the city or district of Munich—out of 400 districts and independent cities in terms of the number of companies engaged in cloud computing (rank 2; rank 1: city of Munich), the Internet of Things (rank 2; rank 1: district of Munich) and smart services (rank 2; rank 1: city of Munich). In terms of the share of IT employment, Frankfurt ranks 8th nationwide with 6.3 per cent, positioned between Munich (7.9 per cent, rank 6) and Berlin (4.7 per cent, rank 28). FRM as a whole records 4.2 per cent, compared with 4.6 per cent in the Munich metropolitan region and 3.5 per cent in Berlin-Brandenburg. Frankfurt am Main (with 30.9 ICT-related research institutions per one million inhabitants) and the other Hessian independent cities in FRM (85.4) also score well above the national average (17.6).

Frankfurt am Main can draw on outstanding strengths—DE-CIX, Frankfurt Airport and the stock exchange—that are unique in Germany. Taken together with mobility, infrastructure, corporate presence and research institutions, the city offers a digital ecosystem that is unparalleled across the Federal Republic, making it highly attractive for knowledge-intensive services, which tend both to grow faster than average and to be more productive. FRM therefore already possesses strong assets in the digital economy, which could be further enhanced in future.

- FRM still shows potential for digital and high-tech business formation. High-tech start-ups include firms in research-intensive industries (leading-edge and high-value technologies) and technology-oriented services (software and other technology-oriented providers). Many start-ups—particularly in the digital sector—are highly relevant for Germany's digital maturity and are innovative and fast-growing.
- In FRM, 2.5 high-tech start-ups per 10,000 working-age residents were founded in 2022 (Frankfurt am Main: 4.2). Berlin-Brandenburg recorded 4.3 (Berlin: 6.0), and the Munich metropolitan region 3.2 (Munich: 5.7).
- In 2024, FRM recorded 2.1 active digital start-ups per 10,000 inhabitants. In Berlin-Brandenburg the figure is 5.3, and in Munich 3.4.
- Within FRM, the city of Frankfurt am Main stands out with 5.1 active digital start-ups per 10,000 inhabitants, compared with 2.9 in the other independent cities and 1.3 in the surrounding districts. Berlin (8.1) and Munich (8.2) nevertheless exhibit considerably higher densities than Frankfurt.

The location analysis shows that Frankfurt's locational strengths closely match the requirements of digital start-ups—particularly those focusing on artificial intelligence—positioning the city to become a fourth major start-up hub alongside Berlin, Munich and Cologne/Düsseldorf. FRM's key comparative advantage lies in its unique digital connectivity—driven by proximity to DE-CIX, Frankfurt Airport, the stock exchange and the high density of data centres—which provides rapid access to global markets. Consequently, the limited commercial land available in Frankfurt am Main could be used more intensively to attract digital start-ups, which require neither significant space nor high energy volumes, thereby closing the gap with Germany's largest metropolitan centres.

To what extent must differentiated answers be provided for Frankfurt am Main and the other subregions of the FRM area?

With regard to the fourth question, Frankfurt am Main has developed into one of Germany's strongest economic centres and currently ranks 4th among all 400 districts and independent cities nationwide. Due to the high demand for industrial and commercial land in Frankfurt, the city is in some cases able to select among investor enquiries and to promote specific proposals from the digital sector through further strategic location profiling. However, the limits of political steering in location decisions must also be acknowledged. Selection could proceed according to two principles: best-in-class companies and the enhancement of related sectoral variety. Strengthening the digital innovation ecosystem in FRM by deliberately improving related variety—through the targeted attraction of additional digital firms, digital start-ups and research institutions with a digital focus—could increase productivity potential. This would allow Frankfurt to ensure, first, that the most successful companies in terms of innovation activity, competitiveness and profitability are prioritised, and second, that firms which build on the technological strengths of existing industries are supported in order to innovate at technological frontiers (IW Consult 2024d).

