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ÚSTAV STAVEBNÍ EKONOMIKY A ŘÍZENÍ

RISK MANAGEMENT IN THE EX-ANTE PHASE OF CONSTRUCTION INVESTMENT PROJECTS

MANAGEMENT RIZIK V EX-ANTE FÁZI STAVEBNĚ INVESTIČNÍCH PROJEKTŮ

DOCTORAL THESIS

DISERTAČNÍ PRÁCE

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ABSTRACT

The aim of this thesis is to create a risk register and evaluate qualitative and sensitivity analysis of the risk assessed in the ex-ante phase of construction investment projects. The research task is to identify and subsequently verify correlations and interactions between the actions of individual risk factors in the evaluation of the economic efficiency of the projects. In every phase of construction there are some risks which must be considered, the phases are divided into parts and the related activities, the research of investing risks in construction projects was performed using the research project samples in different phases, different geographical locations, and different investment amount. The management of risks and risk analysis is described using the sensitivity analysis, SWOT analysis and subsequently the analysis of the risk register and its mitigation actions were completed. The dissertation thesis focuses on financial and environmental risk in construction investing of manufacturing and warehouse facilities.

KEY WORDS

Risk management, qualitative analysis, quantitative analysis, environmental risks, construction projects, manufacturing and warehouse facilities, risk register.

ABSTRAKT

Cílem této práce je vytvořit specifický registr rizik a vyhodnotit kvalitativní a citlivostní analýzu rizik posuzovaných v ex-ante fázi investičních projektů výstavby. Výzkumným úkolem je identifikovat a následně ověřit korelace a interakce mezi působením jednotlivých rizikových faktorů při hodnocení ekonomické efektivnosti projektů. V každé fázi výstavby jsou určitá rizika, která je třeba vzít v úvahu, fáze budou rozděleny na části a související činnosti, výzkum rizik při investování do stavebních projektů bude proveden na vzorcích výzkumných projektů v různých fázích, různé geografické poloze a různé velikosti investice. V této práci je popsáno řízení rizik a analýza rizik pomocí analýzy citlivosti, SWOT analýzy a po analýzách je dokončen registr rizik pro rizika a jeho zmírňující opatření. Autoři se zaměřují na finanční a environmentální rizika při investování do výstavby skladových a výrobních haly.

KLÍČOVÁ SLOVA

Řízení rizik, kvalitativní analýza, kvantitativní analýza, environmentální rizika, stavební projekty, výrobní a skladovací haly, registr rizik

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DECLARATION OF CONFORMITY OF THE PRINTED AND ELECTRONIC FORM OF THE FINAL THESIS

I declare that the electronic form of the submitted this doctorate thesis titled risk management in the ex-ante phase of construction investment projects is identical to the submitted printed form.

Brno…….

……..……….
Ing. Eric Kalisa

DECLARATION OF AUTHORSHIP OF THE FINAL THESIS

I declare that this doctorate thesis titled risk management in the ex-ante phase of construction investment projects are my own work and the result of my own original research. I have clearly indicated the presence of quoted or paraphrased material and provided references for all sources.

Brno, …...   …………..

Ing. Eric Kalisa

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Ing. Eric Kalisa

1 INTRODUCTION

The dissertation thesis was developed within doctoral studies at the Institute of Construction Economics and Management of the Faculty of Civil Engineering of the Brno University of Technology and uses 15 years of experience in different manufacturing and warehouse companies at the top management position with the responsibility for the risk and project management.

More research articles are published about the risk management of construction investment projects in the public area than in the private area.

A construction of building is a highly complex process with many activities and many subjects that are involved in individual phases. For this reason, it is necessary to identify such activities which may bear the potential risk factors that may affect the cost of the project in all phases of the construction project life cycle. Difference between planned construction investment and the real construction investment paid represent a serious financial problem.

Risks in construction process depend on main participants in the process. When the risk is overestimated or ignored, it results in the construction being stopped or suspended. The cause may also be the insolvency of some of the participants. In many cases, the total construction cost is not respected. The construction contract itself does not mean automatically the fulfilment of the contractor' obligations or the enforceability of these obligations by the investor.

Risk reduction measures can be divided in two large groups, namely preventive measures and measures to reduce the negative risk impact if the risk occurs.

In This research, author assesses 12 sample research projects of manufacturing and warehouse facilities in central Europe, where the risk is measured as a deviation from the plan in terms of time planning, planned cost and revenue against the real data. The author analyses 26 countermeasure initiatives to eliminate environment risks in the manufacturing and warehouse facilities from the risk countermeasure perspective and lastly the CEO survey of expected risk is carried out and the risk register for investing in manufacturing and warehouse construction projects is completed.

The research describes the life cycle phases of construction and risks which may happen during different construction processes. