

Article

Risk Analysis in Building Renovations: Strategies for Investors

Daniel Macek *  and Stanislav Vitásek 

Department of Construction Management and Economics, Faculty of Civil Engineering, Czech Technical University in Prague, 166 29 Prague, Czech Republic; stanislav.vitasek@fsv.cvut.cz

* Correspondence: daniel.macek@fsv.cvut.cz; Tel.: +420-2-2435-4529

Abstract: This study explores the diverse array of risks inherent in building renovation investments and proposes effective strategies for risk mitigation tailored to investors. Through a combination of qualitative analysis, expert interviews, and quantitative risk quantification techniques, the research identifies and evaluates key risk factors across regulatory, financial, technical, market, and other domains. Thorough due diligence, proactive stakeholder engagement, and contingency planning emerge as critical components of effective risk management in renovation projects. The study underscores the importance of proactive risk mitigation in enhancing project success and investor returns. By providing investors with a comprehensive understanding of the challenges they may face and practical strategies for addressing them, this research aims to empower stakeholders to make informed decisions and achieve positive outcomes in building renovation investments, ultimately contributing to a more resilient and sustainably built environment.

Keywords: building renovation; construction projects; investment; risk analysis; risk mitigation strategies



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1. Introduction

At the end of 2021, the European Commission proposed a revision of the bloc's Energy Performance of Buildings Directive (EPBD) with the aim of boosting the moribund renovation rate and tackling a third of the EU's carbon dioxide emissions [1,2]. The directive has now been adopted by member countries, paving the way for national renovation plans.

The Czech Republic faces the challenge of accelerating building renovations in order to achieve ambitious energy efficiency and decarbonization goals. Only 1% of buildings are comprehensively renovated annually [3,4], which is an insufficient pace compared to the requirements of the recently updated Energy Efficiency and Energy Performance of Buildings Directives which emphasize the need to double the pace of renovations [5].

The Directive on the energy performance of buildings serves as a means of preparing the European building stock for emission-free operation by 2050. It prescribes the renovation of poorly functioning public and private buildings [6,7].

The transformation of our built environment stands as a cornerstone in the global pursuit of sustainability and resilience. Amidst this imperative, investments in building renovations and operations emerge as critical avenues for progress. These investments not only hold the promise of enhancing energy efficiency and reducing carbon footprints, but also present opportunities for revitalizing communities and improving the quality of life [8].

Nevertheless, the path toward realizing these benefits is fraught with risks and uncertainties. Financial volatility, regulatory fluctuations, technological disruptions, and market dynamics collectively shape the landscape of risk in building renovation and operation investments. Understanding and effectively managing these risks are imperative for ensuring the success and sustainability of such endeavors.

This paper undertakes a thorough examination of the multifaceted risks inherent in investments in building renovations and operations. It endeavors to dissect the complexities of risk, from the macroeconomic factors influencing investment decisions to the micro-level challenges encountered during project execution. By illuminating these risks through

empirical evidence and theoretical frameworks, this study aims to provide stakeholders with a nuanced understanding of the challenges they face.

Drawing on insights from industry best practices, innovative approaches, and lessons learned from past experiences, it offers a roadmap for navigating the uncertainties inherent in building renovation and operation investments.

Ultimately, this research seeks to contribute to the body of knowledge surrounding sustainable urban development by shedding light on a critical yet understudied aspect of the built environment. By empowering investors, policymakers, and practitioners with the knowledge and tools to effectively manage risks, we aspire to foster a more sustainable and resilient future for generations to come.

2. Literature Review

Across Europe, there is a growing recognition of the imperative need for building renovation. This heightened focus is spurred by several factors, notably the aging infrastructure prevalent throughout the continent [9]. Additionally, there is a pressing demand for environmentally sustainable buildings, driven by the imperative to reduce energy consumption and curb greenhouse gas emissions to mitigate the adverse impacts of climate change. Simultaneously, there exists a compelling need to enhance the quality of life, addressing social sustainability concerns such as improving indoor climate conditions. Moreover, improving productivity within the construction sector is paramount to ensuring the economic sustainability of renovation endeavors, particularly in the pursuit of affordable housing solutions [10].

The construction industry has grappled with issues of low productivity and frequent conflicts, prompting a surge of interest in novel collaborative approaches among stakeholders. Strategic partnerships, especially concerning portfolios of renovation projects, are increasingly viewed as promising avenues for achieving more sustainable building renovation outcomes. Particularly for major building clients and companies with advanced collaborative practices, these partnerships offer potential pathways to optimize project efficiencies and outcomes [11,12].

While numerous tools exist for design decision support and systems for certifying building sustainability, the focus on renovation-specific tools and systems remains relatively limited [13]. Measuring the multifaceted dimensions of sustainability in renovation projects presents a considerable challenge, underscoring the need for tailored approaches and methodologies. Regulatory frameworks play a pivotal role in catalyzing markets for sustainable building renovation, often through incentive schemes and stringent building codes [14].

Traditionally, energy renovation efforts have prioritized enhancements in heating, lighting systems, and insulation. However, there is a discernible shift toward a more holistic approach, one that encompasses broader social objectives alongside energy efficiency considerations [15]. This evolving perspective underscores the dynamic nature of sustainable building renovation practices, with a growing emphasis on addressing diverse societal needs and aspirations.

