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Financial Management and Risk Mitigation in Mega-Projects: A Longitudinal Study of Stuttgart 21 in Germany

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Abstract

The paper aims to explore the financial and risk management challenges in mega-projects, focusing on the interplay between these two domains. By examining the Stuttgart 21 project, a large-scale infrastructure initiative in Germany, the study seeks to provide insights into how effective risk management influences financial performance, offering practical recommendations for future mega-project management. The research adopts a case analysis approach, evaluating the Stuttgart 21 project using a longitudinal study of its financial performance through DuPont's financial model. The study also applies the resource-based view (RBV) and risk breakdown structure (RBS) frameworks to assess the project's risk management strategies. The study reveals that inadequate risk management correlates with poor financial outcomes, particularly in cost overruns and debt management. It identifies the gaps in the early stages of risk assessment and budgeting that contribute to these issues. Additionally, the findings highlight the need for better integration of technology and innovation in risk management to avoid scope creep and improve project success rates.

This research contributes to the literature by (1) providing a detailed financial analysis of a specific mega-project, (2) advancing the understanding of practical risk management in complex, multi-stakeholder projects, (3) linking financial performance with risk management strategies, and (4) offering a case-based approach to explore the dynamics of mega-project management. The study's recommendations have practical implications for policymakers and project managers in designing more resilient financial and risk management frameworks for future large-scale infrastructure projects.

Keywords: risk mitigation, Dupont analysis, risk break down structure

1. Introduction

In an increasingly dynamic and competitive global environment, project management has emerged as a critical tool for executing strategic initiatives, such as launching innovative products, advancing sustainability efforts, expanding supplier networks, or establishing efficient distribution systems. Project management provides the framework that ensures initiatives are completed on time, within budget, and to the required quality standards. Among the various types of projects that industries undertake, mega-projects stand out due to their size and complexity. Megaprojects usually involve billion-dollar budgets and coordination with many stakeholders (Shenoy and Mahanty, 2021). Recent trends indicate that megaprojects are not only increasing in size but are also being developed in greater numbers and at higher financial values. Such projects include large-scale transportation networks, energy facilities, and urban development initiatives. These undertakings affect millions of individuals, necessitate extensive planning and execution over several years, and involve numerous stakeholders, often operating on an international scale. It is widely acknowledged that megaprojects play a pivotal role in driving transformative societal change. Their impact is crucial as they influence both society and the economy. The McKinsey Global Institute estimates that global infrastructure spending amounts to $3.4 trillion per year from 2013 to 2030, equivalent to roughly 4% of the global gross domestic product, with most of it allocated to large-scale projects (Flyvbjerg, 2017). However, despite their ambitious goals, many mega-projects fail to meet expectations. The reasons for failure are often multifaceted.

Despite the growing body of literature (Ashkanani & Franzoi, 2022; Söderlund et al., 2017) on project and mega-project management, the failure of mega-projects remains a persistent challenge, with many mega-projects exceeding their budget and deadlines or failing to deliver the expected outcomes. Yet, in society, we see more companies or government agencies embark on more mega-projects. This phenomenon is encapsulated in the term "Mega Project Paradox." This paradox is prominently observed in various industries, including infrastructure, technology, and energy, where such projects' ambitious scale and objectives often lead to significant public and private investments. However, the high failure rate does not deter the launch of many new mega-projects. Large-scale projects usually act as pivotal drivers for innovation in infrastructure, technological progress, and economic development. However, despite the resources and planning involved, many of these projects suffer from significant delays, cost overruns, and underperformance.

Although much research (Hu et al., 2015; Locatelli et al., 2014) has explored specific factors contributing to these failures, several gaps still exist that prevent a complete understanding of why mega-projects so often falter. Mega-projects usually span many years, making it difficult to gather comprehensive data on their progression from inception to completion. There is a lack of longitudinal studies that track mega-projects over time to understand how early decisions impact long-term outcomes. These types of studies would provide a better understanding of how budgeting, stakeholder management, and scope creep issues evolve throughout the project lifecycle. Another less-discussed issue is innovation, technology, and data integration and how this impacts project risk management. Mega-projects often involve cutting-edge technology, yet there needs to be more research on effectively integrating these innovations into large-scale projects. Challenges in adopting new technologies, addressing technological uncertainty, data integration in the operational routine, and managing the risks associated with innovation require further exploration. Understanding how to balance the benefits and dangers of integrating technological advancements with appropriate risk management strategies in mega-projects remains a critical research gap. Governance and organizational structure play a crucial role in determining the success or failure of mega-projects, but the literature often needs more in-depth analysis. External factors such as global economic shifts, environmental challenges, and political instability can dramatically influence mega-projects. However, there is limited research on how to manage these external risks proactively. Studies (He et al., 2021) often focus on internal project management issues but overlook the broader context in which mega-projects operate. A deeper exploration of how mega-projects can be designed to adapt to and mitigate external shocks would be beneficial.