In the Hessian parts of FRM outside Frankfurt, the situation differs in several respects. While land and energy supply are scarce in the metropolis and demand for space is high, the bottleneck in power-ready land in the surrounding region is somewhat less acute, according to expert interviews. At the same time, there is a lower volume of enquiries from highly innovative and fast-growing firms. Data centres may therefore represent welcome investments—not least because they typically provide stable business-tax revenues, as their business models are based on long-term, steady income streams and are less exposed to cyclical fluctuations. Moreover, they neither significantly increase regional demand for skilled labour nor create substantial logistics burdens. Strengthening the connection to Frankfurt's digital ecosystem could enable other FRM cities—such as Darmstadt—to unlock greater potential for attracting digital firms.

New data centres should therefore primarily be located in the surrounding areas of the Frankfurt metropolitan core, considering heterogeneous local conditions such as energy availability and land constraints. Frankfurt itself should focus on strengthening the digital ecosystem by attracting digital companies and start-ups, and thus concentrate more on commercial development rather than additional industrial development. The share of employment in manufacturing in Frankfurt now stands at only 5.5 per cent, compared with 10.3 per cent in Hamburg and 11.0 per cent in Munich (Federal Employment Agency 2025).

The central importance of domestic data centres for innovation, resilience and data sovereignty—and thus for determining whether Germany and Hesse can successfully navigate the digital transformation—makes the data centres in the FRM region critical actors in enabling digital products, processes and business models across the German economy. Forty per cent of cloud users state that cloud technologies increase their operational resilience. Cloud services also strengthen Germany's decentralised economic structure. There are no differences between urban and rural cloud users with regard to their innovation activities: 24.1 per cent of urban firms make intensive use of new, complex cloud technologies, compared with 25.6 per cent in rural areas. Likewise, 71.1 per cent (urban) and 71.2 per cent (rural) report using cloud services to strengthen their innovation activities. This enables a degree of compensation for peripheral disadvantages (IW Consult 2022).

To continue offering these advantages to companies using cloud services—whose share has risen from 37.5 per cent two years ago to around 50 per cent today, with an upward trend—data-centre clusters are a necessary prerequisite, and Frankfurt am Main, with DE-CIX, remains the most suitable location in Germany.

In an overall assessment, the following key results should be highlighted:

- The immediate economic impact of the data centre industry, despite strong future growth, remains relatively small. The current GDP contribution stands at 0.5 percent, which is considerably lower than that of other focal industries in the FRM sector, such as the financial sector (9.2 percent), pharmaceuticals (2.6 percent), or the chemical industry (2.3 percent). The industry's tax revenue amounts to just 0.6 percent of the total taxes generated within the FRM sector.
- Spillover effects resulting from latency, due to the proximity between data centres and businesses, are considered insignificant. Business models that rely on minimal latency are extremely rare.
- The study provides evidence of spillover effects for companies embedded within a digital ecosystem. 20 percent of FRM companies indicate that the existing digital innovation ecosystem and the agglomeration advantages of Frankfurt are important for their business development. For 12 percent of FRM companies, the proximity of data centres is a critical location factor for success. Both groups of companies achieve higher innovation performance in the context of product, service, and process innovations.
- FRM plays a central role in enabling digital transformation across Germany by providing high-performance digital infrastructure. The spillover effects of data centres on the innovation capacity of businesses are significant, as highlighted by relevant studies, even without the necessity of geographical proximity to companies. At least six million employees in Germany work in companies whose business models would be impossible without cloud utilisation. Regional location advantages for data centres are reflected in their significantly above-average willingness to pay for commercial real estate in Frankfurt am Main.
- In the surrounding municipalities of Frankfurt am Main, the opportunity costs, in terms of land competition and electricity availability, are sometimes lower than in the urban areas of the FRM sector. The establishment of data centres can be attractive for municipalities with few attractive settlement applications due to the steady commercial tax revenues and low heavy traffic. In this way, the surrounding municipalities can not only strengthen their own economic position and further develop the local economic structure, but also contribute to reinforcing Germany’s position as a leading data centre hub, positioning themselves as key players in the digital transformation.

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