Enhancing energy efficiency in the building sector is crucial for advancing European and global efforts to combat the prevailing climate crisis. Extensively implementing deep renovation measures holds the potential for substantial reductions in global energy demand, estimated at up to 36% [16]. However, the expansion of the building renovation market remains constrained, primarily due to uncertainties surrounding the assessment of risks [17].

Effectively ensuring safety during deep building renovation projects is a complex endeavor, primarily due to factors such as the project's interactions with its environment, constraints related to space and access, and the unpredictability of existing building conditions. While digital tools like Building Information Modeling (BIM) have been extensively utilized to enhance safety in new construction projects, their application in deep renovation contexts has received comparatively less attention in research [18]. To address this gap, this paper adopts a Design Science Research (DSR) methodology to develop an ontology specifically tailored for identifying and representing hazards in deep building renovations. Through the instantiation of this ontology into a digital tool and subsequent testing using

real industry data from deep renovation projects within the Horizon Europe 2020 research initiative, RINNO, the study demonstrates its efficacy in hazard identification [19]. By focusing on a case study involving multi-residence apartments and multiple renovation scenarios, the research successfully showcases the tool's capability to automatically pinpoint the potential hazards associated with specific renovation strategies. While the immediate application of the proposed ontology aims to mitigate safety risks in building retrofit projects, its broader implication lies in paving the way for future digitally enabled safety management approaches within the realm of building renovation [20–22].

The built environment significantly contributes to climate change, with new construction responsible for a quarter of global greenhouse gas emissions, while heating existing buildings adds another third. Despite this, current directives predominantly focus on new construction, despite a growing emphasis on renovation. Notably, 90% of the European building stock pre-dates 1990, with new residential construction growing at an estimated annual rate of 1% [23]. Balancing a low-energy standard with cost efficiency in existing buildings poses a significant challenge, necessitating comprehensive life cycle assessment (LCA) and life cycle cost analysis (LCC) [23]. Integrated approaches of LCA and LCC have been increasingly applied in building renovation studies, revealing a nexus where renovation strategies are both environmentally friendly and cost-effective. However, the decision-making process for renovation strategies is hindered by the long service life of buildings and associated uncertainties, spanning design and exogenous parameters [24]. These uncertainties, including those related to building operation, component service lives, climate evolution, and economic factors, significantly influence the outcomes of LCA and LCC analyses, sometimes overshadowing the differences between distinct renovation solutions [25,26].

Recent regulations and scientific research underscore the significance of conducting comprehensive Life Cycle Assessments (LCAs) for building renovations. The imperative to evaluate the environmental and economic implications of construction projects—from inception to demolition—has elevated LCA as a foundational analytical tool. By prioritizing LCA analyses, stakeholders in the construction industry can gain valuable insights into the long-term sustainability and viability of their renovation endeavors. This strategic integration of life cycle perspectives not only facilitates informed decision-making but also empowers industry professionals to optimize resource allocation and minimize environmental impacts across the building lifecycle [27].

The European Union's regulatory framework mandates Long-Term Renovation Strategies (LTRSs) to drive the energy transition of existing building stocks, underlining the critical role of whole-life carbon assessment and cost effectiveness in building renovation processes. This regulatory focus aligns with the integration of building performance simulation (BPS) tools and life cycle thinking (LCT) methodologies as promising avenues for evaluating renovation projects. However, challenges persist, notably the performance gap stemming from occupant behavior (OB) and economic scenario uncertainty, posing significant barriers to the accurate assessment of residential building renovation strategies. Addressing these complexities is pivotal for enhancing the efficacy and sustainability of renovation initiatives within the residential sector [28].

The existing building stock significantly contributes to non-renewable resource depletion, energy consumption, material usage, and greenhouse gas (GHG) emissions. To mitigate these impacts, Life Cycle Analysis (LCA) procedures have been developed in recent years. LCA assesses the environmental impact of buildings throughout their entire life cycle, including construction and operational phases. Additionally, the economic, environmental, and social consequences of recent natural disasters have prompted the integration of hazard-induced impacts into LCA procedures. This adaptation acknowledges that buildings must provide safe living and working conditions, even when subjected to hazards such as floods or earthquakes during their service life [29].

Thus, next-generation LCA procedures should encompass not only hazard-induced impacts, but also the contributions of potential retrofitting strategies. These strategies can modify the structural and energy performance of buildings throughout their remaining

service life, enhancing their resilience and sustainability. Integrating these considerations into LCA will provide a more comprehensive evaluation of a building's environmental footprint and its capability to withstand and recover from natural disasters [30].

Building renovation poses significant challenges that often result in high cost and schedule overruns, primarily due to unforeseen complexities and unpredictability inherent in renovation works. One of the main challenges is the disruption caused to occupants, which complicates planning and management efforts. This disruption can lead to dissatisfaction and resistance from those living or working in the building, further complicating the renovation process. Research underscores the importance of addressing these challenges by improving planning and management strategies to maintain the building's functionality and minimize inconvenience to occupants. Enhanced strategies are essential for mitigating cost and schedule overruns, and ensuring successful renovation outcomes [31].

