



DEPARTMENT OF
APPLIED IT

TRANSLATION OF DIGITAL STRATEGY: ANALYZING SCOPE AND SCALE FROM EU GOVERNANCE TO RAIL OPERATORS IN GERMANY AND SWEDEN

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Abstract

The need for digitalization is constantly growing in society, yet many industries are overlooked in this area. The purpose of this study is to investigate how digital strategies in the railway sector are transferred within three layers: EU-, national- and company. This is done by combining translation theory by Røvik (2016) and Bhadraraj et al. (2013) with the concepts of scale and scope. The methodology used was a qualitative design that includes both a document analysis that was used on EU-, national- and company documents, combined with comparative case study where two companies from Germany and Sweden were examined. Key findings with the modes from Røviks (2016) translation are that the approach of Germany had a greater centralised structure in infrastructure projects. In contrast, Sweden had a greater emphasis on the use of digital technologies to improve customer centred solutions. Contributions of this study is the combination of translation theory and digital strategy in the rail sector.

Keywords

Digital Strategy, Knowledge Transfer, Translation Theory, European Union, Rail

Abbreviations

ATO	Automatic Train Operations
BMDV	Bundesministerium für Digitales und Verkehr (Federal Ministry for Digital and Transport)
CEF	Connecting Europe Facility
DB	Deutsche Bahn
EC	European Commission
EU	European Union
ERA	European Railway Agency
ERTMS	European Railway Traffic Management System
ETCS	European Train Control System
RMMS	Rail Market Monitoring Scheme
RWP	Railway Package
SJ	Svenska Järnvägar
TEN-T	Trans-European Transport Network
TSI	Technical Standards for Interoperability

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1 Introduction

Digitalization is fundamentally reshaping the environment in which companies operate. This creates new opportunities to reshape business models and break up incumbent ways of creating products or services (Parviainen et al., 2017). In the transportation sector, introducing new technologies enhances efficiency, safety, and customer experience. Digital solutions are transforming everything from ticketing and scheduling to infrastructure management and real-time communication (Finger et al., 2015). As transportation systems become more complex and demand rises, the strategic deployment of digital technologies becomes essential (Nguyen et al., 2015; XIA & LEE, 2005). A clear, well-defined strategy ensures that digitalization efforts are not only effective but also aligned with broader organizational and societal goals. For instance, adopting responsible digitalization practices could reduce final energy consumption by 9.5% in 2030 and by 25.4% in 2050, compared to what would be expected if current trends continued (Noussan & Tagliapietra, 2020).

Most existing literature either focuses on policy developments or on implementation of infrastructure, without addressing the translation processes between involved organizations critical to successful digital strategy deployment. While substantial research has examined the detailed aspects of initiatives in the European Union (EU) in rail, including standardization and infrastructure deployment (e.g. Abourahim et al., 2022; Djordjević et al., 2025; Stamoulis & Kopanaki, 2024), limited attention has been given to the overall transfer of strategic and organizational mechanisms by which these EU level digital ambitions are translated into national policies and subsequently adopted by rail companies. Digital Infrastructure benefits from standards, as these increase cooperation and compatibility within itself, offering numerous benefits like reduced uncertainty for users and enhanced competition (Shapiro & Varian, 1999). This thesis aims to contribute to the understanding of whether a digital strategy can remain valid and effective when implemented in different national contexts, and how it may change in the process.

A preliminary review of the literature reveals a lack of studies that follow digital rail strategies from the European Commission (EC) through national ministries to infrastructure managers and operating companies. The concept of strategy translation or knowledge transfer across multiple layers of governance, while explored in general public policy and management literature (e.g. Deng et al., 2021; Lim et al., 2015; Ravichandran & Giura, 2019), is rarely applied in the rail or transport sectors. As Jandhyala and Phene (2015) describe, especially innovation can benefit from international cooperation, but they are yet to be studied in detail.

This lack of attention is particularly significant considering the complex multi-stakeholder environment of European rail. Development and implementation of digital strategy hinges on technological readiness and on strategic alignment across levels of governance and organizations (Volberda et al., 2021). Without a clearer understanding of how digital strategies are interpreted, adapted, and implemented at the company level, there is a potential risk of misalignment, inefficiencies, or failed adoption. Understanding how knowledge and strategies are interpreted and enacted across governance levels requires a conceptual framework that captures these processes.

To investigate the strategy of digitalization efforts in the European rail sector, this study examines the following central research questions:

How is Digital Strategy translated throughout organizational levels? A case study from European legislation to railway operators in Germany and Sweden.

The EU has prioritized digital innovation in the rail sector as part of its twin green and digital transition, aiming for a sustainable, smart, and adaptable transport system (European Commission, 2021b). Since 2001, four railway packages (RWP) have established a harmonized legal framework to support market liberalization, cross-border connectivity, and digital transformation. The EU recognizes that achieving this vision requires full support from all transport actors and significant investment, ensuring the transition is socially fair and benefits all European citizens (European Commission, 2020).

“Transport should showcase European ingenuity and industriousness – standing at the vanguard of research, innovation and entrepreneurship, and driving the twin transition“ (European Commission, 2020, p. 25)

This study traces how the European digital strategy is deployed by the governments of Germany and Sweden—two of the largest countries by area in the EU. Germany and Sweden have distinct institutional and operational approaches to rail digitalization, making them particularly relevant for comparative analysis. Within these two countries, the main rail operators—Svenska Järnvägar (SJ) and Deutsche Bahn (DB)—are compared to identify key aspects of their digitalization efforts and the general translation of EU railway law. The two systems are highly comparable as both are classified as Tier One networks, operating rail systems where freight, regional, and high-speed trains share tracks. This contrasts with countries like France, which developed a mostly separate infrastructure for its high-speed service, the TGV (Audier et al., 2017). This approach addresses the lack of research on translation processes in the rail sector and highlights institutional and organizational factors that influence the success or failure of digital strategy alignment.

The purpose of this study is therefore to examine how EU level digital rail strategies are translated into national strategies and ultimately into company-level implementation. Translation theory, which examines how ideas and strategies are adapted and de-contextualized as they move between organizations, is used to investigate the interorganizational composition of rail digitalization (Røvik, 2016). To narrow the focus, translation theory is combined with the scope and scale of digital business strategy, thereby concentrating on actual digitalization with-in the digital rail transformation.

The findings of this study are intended to contribute to the academic understanding of digital transformation in rail transport, and to provide practical implications for policy makers and management responsables in railway companies.

2 Background

This section provides the necessary information about the European legislative environment that shapes the digitalisation of rail in the EU. Then the concept of digital strategy is introduced and defined for the study.

2.1 Evolution of EU Railway Legislation

After being the backbone of economic development in the 19th and till the end of the 20th century, the railway sector experienced rising pressure. The sector experienced a decline in their market share while the transport sector overall was growing. While this was also due to exogenous reasons, like industrial production shifting towards just-in-time deliveries and policies and investments favouring road transport instead of rail, the endogenous reasons were manifold. Among others, the incumbent rail providers were delivering a fragmented service, mainly limited to within national borders. This was causing delays at the frontiers. Furthermore, a lack of adaptability to dynamic markets and changing customer requirements, the absence of one stop shop possibilities and overall high costs. These factors combined were hindering an intermodal shift to rail (Di Pietrantonio & Pelkmans, 2004).

The EU then identified the importance of achieving an international and strong rail system. To develop and create legislation towards this goal has taken a very long time. This is mainly due to structural characteristics in the rail sector which basically consisted of network economies, national monopolies and a lack of interoperability between the national systems (Dehousse & Benedetta, 2015).

To address this complex legislative challenge, the EU adopted a stepwise approach by introducing a series of RWPs. With each new package, the framework was expanded and refined, resulting in a comprehensive set of directives, regulations, and measures, as shown in Table 1 below.