In this research, we use the case analysis approach to closely examine the Stuttgart 21 Project, a traffic and city infrastructure development mega project in Stuttgart, the capital of the state of Baden-Württemberg, in southern Germany. Since its initial announcement in 1994, the project started in 2010, and after 14 years of construction, it is still not completed. Using the resource-based view of the project along with risk management theory, we evaluate the longitudinal financial performance of the company that is responsible for the planning and execution of the project. Using DuPont's financial analysis, we assess how the project has managed its financial resources, including cost projections, budget adherence, revenue generation, and debt management over ten years. By doing so, the study seeks to identify key financial indicators and patterns that contribute to successful or poor financial outcomes in large-scale infrastructure projects. We further examine how risk management has been carried out in terms of assessing and mitigating risks throughout the project life cycles. Risk Breakdown Structure (RBS) and corresponding mitigation strategies could be designed and implemented to prevent the overrun of the triple constraints, i.e., scope, time, and cost. By correlating financial performance with the effectiveness of risk management strategies, the study aims to provide insights into how the two areas influence each other. This will offer a deeper understanding of how comprehensive risk management contributes to financial stability and project success. Through these analyses, we want to propose practical recommendations for improving financial and risk mitigation practices based on the findings from the case study. This will inform project managers, policymakers, and scholars on best practices for managing large-scale infrastructure projects.

The study contributes to the current literature on (1) financial management in mega projects. Mega projects are often plagued by budget overruns, excessive debt, and financial mismanagement, as documented in numerous studies (Flyvbjerg et al., 2003; Merrow, 2011). This study will expand upon this body of literature by providing a detailed case analysis of a specific mega project's financial performance. While prior research has primarily focused on project delays and cost escalations in general terms, this study offers an in-depth look at the financial strategies employed and the challenges encountered, allowing for a granular understanding of the financial dynamics at play in large-scale infrastructure projects. (2) advancing the understanding of risk management practices. Risk management is critical to the success of mega projects, and existing literature has identified common risk factors such as technical failures, regulatory delays, and environmental issues (Winch, 2010; Chapman & Ward, 2004). However, there remains a gap in the literature regarding the practical application and effectiveness of risk mitigation plans in real-world scenarios. This study addresses this gap by examining how risk identification and categorization translated into actionable mitigation strategies (or the lack thereof) in the focal case. This will contribute to the ongoing discourse on how to strengthen risk management processes in the context of complex, multi-stakeholder projects. (3) linking financial performance and risk management. Although previous studies have explored financial performance and risk management as separate domains, there has been limited exploration of the interplay between the two in mega projects (Zou et al., 2007). This study seeks to bridge that gap by analyzing how risk management practices directly influence financial outcomes, particularly in terms of cost containment, debt management, and contingency planning. Understanding this relationship is critical for scholars and practitioners aiming to improve the success rate of large infrastructure projects. (4) filling gaps in case study-based literature. Much mega-project literature is dominated by large-scale, cross-sectional studies or theoretical models (Flyvbjerg et al., 2014). While these approaches offer valuable general insights, they often fail to capture the nuanced challenges that arise in specific projects. This research employs a case analysis method to provide a rich, context-specific exploration of financial and risk management practices, contributing to the growing body of case-based studies that offer actionable lessons for future projects. (5) practical implications for policy and practices. The findings from this study have direct implications for policymakers, project managers, and stakeholders involved in mega-projects. By identifying gaps in financial and risk management practices and proposing recommendations for improvement, the study will provide guidance on how to develop more effective strategies to ensure the success of future projects. This is particularly important given the increasing scale and complexity of modern infrastructure projects, which require more sophisticated management techniques.

2. Literature Review

Megaprojects operate within a highly complex, dynamic, and unpredictable environment characterized by instability, non-linearity, irregularity, and uncertainty. These projects are typically developed and executed over extended timeframes and involve multifaceted decision-making processes spanning various scopes and disciplines (Ashkanani & Franzoi, 2022). The project success and failure factors have been discussed extensively in the literature. Verzuh, (2021) identified five essential characteristics consistently found in successful projects, which include agreement among the project team, customers, and management on the project’s goals; a plan showing an overall path and clear responsibilities that can be used to measure progress during the project; constant, effective communication among everyone involved in the project; a controlled scope; and management support. Mišić and Radujković (2015) analyzed the critical factors that can affect mega-project success or failure through an extensive literature review in addition to well-documented megaprojects from some well-known research centers, and tried to understand whether mega-project success or failure can be well-quantified through critical factors. They grouped the success factors into four categories: legal, risk, political, and project management, totaling twelve factors. As for the failure factors, they have also identified three different categories: strategy, ineffective risk allocation, and close communication, along with nine individual factors. They further suggest research on competence development and stakeholder management to better understand their influence on project success. Wang et al., (2022) conducted an extensive review of studies on the success criteria and critical success factors (CSFs) for mega infrastructure construction projects (MICPs) from journal articles between 2000 and 2018 to identify the publication trend of success criteria and CSFs for MICPs and summarize the findings of success criteria and CSFs studies of MICPs. Their review identified 20 success criteria grouped into five constructs and 36 CSFs grouped into five categories and, respectively, integrated them into two conceptual frameworks. The top five CSFs were adequate resource availability, partnering/relationships with key stakeholders, adequate communication and coordination among related parties, public support or acceptance, and clear strategic vision. Three implications, namely, evaluation indicators, relationships between CSFs and the success of MICPs, and human-related factors, are highlighted in future research. He et al., (2021) adopted mixed research methods, such as literature review, case studies, and expert interviews, and identified eleven driving factors, namely, government support, public support, accumulation and application of technology and experience, development and innovation of technology, innovation, and application of management system, organizational mode and structure, top management support, project culture, megaproject citizenship behavior, corporate reputation, and fulfillment of social responsibilities. They further grouped these factors into five categories: project environment, construction capabilities, organization, positive culture and behavior, and requirements for sustainable development. Shenoy and Mahanty (2021) also recognized that a vast proportion of global megaprojects have not performed up to the expectations of their stakeholders and set out to identify nineteen success factors of megaprojects. These success factors were integrated into a fuzzy-based model to develop the megaproject readiness metric. They claimed that the readiness-based model and metrics provided stakeholders valuable insights into a megaproject's strong and weak areas and helped stakeholders prioritize and systematically eliminate the identified weaknesses and improve megaproject readiness. Hu et al., (2015) discussed the use of a program management approach to improving the performance of a construction megaproject through the coordinated management of its constituent projects. They provided a pragmatic program management framework that can fully address clients' requirements in managing construction megaprojects. Based on a case study of the Shanghai Expo construction, this study aims to identify the principal program organization factors (POFs) that are determinants of the program organization established by a client to manage a megaproject. Consequently, twelve principal POFs are identified and grouped under three main categories (environmental capability, core capacity, and motivational capability of the client's program organization to manage its construction megaproject).