Managing deep renovation projects presents significant challenges due to their interactions with the surrounding environment, limited access and space, and uncertainties about the composition and condition of existing buildings. These factors create complex situations where the interplay between different building areas, the elements involved in the renovation, and various renovation scenarios and activities introduce significant safety risks. Although digital approaches like Building Information Modeling (BIM) have been extensively researched for enhancing safety in new construction projects, there is a lack of focused research on their application in deep building renovation projects. This gap underscores the need for more studies to develop effective digital safety management strategies specifically for deep renovations [32].

Recent renovation activities in Switzerland, encompassing both single-family and multi-family buildings, underscore the importance and drivers of stepwise building renovation. This approach is driven by the need for manageable financial investments, minimized disruption to occupants, and the ability to adapt to evolving energy standards and technologies over time. However, significant obstacles exist, including challenges in implementing comprehensive energy-related renovations and planning long-term phased measures. Analyses of these drivers, alongside the shortcomings and advantages of phased renovation, are encapsulated in a SWOT analysis. The exploration of stepwise renovation's sustainable implementation reveals strategies to meet ambitious energy demand and greenhouse gas reduction targets. Additionally, policy measures are identified to enhance the sustainability of stepwise building renovations, ensuring they align with existing energy and greenhouse gas objectives [33].

The deep renovation of buildings is widely recognized as essential for achieving sustainable development objectives, particularly in reducing energy consumption, enhancing energy efficiency, and mitigating greenhouse gas emissions. In the context of the European Union (EU), however, the current pace of deep renovation in residential buildings falls short of what is needed to meet ambitious climate and energy targets set for the coming years. This gap highlights challenges such as financial constraints, regulatory barriers, technical complexities, and the need for behavioral changes among building owners and occupants. Overcoming these obstacles requires concerted efforts from policymakers, stakeholders, and the construction industry to promote and incentivize deep renovation initiatives. By accelerating the rate of deep renovation, the EU can not only contribute significantly to its climate commitments, but also foster economic growth, improve indoor comfort and health, and enhance the overall sustainability of its building stock [34].

Sustainable development stands as a critical imperative for the future of our society, emphasizing the need to balance environmental, social, and economic considerations in all facets of human activity. In the Architecture, Engineering, and Construction (AEC) industry, sustainable practices are paramount, influencing the design, construction, and operation of both new buildings and the renovation of existing structures. The renovation of office buildings, a cornerstone of the built environment, holds immense potential for advancing sustainability goals. By refurbishing older buildings with energy-efficient systems, sustainable materials, and modern technologies, renovations can substantially reduce carbon footprints and energy consumption while enhancing occupant comfort and

productivity. Moreover, sustainable renovations contribute to reducing operational costs over time, improving building resilience against climate change impacts, and revitalizing urban spaces. This approach not only supports environmental stewardship but also aligns with global efforts to mitigate climate change and achieve sustainable development targets set by international agreements. By embracing sustainable renovation strategies, the AEC industry can play a pivotal role in creating healthier, more efficient, and resilient built environments that benefit society as a whole [35,36].

3. Materials and Methods

At the onset of the risk analysis process, the primary task involves identifying and categorizing the array of risk factors relevant to building renovation investments. These encompass a broad spectrum of potential challenges, ranging from regulatory uncertainties, such as changes in building codes or zoning regulations, to financial constraints like cost overruns or funding limitations, as well as technical risks, including structural deficiencies or unexpected complications during the renovation process. By systematically discerning and evaluating these diverse risk factors, investors can develop a comprehensive understanding of the potential obstacles they may encounter throughout the investment lifecycle. Quantitative analysis techniques are subsequently employed to quantitatively assess the likelihood and impact of the identified risk factors on the overall success of building renovation investments.

As part of the qualitative analysis, an expert group was set up, the aim of which was to identify the risks associated with the renovation of buildings from the investor's point of view. Risk identification took place in the form of brainstorming within the entire group. Before the actual brainstorming, the experts were familiarized with the literature review presented in this article, so that they had time to prepare their own thoughts for their own brainstorming. Simultaneously with the identification of risks, the expert group also dealt with the area of mitigating the impact of risks. The expert group was assembled in such a way that the expertise, practice and experience of the people were as wide and diverse as possible, but at the same time, that the topic affected them professionally.

The qualitative analysis group consisted of 24 seasoned professionals and stakeholders with extensive experience in building renovation investments. This diverse group included five architects and engineers specializing in architectural design, structural engineering, and building systems, providing insights into the technical aspects and feasibility considerations of renovation projects. Additionally, four real estate developers with a track record of successful renovation projects offered perspectives on market dynamics, financial feasibility, and project management. Four regulatory authorities, such as representatives from local government agencies or regulatory bodies responsible for enforcing building codes and zoning regulations, provided insights into regulatory requirements and compliance challenges. Five contractors and construction managers, involved in the execution of renovation projects, offered insights into construction methods, labor considerations, and on-site challenges. Three environmental consultants, experts in environmental sustainability and green building practices, provided insights into environmental regulations, energy efficiency strategies, and sustainable materials. Two financial advisors specializing in real estate finance, investment analysis, and risk management offered insights into financial feasibility, funding options, and risk assessment. Finally, one community stakeholder, representing community organizations, neighborhood associations, or advocacy groups, provided insights into local community dynamics, social impacts, and community engagement strategies. This diverse group of experts provided a comprehensive range of perspectives on the various aspects of building renovation investments, enabling a thorough examination of the associated risks and potential mitigation strategies. Their collective expertise enriched the qualitative analysis process and contributed to the development of informed decision-making frameworks for building renovation projects.