Table 1
Overview European Railway Packages

Railway Package	Objective	Key Measures
1 (2001) 2001/12/EC 2001/13/EC 2001/14/EC 2001/16/EC	Establish a regulatory framework for the rail sector, open the international freight market to competition, and ensure efficient use of infrastructure	Creation of regulatory bodies, imposed accounts separation, and opened the European freight market to competition. It addressed issues such as licensing, infrastructure allocation, and safety certification
2 (2004) 2004/49/EC 2004/50/EC 2004/51/EC 881/2004/EC	Further liberalize rail freight services and enhance safety and interoperability	Established the European Railway Agency (ERA) to develop safety and interoperability standards. It fully opened the rail freight market to competition by 2007
3 (2007) 1370/2007/EC 1371/2007/EC 2007/58/EC 2007/59/EC	Liberalize international passenger services and strengthen passengers' rights	Introduced open access rights for international passenger services, harmonized train driver certification, and established minimum quality standards for passengers
4 (2013) Technical Pillar 2016/796/EC 2016/797/EC 2016/798/EC	Enhance the competitiveness of the railway sector	Reduced costs and administrative burden for railway undertakings operating across Europe, ensured that ERTMS ¹ equipment is interoperable, and reduced remaining national rules to increase transparency
4 (2013) Market Pillar 2016/2338/EU	Complete Market opening	Opens all EU rail passenger markets to competition, allowing any operator to

¹ European Rail Traffic Management System

2016/2370/EU
2016/2337/EU

run services across the EU,
with fair management of
rail infrastructure, and
open data access

In the following years the RWPs were under constant review and were reworked to account for new environments and constant improvements based on feedback from the member states, like improving transparency and access of rail related services and standardization (Dehousse & Benedetta, 2015). The table shows that the RWPs cover multiple disciplines to strengthen rail. From funding, over governance, to safety regulation. Important for this study is the creation of a single European and digitalized railway market. A transparent and interoperable rail system with a central management, represented by ERA and EC, is the basis for being able to create a strategy for a digitalized rail sector (Montero & Finger, 2020). The next section will explain why strategizing in the digital sector needs someone to take decisions.

2.2 Digital Strategy

In this work strategy will be defined as an approach to deal with complex situations. The forming of a strategy requires a sense for the given situation. One needs to be persistent and must balance upcoming issues with purposes, values, and beliefs. Together, it is an approach to overcoming critical obstacles and difficulties by understanding the challenge and finding its crux (Rumelt, 2022). On the company level, a good strategy creates a unique and valuable position, involving a different set of activities than rivals are pursuing. To achieve this the managers must decide which trade-offs they are willing to make. The EU achieved this through creating ERA as central organization to take decisions for the whole network. And finally, the success of a strategy depends on doing many things well and integrate them among each other. If this is not done well, there is no distinctive strategy and little sustainability (Porter, 1996). Before the market opening for non-state-owned carriers for freight (First RWP) and passenger rail (Third RWP) the federal operators had a monopoly. They did not have to take trade-offs towards other competitors into account and did not need a strategy in that sense (Dehousse & Benedetta, 2015). The EU as stated in the RWPs started to break them up and to communicate a Strategy towards a European and Digital Rail Network. This is aimed to harvest the strengths of an open market and the opportunities of Digitalization (European Commission, 2012).

Investigating the digital strategy of the European Rail system is highly interesting, since only recently companies in the rail industry started to be facing an open market. They now operate in business ecosystems that are interconnected such that digital

business strategy cannot be conceived independently of the business ecosystem, alliances, partnerships, and competitors which aligns with the study design of looking at two rail markets in the EU (Bharadwaj, Anandhi et al., 2013).

Now the companies are able and asked to use digital platforms, enabling them to break traditional industry boundaries. With the help of digital resources, they can radically reshape processes internally and externally. That is especially important in the transport and logistic industry where the sharing of information with customers is important (D'Adderio, 2001; Klein & Rai, 2009; Saraf et al., 2007).

In the mean time, terms like “digital”, “digitalization”, and “digitization” are used with increased frequency in information systems research, where every incumbent system (x) is labelled digital (x) showing a new label form, but is the question remains, if this is a buzzword hype or is there actual change going on (Baiyere et al., 2023)? Intricate about this question is, information system research and more specifically the literature on digital transformation is interdisciplinary by nature. It spans across innovation, marketing, and strategy to name just a few (Verhoef et al., 2021). But even more important, digital transformation processes are not contained within single organisations and their processes anymore, they take place at wider scales (Legner et al., 2017; Vial, 2019). Therefore, it is important to understand and research these transformation processes in a broad sense, that is, in relation to governments, economies, societies, and industries, as we do in this thesis (Currie et al., 2022).

3 Theory

To analyze how the EU’s digital strategy for rail is transferred and translated into national contexts—specifically in Germany and Sweden—and subsequently operationalized by their main railway operators, DB and SJ, this thesis draws on Røvik’s translation theory for knowledge transfer alongside Bharadwaj et al.’s digital strategy framework, with particular attention to the dimensions of scope and scale.

To understand more deeply how the Strategy to Digitalize the European Rail Network is formed and passed on to member states and rail companies, this thesis adopts an integrative theoretical approach. We adopt translation theory to analyze the conversion of EU rail digitalization strategies into national and organizational contexts. This provides a robust framework for understanding how ideas and practices are formulated in one organisation and re-embedded within local environments, highlighting the processes of adaptation and modification. The theory foregrounds the political and networked nature of translation with diverse actors throughout the translation

process. It further enriches the analysis by focusing on the boundary-spanning activities of brokers and translators, and the effectiveness of knowledge transfer across organizational boundaries (Brown, 2002; Latour, 1987). This comprehensive approach thus provides a foundation for the empirical investigation, enabling a deeper understanding of how EU digitalization initiatives are interpreted and enacted within the complex realities of national rail systems.

3.1 Røvik's Translation Theory

Røvik's translation theory reconceptualizes knowledge transfer between organizations as a process of translation rather than simple diffusion or copying (Røvik, 2016). In this view, ideas, practices, and strategies do not travel unchanged from one context to another. Instead, they are actively interpreted, modified, and reshaped by actors at each stage of the transfer. Translation is a rule-based activity, with outcomes depending on how translators apply different rules and modes during two key phases, de-contextualization and contextualization (Røvik, 2016).

During de-contextualization, ideas are abstracted from their original context (e.g., federal legislation is formulated as national digitalization goals and standards). On the other hand, contextualization is defined as the process in which these abstracted representations are adapted and embedded into the recipient context (e.g., DB or SJ's strategies and operational practices) (Røvik, 2016).

Røvik identifies three main translation modes, used during contextualization. *Reproducing* is the direct copying of the original idea, in contrast to *modifying*, which adjusts or adds to the original practice to fit local conditions. Finally, *radical* means the transformation of the idea into something substantially new (Røvik, 2016).

These modes are enacted through rules such as copying, addition, omission, and alteration. The choice of mode and rule depends on the translatability of the practice (how explicit, complex, or embedded it is), the transformability (freedom to modify), and the similarity between source and recipient contexts. This framework is highly relevant for our research question, as it captures the complexity and variability in how EU digital strategies are interpreted and implemented at national and organizational levels (Røvik, 2016).

There are more studies which describe the process of translation through multiple layers. One is Czarniawska & Sevón (1996) who describes the process of translation as transformative within organizational change. The authors mention a case of the Swedish railway system. During the middle of the 20th century trains were seen as being something of the past. Despite this, trains gained increased interest, due to the oil crisis of the 1970s, but also environmental concerns. Complaints and an increase of financial problems ultimately led the politicians to divide up the Swedish State

railway in two areas. One which would become an agency that focused on infrastructure, later becoming Trafikverket. The other part, where the primary motive was to compete with other modes of transport, which Czarniawska & Sevón (1996) states would make it more businesslike. The takeaways of this case example were that the Swedish State Railways was previously restrained in their way of conducting their business operations, due to their duties as a public organization. Czarniawska & Sevón (1996) describe how this change redefined their core operations, to not be directly thought of as trains, but instead transportation. Therefore, the new de-contextualization of the organizations purpose led to organizational transformation during contextualization, which made the separate two organizations' objectives clearer. As for this study, it illustrates the importance of policy-making in redefining the strategy of public organizations.