Some researchers also examine operational factors related to megaprojects. Wang et al., (2019) evaluated the relationship between relational quality and megaproject success. Based on the survey data from 172 respondents, partial least square structural equation modelling was used to test the proposed structural model. Their study validated the role of relational quality in promoting megaproject success. To address the usual delay in the megaproject, Eduardo Yamasaki Sato and De Freitas Chagas, (2014) redefine the project lead time for megaproject success. They propose redefining the project lead time concept to encompass the time between the project's initial idea and the moments in which success is being assessed, which can be beyond the project close-out. They further suggest that the conventional project life cycle does not count for the long-term effects of the megaproject, which can have a significant impact on the perception of success. Thus, the megaproject life cycle should include a considerable part of the operational life cycle of the end product or result, and the criteria of success should consist of the long-term benefits of the projects measured over various years after the delivery of the end product or result. Researchers also focus on single critical factors, such as stakeholder management in large construction projects, using questionnaire surveys to improve project performance in the Qatari construction industry (Mashali et al., 2023). However, Ashkanani and Franzoi (2022) argue a gap exists between the existing literature and current practices in the industry for the development and execution of megaprojects. The existing literature generally focuses on individual elements applicable to project management but lacks system consideration. Burtonshaw-Gunn (2016) argues that risk management and finance on construction projects are becoming increasingly crucial to achieving the objectives of the investor, the end-user, and the constructor and its supply chain. Risk and Financial Management in Construction shows the relationship between the Construction Project Manager's task of balancing time, cost, and quality and the need to satisfy the client's requirements efficiently, effectively, and professionally while at the same time contributing to the contractor's future sustainability.

In project management literature, there needs to be more analyses grounded in rigorous financial methodologies, such as the DuPont Model, to uncover the operational margin, potential tax, and interest burdens over extended operational periods. Researchers frequently revert to critical factors and key performance indicators to gauge project performance. However, integrating financial performance analysis with risk management strategies for mega-projects can offer more accurate projections, enabling managers to manage and adjust project trajectories proactively.

3. Methodology

This study employs a case study methodology to explore why mega-projects fail. This approach is selected for its capacity to provide an in-depth and contextual analysis of complex issues, offering detailed insights that might be obscured in broader quantitative studies. To understand the longitudinal financial performance, the five-step DuPont model analysis was conducted to reveal the operational efficiency, tax, and interest burden along with the leverage factor. Data for this research are primarily derived from secondary sources, which include publicly available financial data and other relevant documents. The selection of secondary data sources was guided by their relevance, credibility, and accuracy, ensuring that the information utilized was reliable and applicable to the research objectives.

The analysis of the collected data involves a qualitative examination of the case project, using a project management framework and integrating insights from secondary data and financial records to construct a comprehensive narrative. The analytical process includes thematic analysis to identify and analyze critical themes and patterns from the secondary data and financial information and comparative analysis of financial metrics and contextual information to draw relevant conclusions about the project.

3.1 Stuttgart 21: A Mega-Project

Stuttgart 21 is a traffic and city infrastructure development project in Stuttgart, the capital of the state of Baden-Württemberg, in southern Germany. The project aimed to modernize and reconfigure Stuttgart's existing railway station. The name "Stuttgart 21" comes from the idea that the new station meets the demands of the 21st century. The central part of Stuttgart 21 involved converting the existing terminal station into an underground station. The underground station is designed to reduce traffic congestion and more effectively accommodate high-speed trains. The new underground design also helps free up valuable space for urban development and green spaces in Stuttgart's city center. The region around Stuttgart is well known for its strong high-tech industry. Because of this, many working people use the train to travel to their workplace. The project team estimates that more than ten million passengers will benefit from the reduced travel times after the completion of the project (Überblick Stuttgart 21, n.d.). Stuttgart 21 has experienced multiple delays and cost adjustments throughout its development. The project was initially announced in 1994 by Deutsche Bahn (DB), Germany's leading railway company, which owns most of the country's rail stations and network. After the project announcement, Deutsche Bahn, the German Government, State Baden-Württemberg, and Stuttgart conducted a feasibility study (Die Machbarkeitsstudie, 1996). Over 100 experts in different fields supported the study. Construction began in 2010, 16 years after the project was first announced. The Stuttgart 21 project was initially planned to be completed in 2019 at an estimated cost of €2.45 billion (Stuttgart 21: Chronologie der Kostenexplosion, 2024). The project received financial support from the German Government, the state of Baden-Württemberg, and DB. However, the project faced various challenges, including funding issues, environmental concerns, and protests. Despite these setbacks, DB continued to pursue the completion of the project, which is now expected to be finished in 2026 at an updated cost of more than €11 billion (Houben, 2024).

3.2 Scope and Duration of the Project

In the 1980s, discussions began about improving Stuttgart's railway infrastructure. The existing Stuttgart main railway station was considered outdated and unable to handle the increasing demand for rail travel in Germany. Many ideas and concepts for rail system transformation were evaluated during the early planning stages. On April 18, 1994, former CEO of Deutsche Bahn and Baden-Württemberg's Prime Minister Erwin Teufel officially presented the project at a press conference (Stuttgart 21: Eine Ausführliche Chronologie, n.d.).

The proposed project aimed to achieve several main goals: establishing a rail connection to the airport, retaining the old main station's location, supporting urban development, and implementing a high-speed train route. Following the project announcement, a feasibility study was conducted with the support of over 100 experts from various fields representing Deutsche Bahn, the German Government, the state of Baden-Württemberg, and the city of Stuttgart. The study was presented in 2016, and after its completion, the project was initiated with an estimated cost of €2.45 billion (Die Machbarkeitsstudie, 1996).

Before starting the actual project, the experts from the feasibility study were instructed to carry out a "Pre-Project" to gain more technical and economic insights. The initial plan aimed to begin construction in 2001 and complete the project by 2009, but these plans were quickly discarded. The appointed new CEO of DB temporarily halted the project in 1999. It took several years until a final decision for Stuttgart 21 was made, and the parliament of Baden-Württemberg voted overwhelmingly for its completion (Landtag von Baden-Würrtemberg Entschließung von Stuttgart 21, 2006). Before construction in 2010, all investors had signed a financial agreement in 2009.

3.3 Stakeholder, Ownership, and Budget Issues

On March 30, 2009, seven major entities who financed the project signed an agreement on cost allocation for the Stuttgart 21 project (Finanzierungsvertrag, 2009). The stakeholders involved in funding of the project can be divided into two categories. The first category consists of all corporations affiliated with Deutsche Bahn (DB) and Airport Stuttgart GmbH, and the second category consists of political stakeholders such as the State of Baden-Württemberg and the city of Stuttgart. The financial agreement outlines each stakeholder's specific investments in the project. In addition to these investments, the German Government and the European Union will provide funding. However, Deutsche Bahn is responsible for executing the project. The project's estimated total cost is €3.076 billion, which exceeds the estimated cost of the feasibility study conducted in 2016. The financial agreement also addresses potential cost adjustments for the project, detailing the actions to be taken if the total cost falls below or exceeds the estimated €3.076 billion. If the total cost exceeds this estimated amount, Deutsche Bahn will invest up to an additional €220 million, whereas the state of Baden-Württemberg, the city of Stuttgart, and the Stuttgart Airport GmbH would invest up to €780 million to cover a potential increase of €1 billion. The financial agreement also stipulates that if an "unlikely cost increase" of over €1 billion, the stakeholders would invest an additional €450 million. The financial agreement contractually regulates a cost increase of up to €1.45 billion as the risk buffer. In terms of the further increase in cost, the agreement also stipulates that all the subsidiaries of DB will enter talks with the state (Finanzierungsvertrag, 2009).

The unclear definition of the solution for overspending the budget has led to a dispute over who should bear the additional unforeseen costs. DB wants Baden-Wurttemberg (BW) to share the additional cost, while BW believes DB should bear the costs (Prozess: Wer zahlt die Milliarden-Mehrkosten von Stuttgart 21, 2023). This difference has led to a legal complaint and dispute, which has significant negative consequences on the project, delaying the progress. In addition to the seven entities invested in the project, Stuttgart 21's stakeholders encompass a diverse spectrum, including environmental advocates, residents, taxpayers across Germany (who contribute to project funding), and passengers who benefit from enhanced railway infrastructure. The project's delays have exacerbated frustrations among stakeholders, particularly those anticipating improvements in regional transportation.

3.4 Project Management and Project Team

Stuttgart 21 is one of the largest construction projects in Germany. Because of this, the management approach for Stuttgart 21 involves using multiple subsidiaries structured under GmbH entities, akin to LLCs in the US. This unique strategy deviates from traditional project team management principles. Each phase of the project has been entrusted to a distinct subsidiary. Throughout its evolution, Stuttgart 21 has witnessed variability in leadership across subsidiaries, characterized by differing managerial styles and strategic orientations over time. This variability challenges consistency in decision-making and strategic alignment across the project's duration (Ursprung and Chronologie, n.d.).

Moreover, the workforce assigned to Stuttgart 21 has demonstrated significant growth, from an initial team of ten employees to approximately 500 personnel. This expansion underscores the evolving demands for specialized expertise and capacity as the project progresses through its various phases and complexities while contributing to the dramatically increased project cost. Given the multi-decadal lifespan of Stuttgart 21, effective management practices are crucial, with a diverse skill set encompassing engineering, geological, biological, and financial expertise to address the project's technical, environmental, and economic complexities. The roles of CEO, CTO, and CFO within DB Projekt Stuttgart-Ulm GmbH exemplify the project's structured oversight, reflecting a corporate-like governance approach tailored to effectively manage the project's strategic, technical, and financial dimensions (Über Uns: DB Projekt Stuttgart–Ulm GmbH, n.d.)

Traditional project team management principles emphasize stability and continuity in team composition to foster cohesion and operational efficiency (Verzuh, 2021). However, the frequent turnover in subsidiary leadership roles and varying team sizes may impede the development of a cohesive, long-term project team. The management of Stuttgart 21 through subsidiaries presents a departure from conventional project team management principles, offering both advantages in flexibility and autonomy, alongside challenges in leadership continuity and inter-subsidiary coordination. This approach underscores the project's unique challenges and emphasizes the need for adaptive management strategies to ensure long-term success.

3.5 Deutsche Bahn- Financial Analysis

Deutsche Bahn AG, a public limited company (Aktiengesellschaft), has employed a unique subsidiary structure involving GmbHs (limited liability companies) to manage the Stuttgart 21 project. This setup exempts the subsidiaries from publishing individual financial statements, consolidating their results into Deutsche Bahn AG's overall financial reporting. We analyze Deutsche Bahn AG’s financial statements to provide insights into its capability to finance Stuttgart 21. The three major financial statements, i.e., balance sheet, income statement, and cash flow statement with ten years record (2022 Integrated Report, 2022), provide us the opportunity to use rigorous financial analysis tools such as the five-step DuPont model to evaluate the operational efficiency along with tax and interest burden given the challenging financial conditions this project experienced in a decade.

Deutsche Bahn AG has demonstrated consistent revenue growth over the years, overcoming challenges such as the pandemic downturns in 2020 and 2021, and returned to profitability with a positive EBIT of €1.27 billion in 2022. The balance sheet shows steady growth in both current and non-current assets, with a proportional increase in liabilities and a recovery in equity following a temporary decline in 2020, underscoring the company's improving financial position. Additionally, the cash flow statement reveals a growing cash and cash equivalents position, reaching €5.14 billion in 2022, while persistent negative cash flow from investing activities suggests significant ongoing investments in non-current assets, likely including projects like Stuttgart 21.

3.6 Five-Step DuPont Model Analysis

Return on equity (ROE) is a crucial financial metric that measures a company's ability to generate profit from its shareholders' equity. While more public investment in projects demands the demonstration of return on investment, which is a more broadly used synonym of the return on equity concept, the DuPont analysis would provide insight into how effectively a company uses its equity capital to generate profits. The DuPont Model, as a cornerstone of financial analysis, provides a comprehensive framework for assessing a company's return on equity (ROE) by breaking it down into its constituent components. Developed by the DuPont Corporation in the 1920s, this extended model breaks down ROE into five distinct components, i.e., net profit margin, interest burden, tax burden, asset turnover, and financial leverage, offering a nuanced view of how different elements of financial performance contribute to overall profitability. Given the highly leveraged nature of many mega-projects and their extended duration, the Five-Step DuPont Model offers a detailed perspective on financial performance, highlighting areas of strength and identifying potential issues within the company's financial structure. This model provides a new perspective on the problems related to the over-budget.

The result of the DuPont Model is shown in Figure 1. The chart is notable for the high leverage value with consistently low Return on Equity (ROE) and Return on Assets (ROA). In both 2015 and 2020, the operating profit margin was negative, signifying substantial financial distress experienced by the project during these periods. The high leverage value also indicates the potential interest payment risk. We further explore the individual factors, such as tax burden and interest burden, as well as overall cost increase over the years. The interest burden is the value of EBT divided by the EBIT, so if no interest is paid, the interest burden will be 1, the benchmark value shown in Figure 2. In 2015 and 2021, the project experienced an extremely high-interest burden, with the Interest Burdan value reaching 6 and 2.64, respectively. To put into perspective, if a company was making $6 million in earnings before interest and tax, after paying the interest, it would have only $1 million left, i.e., the interest accounts for about 83% of operating income, an unsustainable financial situation. As the peak in the interest burden periods aligns with the peak tax burden periods, as indicated in Figure 3, the project has been receiving tax rebates or tax credits from the government to deal with the high-interest burden.

Another dimension of the project's financial outcomes is the escalating costs associated with labor and materials. Despite this upward trend, a noteworthy reduction in administrative expenses was observed in the year 2019, as illustrated in Figure 4.

In 2021 and 2022, material costs experienced notable increments of 25% and 18%, respectively. Such substantial increases are particularly impactful given the extensive scale of the project. Over ten years, labor costs have consistently risen at an annual rate of 5%. This steady rate, when compounded over the long duration of the project, will considerably augment the overall labor expenditure.

These financial results would provide the project manager with a longitudinal understanding of the project and, therefore, have better reactive strategic adjustment during the execution.

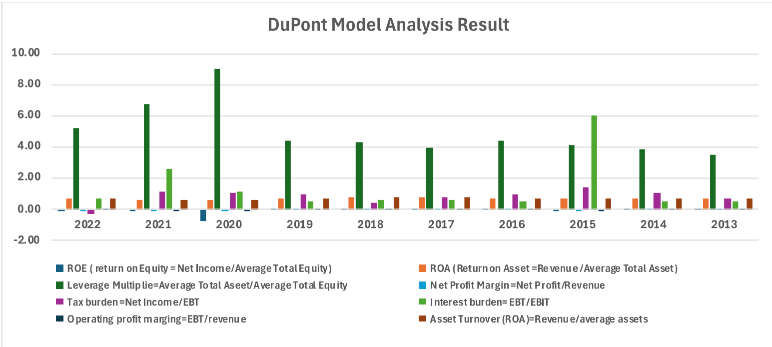

Figure 1. DuPont analysis result for 2013-2022

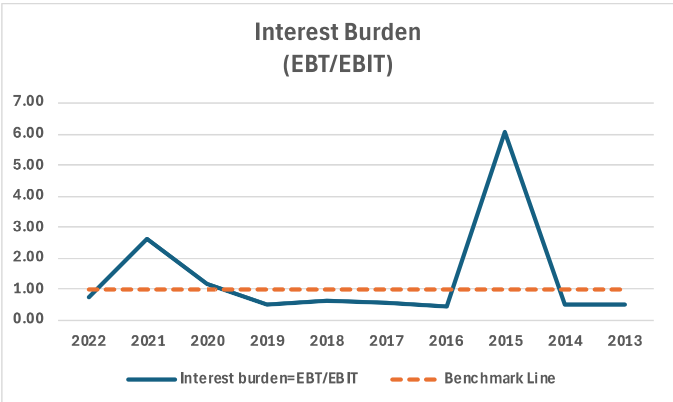

Figure 2. Interest burden

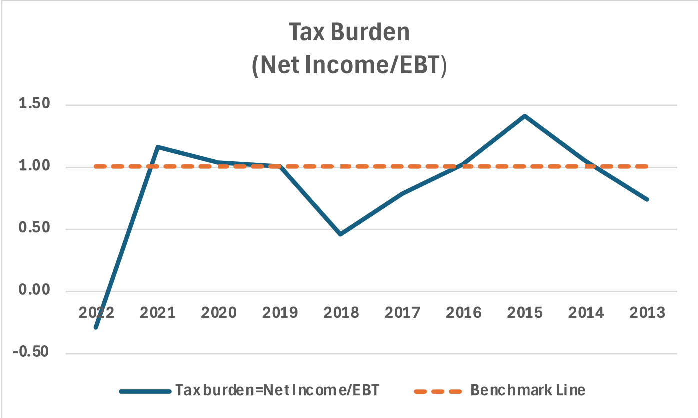

Figure 3. Tax burden

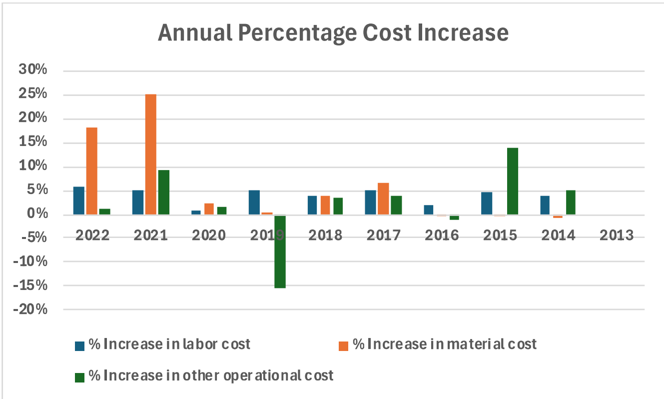

Figure 4. Annual percentage cost increase

3.7 Risk Management

The Stuttgart 21 project has faced significant challenges in risk management and financial forecasting. We analyze the project's risk identification, financial planning, and impact on stakeholder dynamics.

In 2011, DB ProjektBau GmbH, the organization responsible for overseeing Stuttgart 21, conducted a comprehensive risk assessment, which culminated in a detailed 132-page report. The identified risks were categorized into four clusters (A, B, C, and D) based on their probability of occurrence and potential financial impact. Clusters A and B encompassed risks with a likelihood greater than 50%, whereas Clusters C and D contained risks with probabilities below 50%. A total of 121 risks were identified: 23 in Cluster A, 10 in Cluster B, 28 in Cluster C, and 60 in Cluster D. Each risk was analyzed using a structured template, which included identifiers, cluster classifications, financial impact estimates, probability assessments, and concise descriptions of conditions and consequences (Chancen und Risiken, 2011). What needs to be added to the risk categorization is the adoption of a risk breakdown structure. A Risk Breakdown Structure (RBS) (Hillson, 2003) is a hierarchical framework that categorizes risks by source, enabling project teams to organize and assess risk factors more comprehensively. By breaking down risks into specific categories, RBS provides a structured approach to risk management. More importantly, RBS elucidates the complex interplay between different risk factors. By grouping risks based on their sources, project teams can identify interconnected risks that may escalate or compound one another. This holistic view is critical for understanding how a delay in procurement, for instance, may simultaneously trigger financial and operational risks.