The results of the qualitative analysis are the basis for the quantitative analysis. Quantitative analysis took place in the form of a questionnaire, where the interviewees determined for

each risk its probability of occurrence and impact on the project. The results were statistically evaluated. Experts from qualitative analysis and another 73 respondents took part in the questionnaire survey. The structure of the respondents is as follows: 24 architects and engineers, 14 real estate developers, 16 regulatory authorities, 18 contractors and construction managers, 8 environmental consultants, 10 financial advisors, and 7 community stakeholders.

Chronbach's Alpha test was used to determine the consistency of data in the questionnaire. The analysis was carried out separately for the probability of occurrence and separately for the impact of the risk.

Ethical principles, including informed consent, confidentiality, and voluntary participation, were upheld throughout the research process. Participants were provided with clear information about the purpose of the study, and their consent was obtained prior to data collection. Confidentiality of responses was maintained, and data were anonymized to protect participants' identities.

4. Risk Identification and Mitigation Measures

The qualitative analysis revealed a comprehensive list of the 15 most significant risks that are prevalent in building renovation investments. A description and mitigation measures are given for each risk. Recommendations for risk mitigation are based on brainstorming by an expert group for qualitative analysis.

1. Regulatory Risks:

Description: Changes in building codes, zoning regulations, and environmental standards can significantly impact renovation projects, potentially causing costly delays or fines.

Mitigation Measures:

- Stay Informed: Regularly monitor relevant authorities and industry publications for updates.
- Ensure Compliance: Establish a compliance team or hire legal experts to ensure adherence to building codes, zoning regulations, and environmental standards.
- Maintain Communication: Keep open communication channels with regulatory authorities to address any potential compliance issues promptly.

2. Financial Risks:

Description: Building renovation projects often involve substantial financial investments, with risks of cost overruns, funding constraints, or fluctuations in construction costs.

Mitigation Measures:

- Conduct Thorough Analysis: Perform detailed financial analysis and feasibility studies before initiating renovation projects to accurately assess costs and potential returns.
- Develop Financial Plans: Create comprehensive budgeting and financial planning strategies, including contingency funds for unexpected expenses.
- Diversify Funding Sources: Consider alternative financing options to mitigate reliance on a single funding stream.

3. Technical Risks:

Description: Renovation projects may encounter technical challenges such as structural deficiencies, unforeseen complications, or issues with outdated building systems.

Mitigation Measures:

- Detailed Inspections: Conduct thorough property inspections and assessments before starting renovation work to identify potential technical challenges.
- Hire Experts: Engage qualified and experienced architects, engineers, and contractors with expertise in building renovation.
- Project Management: Implement robust project management practices, including regular progress monitoring and quality control measures, to address technical issues promptly.

4. **Market Risks:**
Description: Fluctuations in the real estate market, changes in demand for renovated properties, or shifts in economic conditions can impact the profitability of renovation projects.
Mitigation Measures:
 - Stay Informed: Monitor market trends, demand dynamics, and economic conditions through regular research and analysis.
 - Maintain Flexibility: Plan and design projects with the ability to adapt to changing market conditions.
 - Diversify Portfolios: Consider diversifying investment portfolios across different property types or geographic regions to spread market risk.
5. **Legal Risks:**
Description: Legal issues such as disputes with contractors, violations of building codes, or breaches of contract can arise during renovation projects.
Mitigation Measures:
 - Review Contracts: Ensure all agreements are reviewed by legal experts and include clear provisions for dispute resolution and compliance with building codes and regulations.
 - Maintain Documentation: Keep accurate records of all project activities and communications to mitigate the risk of legal disputes.
 - Legal Guidance: Establish strong relationships with legal advisors and seek their guidance throughout the project lifecycle.
6. **Stakeholder Risks:**
Description: Renovation projects involve multiple stakeholders, including contractors, suppliers, tenants, and local communities, and conflicts among stakeholders can disrupt project timelines and increase costs.
Mitigation Measures:
 - Effective Communication: Foster positive relationships with stakeholders through open communication, transparency, and collaboration.
 - Address Concerns: Actively engage with local communities and address stakeholder concerns to build support for renovation projects.
 - Contingency Plans: Develop plans to manage stakeholder conflicts or disputes and ensure project continuity.
7. **Environmental Risks:**
Description: Renovation projects may have environmental impacts such as pollution, waste generation, or habitat disruption.
Mitigation Measures:
 - Sustainable Practices: Incorporate sustainable design principles and green building practices into renovation projects to minimize environmental impact.
 - Environmental Assessments: Conduct assessments and adhere to regulatory requirements for waste management, pollution prevention, and habitat conservation.
 - Partner with Experts: Collaborate with environmental experts and organizations to implement eco-friendly solutions and promote environmental stewardship.
8. **Schedule Risks:**
Description: Delays in obtaining permits, unexpected construction challenges, or changes in project scope can lead to schedule delays.
Mitigation Measures:
 - Realistic Schedules: Develop project schedules with built-in buffers for potential delays and setbacks.
 - Monitor Progress: Regularly monitor project progress and identify potential schedule risks early to implement corrective measures promptly.