3.2 Bharadwaj et al.'s Digital Strategy Framework: Scope and Scale

Bharadwaj et al. (2013) advance the concept of digital business strategy as a fusion of IT and business strategy, fundamentally transforming how organizations operate and compete. Two key dimensions from their framework guide our analysis:

Scope: The breadth of digital strategy, encompassing which domains (products, services, processes, functions, and even ecosystems) are included. Scope considers how digitalization extends across organizational boundaries, business functions, and the value chain (Bharadwaj et al. 2013).

Scale: The reach and replication of digital initiatives, including how digital platforms, data, and networks are leveraged to achieve network effects, cross-border integration, and rapid scaling of solutions (Bharadwaj et al. 2013).

These dimensions are particularly relevant for understanding the translation of EU digital strategy, as they allow us to distinguish between the intended breadth of digital transformation (scope) and the actual reach and replication of digital solutions (scale) at the national and operator levels.

Additionally, Dąbrowska et al. (2022) provides insight into the topic of digital strategy. The authors illustrates how digital transformation takes place across multiple levels. A substantial part of the literature in this field focuses primarily on the organizational level. Despite this, there are other factors that has an influence, that are both internal and external. Dąbrowska et al. (2022) therefore suggests viewing digital transformation through four perspectives: Individual, organizational, eco-system and lastly geo-political frameworks. In this way, Dąbrowska et al. (2022) provides not only organizations, but also policy makers of how digital transformation is should be guided through strategic measures. Similarly, in this study, digital strategy is

translated from different levels from the EU through the nations and finally to companies. Illustrating, that the process of digital strategy is not limited to exclusively organizations, but rather multiple parties.

3.3 Integrating the Theories

The novel contribution of this thesis is to connect Røvik's translation theory with Bharadwaj et al.'s digital strategy framework. By doing so, we can systematically analyze:

- How the scope and scale of the EU's digital strategy are de-contextualized at the national level (Germany/Sweden) and then contextualized by railway operators (DB/SJ).
- How translation modes (reproducing, modifying, radical) and rules (copying, addition, omission, alteration) shape the breadth and reach of digitalization as strategies move down the governance chain.
- Why certain elements of digital strategy are faithfully reproduced, while others are modified or radically transformed, depending on their translatability, the freedom to adapt, and contextual similarity.

3.4 Relevance to the Research Question

Our research question requires a framework that can capture both the content (scope and scale) and the process (translation) of strategy transfer. Røvik's theory explains the mechanisms and outcomes of knowledge translation, while Bharadwaj et al. provide the analytical dimensions for evaluating the digital strategy itself. Together, these theories allow us to reveal not only what is transferred, but how the scope and scale of digital strategy change as EU legislation is translated into national and organizational practice.

4 Method

The following section will describe in detail how this study was conducted, where the case description, how the data were collected and lastly how it was analysed will be outlined. In addition, considerations that were made to ensure trustworthiness in research will be detailed in this section. Finally, the use of generative AI in this study can be observed in Appendix A. In total, these factors enable us to provide greater detail into the research process.

4.1 Case description

The objective of this study is to examine the transfer of digital strategies across various layers. At the top of this hierarchy is the EU, followed by the nations, Germany and Sweden and lastly to the individual companies, DB and SJ, which also is set in Germany and Sweden. The results section will highlight how digital strategy is transferred, all the way down to the companies. The research design chosen for this study is qualitative, with the use of a document analysis and a comparative case study. The primary reason for this is to compare and examine a large quantity of documents ranging from legislative to strategic. To further examine this research topic, we also adopted a comparative case study design, which are used on a federal- and company layer. This structure allows for gaining a greater understanding of differences and similarities in the adoption of digital strategies that originate from the EU.

4.2 Data collection

As stated in the case description, the documents that were collected combine EU-, national-, and annual reports specifically for the companies. For a more comprehensive overview of the data, please see appendices 1-5. At the EU layer, the data material includes legislation and strategy documents. Furthermore, the data sources were drawn from various institutions and bodies across the EU, including the EC, as well as ERA. The data that we gathered in this specific context were exclusively sourced from EU institutions and bodies. The second layer, which is national, followed a similar approach. The key distinction in this case is that data were collected in two separate contexts: Germany and Sweden. Therefore, the data had been sourced from the governments, agencies of the governments, or other national institutions. A particular exception to this was a data publication by Ericsson (2025), which was a collaborative project with the Swedish government agency Trafikverket. The nature of the project was directly related to the national context, and thereby relevant to our study. Finally, the empirical data from the companies consisted of the annual reports. The period for this stretched from 2019 to 2023 for both the German and Swedish companies. The Swedish company changed the language in its reports from the year 2020 and forward to only being available in Swedish. To resolve the issue, it was necessary to translate the codes used for these specific reports. The language barrier in the Swedish and German sources was solved through us dividing up those sources, where we would discuss the content to eliminate possible language barriers. The divide was done between author one, German native speaker, and author two, Swedish native speaker. Furthermore, a large portion of the content in the annual reports was found to be excessive in relation to our case description. It was therefore decided that the focus would be directed towards chapters where the focus on digital strategy was present. For this reason, it became necessary to ensure that the same chapters of the

annual reports were examined throughout the five-year period. This consistency enabled us to enhance our ability to examine changes and trends within those chapters. Besides that, this limitation of our scope enabled us to ensuring trustworthiness in research by considering transferability, i.e. the extent to which the results of the study can be applied beyond the original context and setting. Shenton (2004) emphasises the importance of stating the limitations of the study as one way of addressing this. This study is explicitly stated within the context of the EU. This boundary of the study is also addressed in the conclusion to highlight limitations to the interpretation of the results in other contexts. Another way of ensuring trustworthiness in research is credibility, which Guba (1981) describes as the aim of which is to determine how the study's findings reflect the real world. Shenton (2004) proposes that credibility can be ensured by triangulation, a methodological approach entailing the utilisation of multiple sources. Our present study draws upon a wide variety of source materials, including annual reports, legislation and strategy documents. This approach ensures a diverse and robust set of data sources, thereby enhancing the study's credibility. Finally, the annual reports were compiled in Atlas TI. This Application was used for the coding and analysis.

4.3 Data analysis

The analysis of the empirical data was conducted through a combination of thematic synthesis and coding. The coding of the annual reports was conducted using descriptive coding, with the process beginning with open coding. The coding process was conducted using an inductive approach, whereby themes and interpretations were derived from the codes. The total number of unique codes for both Sweden and Germany was measured to 362. The creation of categories was predicated on an analysis of the thematic content of the codes, with the objective of identifying the similarities between the topics covered by each code. The following themes are second-order themes: artificial intelligence, digitalization, and internal operations, amongst others.

Regarding the EU and national layer, the documents were not coded. The use of the concept of de-contextualization as an analytical framework enabled us to trace digital strategies from the EU to Germany and Sweden, and ultimately to the companies. The content of these documents was therefore traced, with a specific focus on how they developed all the way down to the companies. This was achieved using a close examination of the modes of the translation theory proposed by Røvik (2016), in which these strategies were translated. By going through the codes together, we thereby increased the dependability of this study. Dependability is described by Guba (1981) as being the equivalent of reliability but in a qualitative context, and it refers to how consistent the results are and therefore whether they could be replicated in another study. As a result, individual inferences would be less prevalent, where de-

creased the risk of subjective interpretation. Shenton (2004) proposes that researchers can address the issue of dependability by offering greater transparency regarding the research process. In conclusion, the incorporation of scale and scope, as established by Bharadwaj et al. (2013), was used as an examination of both the depth and the reach of the strategy documents.

5 Results

The results of the data analysis can be seen in an overview in the table below. This section will introduce all the data that has been collected in the EU, Germany and Sweden, as well as DB and SJ. For every organisation the results are split up into scale and scope to give a well organised view of what is important for this study regarding the digital strategy and the translation thereof between the organisations.