The innovative technology and large volume of data involved in the project also create more challenges in risk management. However, those issues were not explicitly identified in the risk management practices. Another notable issue with the project risk management is that the report did not provide detailed mitigation strategies or financial contingency plans for the identified risks. Without incorporating effective risk mitigation measures or cost estimates, the utility of such risk management practices becomes limited.

The financial framework for Stuttgart 21, including a fixed cost ceiling of €4.526 billion, was formalized in 2009, with construction commencing the following year (Finanzierungsvertrag, 2009). However, a comprehensive risk analysis conducted in 2011 identified potential additional costs exceeding €2 billion due to various project risks (Chancen und Risiken, 2011). Despite external experts raising concerns about possible cost overruns, Deutsche Bahn's delayed disclosure of these risks likely influenced public sentiment and political decision-making. The challenges encountered by DB underscore the inherent complexities of managing large-scale infrastructure projects and emphasize the critical need for robust risk management frameworks to mitigate financial overruns and prevent stakeholder conflicts.

4. Findings, Discussion, and Limitations

Besides the significant financial and risk management issues discussed in the previous sections, the construction of Stuttgart 21 project has sparked considerable controversy and criticism regarding its environmental impact and stakeholder engagement. The project involves constructing an underground rail station and tracks, freeing up the ground space for redevelopment. Deutsche Bahn plans to utilize this space to expand the adjacent park and undertake extensive reforestation efforts by planting thousands of trees in areas previously occupied by train tracks. Despite these efforts, concerns have been raised by environmental organizations regarding the project's compliance with European Union laws protecting wildlife. Specifically, destroying habitats crucial to protected species like lizards has led to legal challenges and temporary halts in construction (Stuttgart 21 und Artenschutz, n.d.).

Since its inception, Stuttgart 21 has been met with vigorous public opposition and protests (Kaiser & Windmann, 2010). Key grievances voiced by protesters include apprehensions over the project's environmental repercussions, substantial cost escalations, perceived deficiencies in public consultation processes, and skepticism regarding its fundamental purpose and benefits. Although protests peaked in 2010, dissent and activism persist, reflecting ongoing discontent within the community.

The Stuttgart 21 project exemplifies the intricate interplay between infrastructure development, environmental conservation, and community interests. Effective management of environmental impacts, robust stakeholder engagement, and transparent communication are pivotal to navigating challenges and fostering broader acceptance of the project's outcomes. Reconciling divergent stakeholder perspectives and addressing environmental concerns will be critical in shaping Stuttgart 21's legacy and contribution to regional development and connectivity.

Extremely high debt level caused the project to use 83% of its operating earnings to pay for interest costs. While the interest payment may seem like an obvious cause for the financial struggle the project has experienced, the more important question is what project management practice leads to the exorbitant level of debt? What could project managers do differently to keep the project under budget?

Risk analysis provided a thorough categorization of potential risks and impact, but not mitigation strategy was provided, making the risk management inexecutable.

In addition to the substantial financial and risk management challenges outlined in previous sections, the Stuttgart 21 project has also been a focal point of significant controversy surrounding its environmental impact and stakeholder engagement. The project entails constructing an underground rail station and tracks, thereby freeing up surface space for redevelopment. Deutsche Bahn has proposed using this space to expand the adjacent park and undertake reforestation efforts, including planting thousands of trees in areas previously occupied by railway infrastructure. While these initiatives represent an effort to mitigate environmental damage, concerns persist among ecological organizations regarding the project's adherence to European Union regulations designed to protect wildlife. Specifically, destroying habitats essential for protected species, such as lizards, has prompted legal disputes and temporary construction halts (Stuttgart 21 und Artenschutz, n.d.).

Beyond environmental concerns, the Stuttgart 21 project has been met with widespread public opposition and protests since its inception (Kaiser & Windmann, 2010). Key grievances expressed by protesters include fears over the project's environmental consequences, substantial cost overruns, inadequate public consultation processes, and doubts about the project's overall purpose and benefits. Although the protests peaked in 2010, public dissent and activism persist, signaling ongoing discontent within the community.

From a project management perspective, the Stuttgart 21 project underscores critical shortcomings in both financial management and risk mitigation planning. One of the most pressing issues is the exceedingly high debt burden, which has resulted in 83% of the project's operating earnings being allocated to interest payments in some years. While these interest payments contribute to the financial strain, the more profound issue lies in the project management practices that led to such a high debt level. A key question arises: what could have been done differently in the early stages of the project to prevent budget overruns and excessive borrowing?