- Collaborative Communication: Maintain open communication with contractors, suppliers, and other project stakeholders to address scheduling issues collaboratively.
9. **Economic Risks:**
Description: Economic downturns, inflation, or changes in interest rates can affect the financial feasibility of renovation projects.
Mitigation Measures:
 - Economic Analysis: Perform comprehensive economic analysis and scenario planning to assess potential impacts of economic fluctuations.
 - Financial Reserves: Establish reserves or contingency funds to cushion the impact of economic downturns or inflationary pressures.
 - Diversify Investments: Spread investment portfolios across different asset classes or industries to mitigate economic risk.
 10. **Supply Chain Risks:**
Description: Disruptions in the supply chain, such as material shortages, labor strikes, or transportation delays, can impact project timelines and costs.
Mitigation Measures:
 - Identify Risks: Evaluate potential supply chain risks, including material shortages and transportation delays.
 - Alternative Sources: Establish alternative supply sources and backup plans to mitigate the impact of disruptions.
 - Communication: Maintain open communication with suppliers and logistics partners to address supply chain issues proactively.
 11. **Quality Risks:**
Description: Ensuring the quality of renovation work is crucial, as poor workmanship, substandard materials, or inadequate quality control can lead to defects, rework, or safety issues.
Mitigation Measures:
 - Quality Assurance: Implement stringent quality assurance protocols and standards.
 - Regular Inspections: Conduct inspections and quality control checks throughout the renovation process.
 - Training and Support: Provide ongoing training and support to contractors and workers to maintain high-quality standards.
 12. **Reputation Risks:**
Description: Negative publicity, public backlash, or damage to the investor's reputation can result from renovation projects perceived as harmful to the community or environment.
Mitigation Measures:
 - Ethical Practices: Prioritize ethical business practices, social responsibility, and environmental sustainability.
 - Engage Communities: Engage with local communities and stakeholders to address concerns and promote positive perceptions.
 - Transparent Response: Respond promptly and transparently to any negative publicity or reputation challenges and take corrective actions as needed.
 13. **Insurance Risks:**
Description: Renovation projects may be exposed to various insurance risks, including property damage, liability claims, or construction-related accidents.
Mitigation Measures:
 - Comprehensive Coverage: Obtain insurance coverage tailored to the specific risks associated with renovation projects.
 - Review Policies: Regularly review insurance policies to ensure adequate coverage and compliance.

- Insurance Advisors: Work closely with insurance brokers and advisors to assess needs and identify risk mitigation strategies.
14. Technology Risks:
Description: Incorporating new technologies or innovative construction methods into renovation projects can introduce risks such as compatibility issues, system failures, or cybersecurity threats.
Mitigation Measures:
- Risk Assessments: Conduct thorough risk assessments and due diligence before implementing new technologies or methods.
 - IT Security: Invest in robust IT security measures, including encryption, firewalls, and malware detection software.
 - Training: Provide training and support to project teams to ensure proper use and maintenance of technology tools and systems.
15. Operational Risks:
Description: After completion, renovated buildings may face operational risks such as maintenance challenges, tenant turnover, or changes in market demand.
Mitigation Measures:
- Operational Plans: Develop comprehensive operational plans and maintenance schedules.
 - Resource Allocation: Allocate sufficient resources and staffing for ongoing maintenance and operational activities.
 - Market Trends: Stay informed about market trends and changes in tenant preferences to adapt strategies and maximize returns on investment.

5. Quantitative Analysis

In conjunction with the aforementioned methods, the risk quantification process employed a diverse approach to assess both the likelihood and potential impact of identified risk events. Through these methods, probabilities were assigned to each risk event, and their potential consequences on project objectives were evaluated. Finally, a risk matrix was used to categorize and prioritize risks based on their probability and impact scores.

Numerical values corresponding to the probability of occurrence and potential impact of each risk are individually assigned based on Tables 1 and 2. To mitigate bias, an even number of qualification steps is deliberately chosen in the table, avoiding assumptions about the neutrality of the mean. It is important to note that risks categorized with lower classification levels often exhibit a higher probability of occurrence but are rated with lower severity, and vice versa. Essentially, a higher probability of occurrence typically correlates with a lower impact, and vice versa. However, exceptions to this rule may occur, as is common in risk assessment scenarios.

Table 1. Probability of risk occurrence.

Description of the Risk Assessment	Description of Frequencies of Occurrence	Classification
Unlikely	The occurrence is unlikely	1
Very unlikely	Insignificant frequency	2
Not very likely	Occasional occurrence	3
Probably	Frequent occurrence	4
Very likely	Very common occurrence	5
Almost certainly	A regular occurrence	6

As part of the qualitative analysis, the experts who participated in the qualitative analysis were approached again to evaluate the selected risks in terms of the probability of their occurrence and the severity of the impact on the project. Each risk was assigned an average value from all ratings rounded to a whole number.

Table 2. Impact of risk.