Table 2
Overview Digital Strategy by Organization

Row	Level	Scope of Digital Strategy	Scale of Digital Strategy	Examples
1	EU	Transnational and cross-functional interoperability, market liberalization	Leveraging network effects and partnerships, Standardizing the Network	Scope: Single European Railway Area, TEN-T ² Scale: Europe's Rail Joint Undertaking, TSI ³
2	National, Germany	Systemic integration, innovate	Industrial capacity increase, Integrate new technologies and suppliers	Scope: "European Platform", Federal Rail Research Program Scale: Continuous projects, EU projects: TEN-T, ERTMS
3	National, Sweden	Partnerships, digital infrastructure	Deployment of ERTMS, Following EU standards	Scope: Adopting EU ecosystem, MORANE2

² Trans-European Transport Network

³ Technical Standards for Interoperability

				Scale: ERTMS, open market
4	Germany, DB	Infrastructure, broadening digitalization	European collaboration, Upskilling Work Force	Scope: Digital Rail Germany, specific digitalization projects Scale: Cross-border collaboration, workforce digitalization
5	Sweden, SJ	Innovation driven by customer focus, digital services	Modernization of fleet, 5G abilities	Scope: App service, Enhancing customer experience Scale: Investment in modern fleet, Upgrading 5G WiFi

5.1 European Scope of Digital Strategy

Scope refers to the breadth of digital transformation, including the domains, functions, and boundaries it encompasses (Bharadwaj et al., 2013). At the EU level, the digital rail strategy is intentionally broad and transfunctional, orchestrating transformation across governments, railway operators, and national borders. This transcends into all aspects of rail operations, embedding digitalization into infrastructure management, regulatory compliance, and innovation by enabling and enforcing the exchange of data between national and European systems (European Commission, 2021a).

The EU's digital rail strategy integrates multiple domains into a cross-border ecosystem. This aligns with Bharadwaj et al.'s concept of transfunctional and ecosystem-wide digital strategies. This ecosystem approach is evident in the EU's push for ERTMS/ETCS (European Rail Traffic Management System; European Train Control System), which standardizes signaling and control systems to ensure interoperability across borders (European Commission, 2023). Therefore, showing an effort to digitalize rail infrastructure to enable seamless transfer of goods and passengers across the Union.

“[...] promotion of interoperability between digital systems of all transport modes, with adequate network capacity between regions and Member States;” Regulation 2024/1679 (Article 4, 2(b)(ii))

One key initiative in the digital strategy is market liberalization, breaking up incumbent monopolies. The monopolies could be seen as the traditional functional and process silos as described by Bharadwaj et al., represented by the Union Member-states. To further accomplish an open market, interoperability standards for digital and analog rail technology are being put into place. These initiatives require coordination across legal, technical, and operational domains. For instance, the Fourth RWP (2016) harmonizes technical regulations to ensure cross-border compatibility while mandating non-discriminatory access to rail infrastructure (DIRECTIVE (EU) 2016/2370; REGULATION (EU) 2016/2337; REGULATION (EU) 2016/2338, 2016). This aligns with the EU's vision of a Single European Railway Area, where seamless interoperability and standardized practices enable rail to compete with other transport modes (European Commission, 2021a).

“[...] the European Parliament [...] establishes a single European railway area with common rules on the governance of railway undertakings and infrastructure managers, on infrastructure financing and charging, [...]” Directive 2016/2370 (1)

5.2 European Scale of Digital Strategy

Scale concerns how digital initiatives are replicated, networked, and expanded to achieve system-wide transformation (Bharadwaj et al., 2013). Due to the EU being a body constituted of multiple members, the Union must build the groundwork for digital solutions to be scaled across the rail network. By standardizing technologies (e.g., ERTMS/ETCS) and regulatory frameworks, the EU amplifies network effects: the value of the rail system increases as more countries and operators adopt shared protocols. For instance, the Fourth RWP (Directive (EU) 2016/797) mandates interoperability across signaling, rolling stock, and safety systems, creating a "plug-and-play" rail network (European Union, 2016). While interoperability in scope was part of creating the network itself for the member countries to work in, in scale it is more about using standardization to leverage network effects where countries come together at Union level to refine the digitalization of rail.

“[...] the objective of this Directive, namely interoperability within the rail system on a Union-wide scale, cannot be sufficiently achieved by the Member States but can rather, by reason of its scale and effects, be better achieved at Union level, [...]” Directive 2016/797 (69)

The EU fosters collaboration between member states, infrastructure managers, and private stakeholders to scale innovations in digitalization. The Connecting Europe Facility (CEF2 Digital) plans to allocate €3 billion to fund pan-European projects like 5G corridors and digital connectivity infrastructure, which in return should attract private investors to increase funding even more, increasing the volume of research and innovation within the rail sector (European Commission, 2019). Programs

such as Shift2Rail (now part of Europe’s Rail Joint Undertaking) exemplify this approach, pooling resources from 100+ partners to co-develop technologies like Digital Automatic Coupling (DAC) and AI-driven traffic management (European Commission, 2022).

“The Commission is also planning to put forward a proposal for a European Partnership on Rail Research and Innovation [...]. The future partnership will focus on accelerating research and development of innovative technologies and operational solutions, facilitated by digitalisation and automation.” Seventh monitoring report on the development of the rail market under Article 15(4) of Directive 2012/34/EU of the European Parliament and of the Council (6.4)

Europe’s Rail Joint Undertaking (formally: Shift2Rail) is the European partnership for rail research and innovation under the Horizon Europe programme (2020-2027).⁴

The EU's digital rail strategy, when seen through the lens of Scale and Scope as developed by Bharadwaj et al., demonstrates a broad and scalable approach to digital transformation. It shows a holistic approach towards digital transformation within the Union and deep dedication to transforming the rail industry by setting aside funds and personnel for the process. Meanwhile, it is important to considerate that what we have presented does not aim to show the complete efforts of the EU towards Digitalization. Nevertheless, it provides a comprehensive overview of the range of subjects covered, which is essential for developing an effective digital strategy.

5.3 Translation

The EU sets the strategic direction, but member states must de-contextualize these directives to fit their own markets, and companies must further contextualize them for operational implementation. To get an insight into this process will be explored on the 5th biggest (Sweden) and 6th biggest (Germany) countries by size in the EU. Firstly, the decontextualisation of the scope and scale of the countries' digital strategies will be demonstrated, after which the contextualisation of their largest rail operators, DB in Germany and SJ in Sweden, will be shown..

5.3.1 Federal De-contextualization

To fit to the German and Swedish Market, the governments must de-contextualize their Strategy to communicate them to their respective markets and create a common ground for all rail operators that can act upon this base and form their business around it. This is crucial to enable open market dynamics as aspired by the EU.

⁴ <https://rail-research.europa.eu/who-we-are/>

5.3.2 Germany

Scope of Digitalization

Germany's digital strategy is shaped by systemic integration of smart infrastructure, such as ETCS and digital interlockings, following EU standards but also advancing national innovation. The rail system is closely connected, and disruptions can spread across regional lines. Therefore, the government prioritizes synchronized upgrades of infrastructure and rolling stock to enable ETCS-only routes. This avoids having to deal with multiple configurations of trains and track infrastructure operating alongside (BMDV, 2024).

“In principle, infrastructure retrofitting sets the pace for the overall program — coordination and synchronization between infrastructure and vehicle equipment is necessary.” (BMDV, 2024, p. 14, translated)

The Federal Rail Research Program supports innovation in areas like automated train operation and predictive maintenance, with research findings rapidly transferred into practice.

“Research findings are to be made available more quickly and effectively for the overall rail system in the future, in order to give the mode of transport the necessary boost in innovation. The key to accelerating these processes lies in application-oriented research.” (BMDV, 2022, p. 11, translated)

The Federal Ministry for Digital and Transport (BMDV) is also working on the development of a comprehensive concept for the strategic management of the rail digitalization program. Core components of this concept include a stronger role for the federal government in the strategic steering of digitalization and the establishment of an operational steering institution in cooperation with the sector. This aims to mediate the narrow scope of German federal states that oversaw the rail infrastructure in their state. With the new steering institution a holistic national scope is achieved for the digitalization of the whole network (Bundesregierung, 2025).

Scale of Digitalization

Germany's strategy is designed for large-scale implementation, focusing on increasing capacity and improving system efficiency. On selected routes, especially those with a mix of traffic types and vehicle characteristics, digital infrastructure like ETCS can lead to a significant capacity increase. The implementation is done in several bigger projects that are shaped by some delays and more costs than planned. Additionally, the government assessed, it has to increase the continuity in the financing to increase planning certainty for the stakeholders (BMDV, 2024).

“[...] the digitalization of rail offers several [...] significant benefits:

- *Lower costs for network access by reducing ongoing operating expenses,*

- *Simplification of cross-border traffic [...],*
- *Improved punctuality and resilience through the replacement of failure-prone old technology and standardization, and*
- *Demographic resilience through more efficient use of personnel.*” (Bundesregierung, 2025, p. 5, translated)

On the technological side, the digital strategy is based on scalable and modular platforms with standardized interfaces. This approach allows for the smooth integration of new technologies and suppliers, while also taking advantage of economies of scale.

At the European level, the strategy is aligned with EU requirements like TEN-T and ERTMS. It supports cross-border interoperability and is closely coordinated with European partners and EU funding, ensuring consistent and effective implementation across national borders. This enables Germany to take advantage of the EU intended network effects.

“[...] to ensure interoperability in Europe and to benefit from economies of scale, the development of rail technology must be considered at least within a European context. [...] a clear European orientation, aiming to promote solutions that enable seamless rail transport across Europe, positioning Germany as a core country within European corridors.” (Bundesregierung, 2025, p. 17, translated)

In Germany's de-contextualization there is a clear dedication to integrate digital technologies according to the European Standard and an effort to innovate around them to become a leader in rail technologies. They are trying to benefit from scaling digital technologies to achieve higher volumes on existing lines, profiting from standardization and modular platforms.

5.3.3 Sweden

Scope of Digitalization

Sweden is a part of Europe's Rail, where Trafikverket is a founding member. The goal stated by Europe's Rail Joint Undertaking (n.d.) is that the partnerships among the members and participants will strengthen competitiveness and ultimately contribute to R&D. Connecting Europe Facility, which is a fund, has also a central role within the EU-ecosystem, specifically the TEN-T. Trafikverket (2025) describes the necessity of collaboration with partners for the use and development of digital technologies as follows:

“There is huge potential in the use of digitization and automation to reduce the cost of rail, increase its capacity and improve its flexibility and reliability. EU-Rail is a key enabler to increase the uptake of digital technologies in the rail sector” (Trafikverket, 2025, translated).

There are several areas where innovation is emerging in the Swedish railway sector. Trafikverket (2025) argues for the necessity of upgrading the mobile communication system to 5G, which currently is operated on 2G network. This project is being implemented with the directives from Europe's Rail Flagship project. Partnerships are formed where Ericsson and Telia together with Trafikverket will be cooperating for the introduction of 5G in the Swedish railway sector. The joint project is called MORANE2 and is expected to be ready by 2027. The most central goal of this initiative is to digitalize rail operations. A byproduct of that will be more opportunities for automatic train operations (Ericsson, 2025).

Trafikverket (2025) stated that digitalizing and automating segments of the railway system is a central aspect in the goal of reaching a more unified European rail infrastructure. One crucial factor in this process is the introduction of the standardized signalling system ERTMS. The goal of this is to improve punctuality, but also to help with monitoring. An important ambition mentioned by The Swedish Transport Agency is that it ultimately will be crucial in the development of new innovations of the future (Trafikverket, 2025). Thereby affecting the scope of new digital technologies and innovations.

Scale of Digitalization

The process of implementing digital projects in relation to infrastructure has received EU funds through CEF. The total sum that CEF has provided amounts to € 71 million. As an example, ERTMS on the route “Malmbanan”, was granted €44 million in CEF funding (Trafikverket, 2024). Another project that CEF has provided funds for was 5G4RAILSCAND, which aims to create 5G infrastructure for the railway sector, which amounted to €18 million to (Trafikverket, 2024). This illustrates the dependencies in which Sweden has in relation to EU when it comes to such projects. It is detailed in Prop. 2024/25:28 that there have occurred problems related to cost increase in infrastructure projects. Therefore, the Swedish government has issued directives to Trafikverket to increase the monitoring of spending (Prop. 2024/25:28). Furthermore, the Swedish National Audit Office suggested in their report multiple adjustments for the Trafikverket to mitigate further obstacles in the implementation process to reduce the risk of further cost increases (RiR 2018:21).

The major technological scaling opportunities relate to ERTMS. One specific benefit that the Swedish government addressed in proposition 2024/25:28 (2024), with regards to the transition to ERTMS is that it will provide greater safety, punctuality but also an increase in capacity. By introducing this new signalling system, it therefore is required that the old Automatic Train Control system is dismantled (2024/25:28). Furthermore, Trafikverket (2025) it will enable areas of the railway sector to operate in larger sectors, thereby enabling scaling. The agency that will be

responsible in the oversight and strategic planning of this will be Trafikverket (proposition 2024/25:28). As of 2024, there have been four pilot tests where ERTMS has been implemented (Trafikverket, 2025).

“Bringing the entire Swedish rail network within the scope of the Directive's technical harmonization requirements should, however, benefit the further development of the rail market for all parties concerned. The proposed regulatory framework should provide predictability for market players, which means cost savings for future investments in rail infrastructure and other rail equipment.” (Prop. 2024/25:28, 2024, p.78. translated).

From the EU level, the RWPs sought to open the competition within the European railway market. The packages were set between the years of 2001 to 2016 (European Commission, n.d.). By that point, Sweden had already started to deregulate its railway market. In Proposition 2003/04:123 it is commented in relation to directive 91/440/EEG where it is stated that Sweden is abiding by the rules of the directive:

“Following the incorporation of the Swedish State Railways, there is no longer any fully regulated railway undertaking under public law in Sweden. The civil law regulatory framework that applies to activities conducted on commercial grounds may be considered to ensure the Directive's requirements for the management independence of railway undertakings in relation to the State” (Prop. 2003/04:123, 2004, p. 101. translated)

5.3.4 Deutsche Bahn

These are the most important results for DB regarding their Digital Business Strategy.

Development Over Time (2019–2023)

From 2019 to 2023, DB's strategic priorities evolved to reflect both the broadening scope and expanding scale of its digital transformation. In terms of scope, digitalization emerged as the dominant and persistent theme, maintaining consistent emphasis across annual reports. Early years focused heavily on customer-centric initiatives, but this explicit focus diminished over time, suggesting a shift toward embedding customer needs into broader operational frameworks. The “Digital Rail Germany” initiative remained a steady priority, reflecting commitments to network-wide infrastructure modernization, while the organization gradually expanded its digital agenda to encompass advanced technologies, workforce upskilling, and new business models. By 2023, digitalization efforts extended beyond core infrastructure to specific fields including predictive maintenance, automated fleet management, and

modular system architectures, illustrating a deliberate broadening of strategic domains. In the results it is also evident how DB is still in charge of both infrastructure and rail operations, in contrast to the demanded division of these two by the EU.

Regarding scale, infrastructure modernization retained prominence, though attention faded slightly in 2023, likely due to project completion or shifting priorities. Automation and innovation fluctuated, with peaks in 2019 and 2022 followed by consolidation phases, indicating cycles of experimentation and refinement. Cross-border collaboration and regulatory alignment grew steadily, with heightened focus on European networks and legislation around 2022, underscoring efforts to harmonize standards and leverage EU-wide interoperability. Operational scaling became increasingly evident through the rapid adoption and integration of digital maintenance tools and interlocking systems, which peaked in emphasis by 2023. Workforce digitalization also gained traction, reflecting systemic efforts to align human resources with technological advancements.

5.3.5 Svenska Järnvägar

Development Over Time (2019–2023)

Firstly, the prevailing trend that was evident in the case of SJ was that the emphasis on digitisation efforts remained constant throughout the period under consideration. The only exception to this trend is observed in the year 2023, where a marginal decrease is noted. In terms of scope, one of the primary elements of these was the fleet of trains. The investment in rail infrastructure is of great importance, encompassing both the physical assets and the technological systems that support them. The necessity to upgrade and modernise these components is a continuous and ongoing process. In addition, the relationship between Trafikverket is of mutual dependence, where Trafikverket oversees the maintenance of rail infrastructure. Moreover, there has been an increase in the number of code occurrences dealing with capacity issues relating to infrastructure over time. In addition, the recommendation was made for the federal government to make further investments in infrastructure, with a view to mitigating the issue under discussion. As a result, the recommendation was made for the federal government to make further investments in infrastructure, with a view to mitigating the issue under discussion.

In the preceding annual report, greater emphasis was placed on customer aspects in relation to technology and digitalization. For instance, the use of services such as the company's mobile application is intended to address customer needs whilst simultaneously enhancing the experience. The emphasis on leveraging digital technology was also directed towards internal operations. To illustrate this point, it is suggested in the annual reports that the use of digital technologies could increase the efficiency of employees by the use of automation. Above all, it underscores how SJ broadens

its scope by continually making digital investments, to satisfy customer needs, while also refining their internal operations.

Regarding scale, interoperability has been a consistent theme throughout the years. This is particularly evident in the context of the Fourth RWP, where SJ underscores the imperative for fair competition. As is often observed, Sweden was among the first to deregulate its railway market. However, many other countries have yet to follow suit. The impact of this delay on the competitiveness of SJ is potentially negative. Interoperability also encompasses adherence to EU standards, including ERTMS.

5.3.6 Differences and Similarities

DB and SJ are both advancing digitalization in rail operations, but their approaches differ. DB has shifted from broad, overarching digital strategies to a focused, project-based approach, targeting specific operational areas such as digital maintenance and interlockings. This mirrors the German federal model, emphasizing technological leadership and expanding digitalization to peripheral activities like multimodal mobility and fleet control.

In contrast, SJ's strategy is characterized by regulatory compliance and incremental innovation. Rather than pursuing radical transformation, SJ focuses on cost-effective retrofitting and extends deadlines for major projects like ERTMS implementation. The company also invests in new technology, such as 5G, which seeks to improve customer experience through improved connectivity. Despite some differences in comparison with Trafikverket's joint project on 5G with MORANE2, it illustrates ambition toward improved connectivity in 5G. Operating in a fully separated and liberalized market, SJ's efforts are shaped by a pragmatic response to funding constraints and the complexities of Sweden's fragmented rail governance.

Despite their differences, both companies are committed to digital modernization and participate in cross-border European initiatives, aiming for greater interoperability and efficiency. However, DB's approach is more radical and anticipatory of structural change, while SJ's is incremental and compliance-driven, shaped by market structure and governance realities.

6 Discussion

The following discussion interprets the key results of this thesis considering the theoretical framework and research question outlined earlier. By combining these two we gain an understanding of how digital strategy is formed throughout the organisation under review.

6.1 Strategic Tensions and Explicitness

The EU's digital rail strategy stands out for its high degree of explicitness, even as it addresses complex and deeply embedded challenges across the continent. Contrary to Røvik's (2016) view that complexity and embeddedness make practices difficult to articulate clearly, the EU achieves clarity by systematically breaking down multifaceted issues—such as economic, environmental, and technical goals—into clear, actionable components. These are then codified through binding laws, directives, technical standards, and detailed guidance documents, which minimize the risk of misinterpretation during national implementation. For example, Technical Specifications for Interoperability (TSIs) and operational manuals from the ERA translate complex requirements into practical, replicable frameworks. Robust governance mechanisms, including ERA oversight, standardized data collection via the Rail Market Monitoring Scheme (RMMS), and legal enforcement procedures, ensure that this explicitness is not only theoretical but actively monitored and enforced. As a result, the EU's digital rail strategy is both transparent and operational, enabling consistent and scalable implementation across diverse national contexts. The results show that EU has developed their strategy around renewing and connecting their infrastructure. This addresses the challenge of the aged and overused rail system. By being persistent they are working gradually to a better rail system across the Union. And finally, constantly using the mentioned mechanisms to re-work their RWP to react to new situations. Our findings show that the EU has identified that digitalization is a pre-requisite to prepare the transportation sector in the Union for the future. They tackle a complex task, while also creating a unique asset compared to other regions. The EU works on the basis for seamless transport by rail across borders in a seamless and efficient way.

Germany's approach to de-contextualization demonstrates a strong emphasis on systemic integration, with digitalization focusing on synchronized infrastructure and rolling stock upgrades, using long-term secured projects. To accomplish this, they re-thought the federal state system that was traditionally in charge of overseeing railway operations and infrastructure. This was basically creating a patchwork for operators. The current strategy is demonstrating a reproducing mode or copying of translation with elements of modification, maintaining close alignment with EU directives while emphasizing technological leadership and innovation. The Federal Rail Research Program explicitly supports rapid transfer of innovation into practice, by enabling field research and fostering an innovation friendly environment in Germany. Finally, Germany focusses on interoperability across its borders to neighboring states, positioning Germany as "a core country within European corridors" (Bundesregierung, 2025, p. 17). This is in line with the call for innovation, and interoperability from the EU.

Sweden, while similarly committed to EU alignment, presents a more implementation-focused approach. Trafikverket depends on EU funding for the projects and oversees the introduction of ERTMS, emphasizing improved punctuality and monitoring capabilities. Unlike Germany's broad digital platform focus, Sweden specifically prioritizes communication technology upgrades, for example from 2G to 5G through the MORANE2 project, creating "opportunities for ATO" (Ericsson, 2025). This approach mirrors Røviks (2016) Modifying mode, as Sweden is malleating the EU strategy to focus on specific technologies and their implementation, while receiving funding from the Union. In addition, given the focus from SJ on 5G implementation, where increase in connectivity is in focus, primarily to improve customer needs. Despite differences in terms of use and goals of MORANE2 compared with SJs 5G investments, they both indicate a trend towards 5G investments within the sector.

The most notable differences emerge in implementation timelines and governance approaches. While Germany mentions delays in some projects, Sweden has postponed full ERTMS deployment from the original EU timeline of 2035 to 2042. Sweden explicitly acknowledges "problems related to cost increase in infrastructure projects" (Prop. 2024/25:28), prompting increased government monitoring of spending. Germany's strategy, by contrast, emphasizes technological leadership and innovation without highlighting major implementation challenges, but plans to increase continuity in projects to decrease occurring implementation problems.

Both countries recognize digitalization's role in capacity enhancement but pursue this through different means: Germany through synchronizing infrastructure upgrades, and Sweden through reducing interlockings and therefore complexity "enabling areas of the railway sector to operate in larger sectors" (Trafikverket, 2025). This reflects different approaches to translation but with similar objectives within the common EU framework.

6.2 DB and SJ's Digital Strategy Contextualization

DB and SJ have translated EU digital rail directives into their operational strategies through distinct approaches, shaped by their national institutional contexts. Both align with EU goals like ERTMS adoption and interoperability but diverge in implementation modes (Røvik, 2016) and strategic focus (Bharadwaj et al., 2013).

6.2.1 Deutsche Bahn (Germany): Industrial Scaling and Systemic Integration

DB's results reflected the focused project approach on specific areas of digitalization, as can be seen with the decline of overarching codes like "digitalization" making way for more specific operational areas, such as "Digital Maintenance" and "Digital Interlockings". This is a direct copy of the federal approach, using projects to

implement and test a variety of technologies in the field. Topics like “Digital Automatic Coupling”, “Multimodal Digital Mobility”, and “Digital Fleet Control” show the company is widening its scope of digitalization to the periphery of DBs operations following the governments call for technological leadership. It also suggests that digitalization (x) is going away from buzzword characteristics and describes actual projects and efforts in the organization.

In terms of scale the results suggest a strategic shift in the companies’ approach to digitalization. While infrastructure and its modernization were highly apparent in the beginning a decline can be seen, while cross-border collaboration and regulatory alignment grew, plateauing in 2022. This suggests that DB is trying to play its geographical role, being in the middle of Europe with many neighbouring states, and at the same time reducing the communication of restoring infrastructure as precaution of a potential split up between the infrastructure and rolling stock division. DB being in charge of both disciplines is an omission of the EU requirement to separate infrastructure and operation managers into distinct operations. Potentially, this shift could be the preparation for a translation in Røviks (2016) radical mode, if the DB group prepares this split before the government pursues it. Finally, DB broadens the scope wider, by making sure that the workforce is prepared for the digital age in rail operations. All this being mostly copying from the source context and imprinting their own strategy by preparing for a potential split up, answering criticism regarding favoring DB’s subsidiaries in capacity allocation.

6.2.2 Statens Järnvägar (Sweden): Incremental Compliance and Cross-Border Pragmatism

SJ’s strategy emphasizes regulatory compliance and incremental innovation. It adopts ERTMS but extends deadlines to 2042 (Proposition 2024/25:28), prioritizing cost-effective retrofitting over systemic overhaul. SJ collaborates with external partners, yet avoids radical shifts, reflecting modifying mode translation. Unlike DB, SJ operates in a fully separated market, aligning with EU liberalization ideals, but struggles with funding gaps (e.g., €71 million CEF grant for Malmbanan ERTMS) and project delays due to Sweden’s fragmented governance (RiR 2018:21). In addition, it also aligns with how Czarniawska & Sevón (1996) stated that the strategy of SJ was redefined, where it at the same time follows the EU liberalization.

To summarize the translation modes observed across different governance levels and organizations, Table 3 provides an overview of how scope and scale are addressed in Germany and Sweden, and by their respective rail operators.

Table 3
Overview of translation rules in scope and scale by organization level

Translation Rules			
Row	Translation level	Scope	Scale
1	EU - Germany	Copying, Modifying	Copying
2	EU - Sweden	Modifying	Modifying
3	Germany - DB	Copying, Omitting	Copying, Radical
4	Sweden - SJ	Copying	Copying

Table 3 summarizes the dominant translation modes—copying, modifying, omitting, and radical—across the EU, national, and company levels for both Germany and Sweden. The table reveals a clear tendency towards copying as the main translation mode, particularly at the company level, with some instances of modifying, omitting, and radical adaptation. At the national level, Sweden modifies the EU’s strategic direction in both scope and scale, whereas SJ primarily copies the national approach in its own contextualization. In Germany, the national strategy combines copying and modifying, while DB predominantly copies but also employs omitting (in scope) and radical (in scale) modes. These findings highlight how institutional context and organizational autonomy influence the translation of digital strategies.

6.3 Wider Context and Systemic Implications

The study finds that while EU digital strategies are clearly articulated and widely endorsed at a high level, their implementation varies as they are interpreted and applied across different levels of governance. This is true for technical adjustments on the one hand but goes deeper and manifests itself in the reshape of the original strategic intent as policies are adapted locally.

At the national level, Germany tailors to the digital agenda of the EU by emphasizing coordination and innovation leadership, whereas Sweden keeps focusing on adaption and selective compliance. These approaches make sense given each country's institutional context, yet they mirror different understandings of which EU’s digital ambitions to follow, stemming from the deep integration of legacy systems and infrastructure.

More broadly, these patterns highlight the path-dependent nature of digital strategy implementation. National governance models, financial capacities, and institutional histories all shape how EU strategies are received and reinterpreted. While this analysis focuses on the rail sector, similar dynamics are likely to appear in areas like energy, healthcare, or telecommunications. The framework used here - combining Røvik’s theory of translation with Bharadaj et al.’s concepts of scope and scale - provides a focused view for analyzing digital strategy alignment in other complex,

multi-level systems. Additionally, this further demonstrates that the process of analyzing digital strategy is not limited to exclusively organizations, but rather multiple parties, as pointed out by Dąbrowska et al. (2022).

In conclusion, the coherence of EU's digital strategy would benefit from somewhat tighter enforcement and more importantly mechanisms that support mutual learning and policy alignment across member states. If not done correctly, the strategy to accomplish digital transformation is at risk of remaining fragmented, undermining both their effectiveness and the EU's broader integration goals.

7 Conclusion

7.1.1 Digital Strategy Translation in European Railways: From EU Policy to Operational Implementation

This study has examined how the EU's digital rail strategy is transferred and translated to railway operators in Europe, focusing on the translation processes from the EU to national contexts (Germany and Sweden) and subsequently to major rail operators (DB and SJ). By employing Røvik's (2016) translation theory alongside Bharadwaj et al.'s (2013) digital strategy framework of scope and scale, we have shown that while the EU sets a clear and technically articulated vision for digital transformation, the strategies that emerge at lower levels vary in content, intensity and strategic focus.

As our theory suggests, the translation of digital strategy is not a linear process. It is shaped by institutional contexts, organizational autonomy, and the interpretative flexibility of the strategy itself.

7.1.2 Theoretical Implications

This study demonstrates firstly that digital strategy can be researched in terms of translatability between different organizations. The translation of digital strategies varies significantly based on institutional contexts and strategic priorities. The EU achieves high explicitness despite complex cross-border challenges, expanding aspects of Røvik's (2016) framework which suggests that embedded practices are difficult to articulate clearly. This might come across as dichotomy but is not contradicting to each other. A clear strategy and framework cannot tear down decades of history in the rail sector that needs to overcome and worked on to enable a true European rail network.

Second, we identify distinctive patterns in how scope and scale dimensions of digital strategy are translated across governance levels. DB exemplifies scale-driven digital

strategy (Bharadwaj et al., 2013), prioritizing network-wide replication, while SJ focuses more on scope, embedding compliance into existing operations. These different approaches reflect the tension between faithfully reproducing EU standards and modifying them to fit national path dependencies.

Third, our analysis reveals that translation modes vary not only between organizations but also across the dimensions of scope and scale within the same organization. This nuanced finding extends Røvik's framework by showing that translation is not uniform across all aspects of a strategy but can vary based on specific strategic dimensions. The combination of Bharadwaj's (2013) definition of scope and scale and Røvik's (2016) translation modes creates a way of researching digital business strategy across organisations in a comprehensive manner to deeper understand the dynamics at work, forming the reality in Rail infrastructure from high level policy to performing rail service providers.

Regarding other fields this study establishes a new way of researching digital strategy across multiple organizational levels. It is shown that research can investigate complex issues travelling across organizations with our combined framework. The rail industry is an infrastructure heavy one with a complex regulatory environment and long legacy, similar to others like health care and the energy sector. Therefore, our framework could be used to investigate if these sectors are showing related effects as were discovered in this thesis.

7.1.3 Practical Implications

For policymakers at the EU level, our findings highlight the importance of explicit strategy articulation through detailed technical specifications and governance mechanisms to ensure consistent implementation. For national governments, the study demonstrates the need to balance faithful reproduction of EU directives with adaptations to local contexts and constraints.

Railway operators can learn from the contrasting approaches of DB and SJ. DB's project-based focus demonstrates how organizations can systematically implement digital initiatives while preparing for structural changes. SJ's incremental approach illustrates how companies operating with funding constraints can still advance digital transformation through targeted innovations and strategic partnerships.

In general, policy makers can take from our study that structured governance mechanisms (de-contextualization) are needed to minimize divergence in translation while maintaining a clear formulation of possible adjustments for contextualization in the subsequent countries and organizations.

7.1.4 Limitations and Future Research

As acknowledged in our methodology, this study is limited by the dynamic nature of digital strategies, which evolve rapidly in response to technological advancements. Strategies captured in this research may already be shifting as new technologies emerge. Additionally, our exclusive focus on the EU, Germany, and Sweden, limits the generalizability of findings to other regulatory environments. Finally, the limited size of the study only allowed for a small overview over ongoing activities rather than a holistic overview.

Future research should explore digital strategy implementation in railway sectors beyond the EU to identify potential differences in translation approaches. Furthermore, a longitudinal study would provide valuable insights into how translation processes evolve over time as technologies mature and institutional contexts change. Additional research could also examine how other stakeholders, such as technology providers and passenger associations, influence the translation process. We also identified fields that could be seen through our theoretical lens like, Governance, Financing, and Legislation. They all have a distinctive part in the development of digital strategy and could be analyzed more deeply in future research.

7.1.5 Final Remarks

The translation of the EU's digital rail strategy to railway operators exemplifies the complex interplay between supranational directives, national contexts, and organizational strategies. Our study reveals that this is not a straightforward implementation process but rather a multi-faceted translation shaped by institutional legacies, strategic priorities, and available resources. The divergent approaches of Germany/DB and Sweden/SJ highlight how similar EU directives can lead to different outcomes based on translation modes and strategic emphases.

By integrating Røvik's translation theory with Bharadwaj et al.'s digital strategy framework, this research provides a nuanced understanding of how digital transformation initiatives move through organizations, offering valuable insights for both theory and practice in an era of accelerating digitalization across critical infrastructure sectors.

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9 Appendices

Appendix A

The use of generative AI

We acknowledge the importance to be transparent about how generative AI has been used in this study. In this particular context, it is critical for us to establish and define the boundaries of how this technology should be used. Consequently, we have restricted its utilisation to two specific purposes. The first was to use it as a tool to complement a database such as SCOPUS, where additional relevant data could be found in a more accessible way. It is thus important to point out that the sources were rigorously checked for validity, as they were published in reputable journals and peer-reviewed. In essence, the utilisation of the technology is comparable to the way in which search engines work. The second use of generative AI was in relation to language and grammar, where it was used to improve the overall flow of the text. It is crucial to emphasise that its use was strictly limited to improving aspects of the text, rather than generating new sections of text. The net effect of these uses of generative AI was an enhancement of the language, which was beneficial to the reader. It is therefore clear that generative AI was used with extreme caution and with a clear definition of the boundaries of its use.

Appendix 1

Documents under review for European De-Contextualization⁵

Row	Type & Date	Title & Access
1	Commission Regulation 2014	Commission Regulation (EU) No 1299/2014 on the technical specifications for interoperability relating to the 'infrastructure' subsystem of the rail system in the European Union
2	Council Regulation 2014	Council Regulation (EU) No 642/2014 establishing the Shift2Rail Joint Undertaking https://eur-lex.europa.eu/eli/reg/2014/642/oj/eng
3	Directive 2008	Directive 2008/57/EC of the European Parliament and of the Council on the interoperability of the rail system within the Community https://eur-lex.europa.eu/eli/dir/2008/57/oj/eng
4	Directive 2016	Directive (EU) 2016/797 of the European Parliament and of the Council on the interoperability of the rail system within the European Union

⁵ Excluding The Four Railway Packages as listed in the Literature Part

		https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016L0797
5	Report 2016	ERTMS – Second Work plan of the European Coordinator https://transport.ec.europa.eu/document/download/32d91e34-557e-40f7-a6cd-e0fba765ab3e_en?filename=tent-coordinators-2nd-workplan-ertms.pdf&prefLang=it
6	Press Release 2023	Green Deal: Greening freight for more economic gain with less environmental impact https://ec.europa.eu/commission/presscorner/detail/en/ip_23_3767
7	Application Guide 2023	Guide for the application of the Technical Specifications for Interoperability (TSIs) https://www.era.europa.eu/system/files/2023-12/TSI_General_Guide.pdf?t=1714554085
8	Harmonised Standards	Rail system: Interoperability https://single-market-economy.ec.europa.eu/single-market/european-standards/harmonised-standards/rail-system-interoperability_en
9	Press Release	State aid: Commission opens in-depth investigation into German support measures in favour of DB Cargo https://ec.europa.eu/commission/presscorner/detail/en/ip_22_681
10	Act	White Paper: A strategy for revitalising the Community's railways https://eur-lex.europa.eu/EN/legal-content/summary/white-paper-a-strategy-for-revitalising-the-community-s-railways.html

Appendix 2

Documents under review for German De-Contextualization⁶

Row	Type & Date	Title & Access
1	Study by Technische Universität Dresden and hwh GmbH for BMVI (2020)	Development of a Concept for the EU wide Migration to a Digital Automatic Coupling System (DAC) for Rail Freight Transportation

⁶ Excluding The Four Railway Packages as listed in the Literature Part

2	Antwort der Bundesregierung (Answer of the Federal Government) (2025)	Digitalisierung der Schiene
3	Deutscher Bundestag (2023)	Entwurf eines Vierten Gesetzes zur Änderung des Bundesschienenwegeausbaugesetzes
4	Eisenbahn – Bundesamt (2017)	Nationaler Umsetzungsplan ETCS
5	Study of the BMDV (2024)	Neuausrichtung der Gesamtstrategie zur Digitalisierung der Schiene
6	Study of the BMVI (2015)	Road Map for Digital Design and Construction

Appendix 3

Documents under review for Sweden De-Contextualization⁷

Row	Type & Date	Title & Access
1	Article by European Commission (n.d.)	Railway packages. Directorate-General for Mobility and Transport (Accessed: 2025-04-23)
2	Article by Europe's Rail Joint Undertaking (n.d.)	About Europe's Rail (Accessed: 2025-04-17).
3	Article by Ericsson (2025)	Telia, Ericsson, and Trafikverket (Swedish Transport Administration) in Flagship European Innovation Project: From 2G to 5G on Swedish train routes (Accessed: 2025-04-18)
4	Proposition by Regeringen (2024)	The road to a reliable transport infrastructure – for a functioning Sweden. Proposition 2024/25:28. (Accessed: 2025-04-17)
5	Proposition by Regeringen (2004)	Proposal for a new Railway Act proposition 2003/04:123 (Accessed: 2025-04-17)
6	Article by Trafikverket (2025a)	Apply for funding from Connecting Europe Facility (CEF) (Accessed: 2025-04-22)

7	Article by Trafikverket (2025b)	Europe's Rail keeps moving forward (Accessed: 2025-04-23)
8	Article by Trafikverket (2025c)	European Rail Traffic Management System. (Accessed: 2025-04-19)

Appendix 4

Summary Table: DB annual reports Top Code Trends (2019–2023)

Row	Code	2019	2020	2021	2022	2023	Total
1	Digitalization	21	15	20	18	13	87
2	Infrastructure	12	10	10	12	7	51
3	Customer Focus	15	10	10	6	7	48
4	European Legislation	3	9	7	11	6	36
5	Automation	9	2	6	7	8	32
6	Innovation	8	5	8	9	2	32
7	European Network	3	4	7	9	7	30
8	Digital Maintenance	2	1	2	5	9	19
9	Digital Interlockings	0	0	4	3	4	11
10	Digital Rail	1	1	3	3	3	11
11	Digital Employees	0	2	3	3	2	10
12	Digital Technologies	5	2	1	0	0	8
13	Digital Transformation	1	2	3	2	0	8
14	Digital Business Models	0	0	3	2	0	5
15	Digital Operations	2	0	0	1	1	4
16	Digital Fleet Control	0	0	0	1	2	3

Appendix 5

Summary Table: SJ annual reports Top Code Trends (2019–2023)

Row	Code	2019	2020	2021	2022	2023	Total
1	Digitalization efforts	18	15	13	15	6	67
2	Digitalization	4	9	2	1	1	17

3	Automation	4	2	0	2	0	8
4	AI Codes	3	1	2	1	0	7
5	Digital solutions	1	0	6	0	0	7
6	Digital tools	4	1	1	1	0	7
7	Digital ambition	4	1	0	0	1	6
8	Digital Channels	1	3	2	0	0	6
9	Latest-technology trains	2	0	0	3	1	6
10	Digital Maintenance	0	3	2	0	0	5
11	Digital investments	1	1	0	2	1	5
12	Technology investment	0	0	3	2	0	5
13	Reduce technical barriers	1	2	1	0	1	5
14	Cyber Security	0	0	1	1	3	5
15	IT platforms	1	1	1	0	1	4
16	Digital recognition	3	1	0	0	0	4