Despite the detailed risk analysis conducted in 2011, which provided a thorough categorization of potential risks and their financial impacts, the absence of a comprehensive risk mitigation plan rendered the risk management process ineffective. Identifying risks without implementing corresponding mitigation strategies leaves the project vulnerable to unforeseen challenges and financial overruns. In this case, the lack of a proactive approach to managing both financial risks and environmental concerns has not only strained the project's budget but also undermined public trust and stakeholder support. The Stuttgart 21 project thus serves as a cautionary tale of the need for a holistic and integrated approach to managing large-scale infrastructure developments. Beyond financial planning, effective project management must incorporate robust risk mitigation strategies, transparent communication with stakeholders, and careful consideration of environmental impacts. Failure to address these key areas can lead to significant financial burdens, ecological degradation, and a loss of public confidence. The legacy of Stuttgart 21 will ultimately depend on the extent to which these challenges are acknowledged and addressed in its final implementation and long-term outcomes.

It is important to recognize that reliance on secondary data and publicly available financial information introduces certain limitations, such as inherent biases within the sources and the absence of primary data collection. This study mitigates these limitations by cross-verifying data from multiple sources, thereby enhancing the accuracy and reliability of the findings.

Another notable limitation of this study pertains to the use of case study methods, which may impede the generalizability of the findings to other mega-projects. Each mega-project operates within unique socio-political, economic, and environmental contexts, making broad generalizations challenging.

Additionally, we acknowledge that the analysis may have simplified certain aspects of the mega-project due to the absence of primary data or detailed project-specific information. Mega-projects are characterized by complex interdependencies, and secondary data may not fully capture the nuanced factors that influence project outcomes.

5. Conclusion

In conclusion, this study aims to contribute to the broader literature on mega-project management by providing an in-depth case analysis of financial performance and risk mitigation strategies. By addressing gaps in the current understanding of how these two domains intersect and offering practical recommendations for improvement, this research is poised to inform both academic discussions and real-world practices in the management of large-scale infrastructure initiatives.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal and publisher adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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Appendix 1. Income Statement

(€ million)	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
STATEMENT OF INCOME										
Revenues	56,296	47,075	39,901	44,430	44,065	42,693	40,557	40,403	39,728	39,107
Overall performance	60,425	50,959	43,465	47,596	47,156	45,593	43,298	43,102	42,422	41,756
Other operating income	4,541	5,901	3,439	3,030	2,998	2,954	2,834	2,772	2,824	2,853
Cost of materials	-33,623	-28,419	-22,757	-22,262	-22,258	-21,457	-20,101	-20,208	-20,250	-20,414
Personnel expenses	-20,300	-19,219	-18,297	-18,152	-17,301	-16,665	-15,876	-15,599	-14,919	-14,383
Depreciation [1)]	-3,998	-3,804	-5,372	-3,671	-2,688	-2,847	-3,017	-4,471	-3,190	-3,228
Other operating expenses [1)]	-5,777	-5,716	-5,235	-5,157	-6,088	-5,890	-5,677	-5,750	-5,057	-4,817
Operating profit/loss (EBIT)	1,268	-298	-4,757	1,384	1,819	1,688	1,461	-154	1,830	1,767
Result from investments accounted for using the equity method	-5	-10	-21	-12	12	14	33	22	8	3
Other financial result	20	48	-91	-36	-14	-30	-16	0	-3	-15
Net interest income [1)]	-351	-528	-615	-655	-645	-704	-772	-800	-898	-879
Profit/loss before taxes on income	932	-788	-5,484	681	1,172	968	706	-932	937	876
Net profit/loss for the year	-227	-911	-5,707	680	542	765	716	-1,311	988	649
Dividend payment (for previous year)	–	–	650	650	450	600	850	700	200	525

Appendix 2. Balance Sheet

BALANCE SHEET AS OF DEC 31	**2022**	**2021**	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**
Non-current assets [1)]	59,044	56,149	52,964	53,213	46,646	45,625	45,290	45,199	45,530	43,949
thereof property, plant and equipment and intangible assets [1)]	55,122	52,487	49,994	50,485	44,487	43,207	42,575	42,821	43,217	41,811
Current assets	17,259	15,694	12,471	12,615	11,881	10,811	11,034	10,860	10,353	8,945
thereof cash and cash equivalents	5,138	4,591	3,411	3,993	3,544	3,397	4,450	4,549	4,031	2,861
Equity	14,679	10,621	7,270	14,927	13,592	14,238	12,657	13,445	14,525	14,912
Equity ratio [1)] (%)	19.2	14.8	11.1	22.7	23.2	25.2	22.5	24.0	26.0	28.2
Non-current liabilities [1)]	39,145	39,631	37,686	32,820	29,104	27,510	28,525	28,091	28,527	26,284
thereof financial debt [1)]	3,186	30,322	27,070	23,977	20,626	19,716	20,042	19,753	19,173	18,066
thereof pension obligations	2,970	5,031	6,517	5,354	4,823	3,940	4,522	3,688	4,357	3,164
Current liabilities	22,479	21,591	20,479	18,081	15,831	14,688	15,142	14,523	12,831	11,698
thereof financial debt [1)]	4,087	4,164	6,254	4,716	2,618	2,360	2,439	2,675	1,161	1,247
Net financial debt [1)]	28,827	29,107	29,345	24,175	19,549	18,623	17,624	17,491	16,212	16,362
Total assets total [1)]	76,303	71,843	65,435	65,828	58,527	56,436	56,324	56,059	55,883	52,894

Source of all financial statements: *Deutsche Bahn 2022 Integrated Report*. (2022). Deutsche Bahn AG.