Impact	Solution Description	Classification
Unimportant	No priority	1
Low	Low priority	2
Medium	The solution is not urgent	3
High	Priority	4
Very high	Urgently	5
Catastrophic	Without delay	6

Table 3 summarizes the evaluation results.

Table 3. Risk matrix.

Risk Description	Probability	Impact
1. Regulatory Risks	5	5
2. Financial Risks	4	6
3. Technical Risks	4	4
4. Market Risks	5	5
5. Legal Risks	3	6
6. Stakeholder Risks	2	4
7. Environmental Risks	4	5
8. Schedule Risks	5	4
9. Economic Risks	3	6
10. Supply Chain Risks	2	3
11. Quality Risks	3	5
12. Reputation Risks	2	5
13. Insurance Risks	3	4
14. Technology Risks	1	5
15. Operational Risks	3	3

The risk map in Figure 1 provides a visual representation of the probability of occurrence and the impact of individual risks on the project. The columns represent the probability levels, while the rows indicate the impact levels of the risks. Each risk is classified based on its probability and impact, as quantified in the previous chapter.

		Probability of risk occurrence					
		1	2	3	4	5	6
Impact of risk	1						
	2						
	3		10	15			
	4		6	13	3	8	
	5	14	12	11	7	1, 4	
	6			5, 9	2		
Risk intensity		I		II		III	

Figure 1. Risk map.

Additionally, the risk matrix is color-coded into three zones, each indicating risks with different intensity levels. Risks in Zone I represent the lowest intensity, while those in Zone III represent the highest intensity. The colors assigned to each zone correspond to the risk intensity values from I to III. This color-coded scheme helps stakeholders quickly identify and prioritize risks based on their severity and likelihood of occurrence.

Chronbach's alpha for the probability of risk occurrence is 0.763 and Chronbach's alpha for impact of risk is 0.782. From the point of view of data consistency evaluation, it can be stated that the results are acceptable.

Tables 4–10 show the risk matrix for individual groups of respondents.

Table 4. Architects and engineers risk matrix.

Risk Description	Probability	Impact
1. Regulatory Risks	4	4
2. Financial Risks	3	5
3. Technical Risks	5	5
4. Market Risks	3	4
5. Legal Risks	2	4
6. Stakeholder Risks	2	3
7. Environmental Risks	3	4
8. Schedule Risks	4	4
9. Economic Risks	3	4
10. Supply Chain Risks	2	3
11. Quality Risks	4	5
12. Reputation Risks	3	4
13. Insurance Risks	2	4
14. Technology Risks	2	4
15. Operational Risks	3	3

Table 5. Real estate developers risk matrix.

Risk Description	Probability	Impact
1. Regulatory Risks	5	5
2. Financial Risks	5	6
3. Technical Risks	4	4
4. Market Risks	5	6
5. Legal Risks	4	5
6. Stakeholder Risks	3	4
7. Environmental Risks	4	4
8. Schedule Risks	4	5
9. Economic Risks	4	6
10. Supply Chain Risks	3	4
11. Quality Risks	3	4
12. Reputation Risks	3	5
13. Insurance Risks	4	4
14. Technology Risks	2	5
15. Operational Risks	3	4

Table 6. Regulatory authorities risk matrix.

Risk Description	Probability	Impact
1. Regulatory Risks	5	5
2. Financial Risks	4	5
3. Technical Risks	4	5
4. Market Risks	4	5
5. Legal Risks	5	6
6. Stakeholder Risks	3	4
7. Environmental Risks	5	5
8. Schedule Risks	4	4
9. Economic Risks	4	6
10. Supply Chain Risks	3	3
11. Quality Risks	4	5
12. Reputation Risks	4	5
13. Insurance Risks	3	4
14. Technology Risks	2	5
15. Operational Risks	4	4

Table 7. Contractors and construction managers risk matrix.

Risk Description	Probability	Impact
1. Regulatory Risks	4	4
2. Financial Risks	4	5
3. Technical Risks	5	5
4. Market Risks	4	5
5. Legal Risks	4	5
6. Stakeholder Risks	3	3
7. Environmental Risks	4	4
8. Schedule Risks	5	4
9. Economic Risks	4	5
10. Supply Chain Risks	3	4
11. Quality Risks	5	5
12. Reputation Risks	3	5
13. Insurance Risks	4	4
14. Technology Risks	3	5
15. Operational Risks	3	4

Table 8. Environmental consultants risk matrix.

Risk Description	Probability	Impact
1. Regulatory Risks	5	4
2. Financial Risks	4	5
3. Technical Risks	3	4
4. Market Risks	4	5
5. Legal Risks	3	5
6. Stakeholder Risks	3	3
7. Environmental Risks	5	5
8. Schedule Risks	4	4
9. Economic Risks	3	5
10. Supply Chain Risks	3	3
11. Quality Risks	4	4
12. Reputation Risks	3	5
13. Insurance Risks	3	4
14. Technology Risks	2	5
15. Operational Risks	3	4

Table 9. Financial advisors risk matrix.

Risk Description	Probability	Impact
1. Regulatory Risks	5	5
2. Financial Risks	5	6
3. Technical Risks	3	4
4. Market Risks	5	6
5. Legal Risks	4	5
6. Stakeholder Risks	2	3
7. Environmental Risks	4	4
8. Schedule Risks	4	5
9. Economic Risks	5	6
10. Supply Chain Risks	3	4
11. Quality Risks	3	4
12. Reputation Risks	3	5
13. Insurance Risks	4	4
14. Technology Risks	2	5
15. Operational Risks	4	4

Table 10. Community stakeholders risk matrix.

Risk Description	Probability	Impact
1. Regulatory Risks	5	5
2. Financial Risks	4	6
3. Technical Risks	3	4
4. Market Risks	5	5
5. Legal Risks	3	5
6. Stakeholder Risks	3	4
7. Environmental Risks	5	5
8. Schedule Risks	5	4
9. Economic Risks	3	6
10. Supply Chain Risks	2	3
11. Quality Risks	4	5
12. Reputation Risks	3	5
13. Insurance Risks	3	4
14. Technology Risks	2	5
15. Operational Risks	3	4

6. Discussion

The diverse perspectives from the various expert groups highlight the multifaceted nature of risks associated with building renovation projects. This section discusses the differences in risk perceptions among these groups and their implications for managing renovation projects.

Regulatory Risks: Regulatory authorities and community stakeholders perceive these risks as the highest due to their direct involvement in navigating and ensuring compliance with complex regulatory landscapes. Architects and engineers, while aware, may rate them slightly lower due to a focus on technical solutions rather than the broader regulatory environment. The high probability and impact in the overall risk matrix indicate that any changes in regulations could significantly affect the project. This risk should be closely monitored and addressed promptly to ensure compliance and avoid delays or penalties.

Financial Risks: Real estate developers and financial advisors rate financial risks higher due to their primary responsibility for funding and financial feasibility. They are more sensitive to fluctuations in construction costs, funding availability, and economic conditions compared to other groups. The moderate-to-high probability and impact suggest that financial challenges could pose significant obstacles to the project's success. Effective budget management and contingency planning are crucial to mitigate these risks and maintain financial stability.

Technical Risks: Contractors and construction managers rate technical risks highest as they directly manage construction processes and encounter technical challenges on-site. Environmental consultants rate these risks lower, focusing more on environmental impacts and sustainability. With a moderate to high probability and impact, technical challenges could lead to delays and additional costs. Thorough assessments and proactive measures are necessary to address potential issues and ensure smooth project execution.

Market Risks: Real estate developers, regulatory authorities, and community stakeholders rate market risks highest due to their awareness of market demand, economic conditions, and community acceptance, which can significantly impact project success. The moderate to high probability and impact in the overall matrix indicate that market fluctuations could affect project profitability. Conducting thorough market research and staying informed about economic trends are essential to navigate these risks effectively.

Legal Risks: Real estate developers and regulatory authorities rate legal risks higher, reflecting their engagement in contractual negotiations, compliance, and potential legal disputes. Architects and engineers, while aware, are less directly involved in legal aspects compared to these groups. Although the impact is moderate, legal issues could still disrupt the project if not addressed promptly. Proper documentation and legal assistance are essential to mitigate the risk of disputes or violations.

Stakeholder Risks: Community stakeholders and contractors rate stakeholder risks higher, given their direct interaction with local communities, tenants, and project stakeholders. They are more sensitive to community relations and stakeholder management compared to other groups. The moderate risk suggests that conflicts among stakeholders could impact project timelines and costs. Effective communication and conflict resolution strategies are necessary to maintain positive relationships and minimize disruptions.

Environmental Risks: Environmental consultants and community stakeholders rate environmental risks higher due to their focus on sustainability, environmental impact assessments, and adherence to green building practices. Other groups also acknowledge these risks but rate them lower. The moderate probability and impact indicate that environmental factors could affect the project's success. Implementing sustainable practices and complying with regulations are essential to mitigate these risks.

Schedule Risks: Real estate developers and contractors rate schedule risks higher due to their focus on project timelines, construction phases, and coordination of multiple stakeholders. They are more directly affected by delays and schedule disruptions compared to other groups. With a moderate to high probability and impact, schedule delays could significantly impact project timelines and budgets. Developing contingency plans and closely monitoring project schedules are essential to mitigate these risks.

Economic Risks: Real estate developers and financial advisors rate economic risks highest, reflecting their concern over economic downturns, inflation, and interest rate fluctuations impacting project financing and profitability. Despite the moderate impact in the overall matrix, economic fluctuations could affect project feasibility. Evaluating economic risks and adjusting strategies accordingly are necessary to ensure financial viability.

Supply Chain Risks: Contractors rate supply chain risks higher due to their dependence on timely delivery of materials and labor resources. Other groups acknowledge supply chain risks but rate them lower due to less direct involvement in procurement and logistics. The moderate risk suggests that disruptions in the supply chain could impact project execution. Diversifying suppliers and establishing contingency plans are crucial to maintain a reliable supply of materials and labor.

Quality Risks: Contractors rate quality risks highest as they are responsible for ensuring construction standards and workmanship. Architects and engineers also rate these risks high due to their focus on technical specifications and project outcomes. The moderate probability and impact indicate that quality issues could affect project outcomes. Implementing quality assurance measures and conducting regular inspections are essential to mitigate these risks.

Reputation Risks: Community stakeholders rate reputation risks higher, reflecting their focus on community relations, public perception, and social impacts of renovation projects. Real estate developers also acknowledge these risks but rate them lower compared to community stakeholders. Although the impact is moderate, negative publicity could harm the project's reputation. Addressing community concerns and prioritizing ethical practices are necessary to maintain a positive image.

Insurance Risks: Real estate developers and contractors rate insurance risks higher due to their responsibility for project insurance coverage and risk management. Other groups acknowledge these risks but rate them lower due to less direct involvement in insurance decisions. Despite the moderate impact in the overall matrix, insurance issues could lead to financial losses. Obtaining comprehensive coverage and understanding policy terms are essential to mitigate these risks.

Technology Risks: Real estate developers and architects rate technology risks lower, reflecting a lesser focus on implementing new technologies compared to other project aspects. Environmental consultants and contractors may rate these risks higher due to their reliance on technology for environmental assessments and construction management. The moderate impact suggests that technology issues could disrupt project operations. Implementing robust IT security measures and staying updated on technology trends are necessary to mitigate these risks.

Operational Risks: Real estate developers and contractors rate operational risks higher due to their responsibility for long-term building management and maintenance. Other groups acknowledge these risks but rate them lower due to less direct involvement in operational phases. With a moderate-to-high probability and impact, operational challenges could affect long-term project success. Developing comprehensive management plans and adapting to market changes are essential to mitigate these risks.

7. Conclusions

This paper provides a comprehensive examination of the various risks associated with building renovation projects, highlighting the perspectives of different expert groups and proposing effective mitigation strategies.

Fifteen main risks have been identified that investors in the renovation of buildings should include in their decision-making about the planned investment. For each risk, its probability of occurrence and its impact on the project is defined, as determined from the questionnaire survey.

Each investor has their own individual approach to solving and taking risks related to the project. However, the results of the study serve as a basis from which investors should proceed, so that they do not overlook any significant risks and, at the same time, to have an idea of how risks are perceived in the professional sphere from the point of view of their probability of occurrence and their impact. At the same time, the study provides insight into the perception of risks associated with the reconstruction of buildings from the point of view of various professional groups.

The study describes the areas of risk mitigation, which the investor can further use for the risk analysis of a specific project.

The “4T” strategy is suitable for dealing with specific risks. When the investor chooses one of the approaches—Take (low impact, low probability), Treat (low impact, high probability), Transfer (high impact, low probability), and Terminate (high impact, high) for individual risks [37]—the choice of a specific solution is up to the investor themselves.

The Take strategy, i.e., taking over the risk, characterizes a situation where the decision-maker consciously decides not to take any measures against the risk, as they evaluate this option as the most effective in terms of costs. It is also sometimes referred to as a “zero strategy”. Any consequences of this risk are covered by the reserves. In no case is this a situation where the investor has not identified the given risk and therefore does not take any measures against it. The risk is known to the investor, and, after consideration, they decide that it is most efficient to accept this risk from the point of view of the costs of the measures and the amount of possible impact. This strategy tends to be used for risks with low probability and low impact.

The Treat strategy, or risk retention, has three basic forms:

- Prevention;
- Diversification;
- Allocation.

Risk prevention can be divided into two approaches, proactive and reactive. A proactive approach tries to prevent the occurrence of a risk, reactive prevention aims to prepare for the outbreak of a risk and thus reduce its impact.

Risk diversification consists of rebuilding the risk portfolio. With this restructuring, some risks may decrease and others may increase. What is important, however, is that the overall risk of the project or business will be reduced. Sometimes it can be concluded that the risk is not diversifiable.

By risk allocation, we mean their redistribution to administrators so that risk management is as efficient as possible. We distinguish between two risk allocation approaches, risk centralization and risk decentralization. The essence of centralization lies in the concentration of risks with a single administrator. Decentralization always assigns a specific risk to the administrator who is able to manage it most effectively. The Treat strategy tends to be used for risks with high probability and low impact.

The Transfer strategy, i.e., the transfer of risk to a third party, can take many forms. Often this transfer is associated with payment. Backup or risk sharing is good and often necessary to include in the contract. Probably the most used tool is insurance. The following methods are also often used:

- Leasing;
- Factoring;
- Forfaiting;
- Letter of credit;
- Documentary direct debit;
- Conclusion of a long-term contract for the supply of raw materials at fixed prices;
- Conclusion of a commercial contract ensuring the purchase of a certain number of products.

This strategy is used for risks with a low probability of occurrence and high impact.

The Terminate strategy, or avoiding the risk by not performing the analyzed activity, is an extreme variant. The size of the cost of adopting this strategy is highly dependent on the stage of the investor's project or activity. It should also not be forgotten that by not participating in the project or by terminating the activity, the company may lose future profits or a competitive advantage. As already mentioned in this thesis, it is not possible to avoid risk in the long term if the organization wants to move and grow. This strategy is used in cases where a high probability of a risk outbreak that would have a fatal impact has been identified.

In conclusion, the paper provides a roadmap for navigating the uncertainties inherent in renovation projects. By empowering stakeholders with the knowledge, tools, and strategies needed to effectively manage risks, we can pave the way for a more resilient, sustainable, and prosperous future in the realm of building renovation investments.

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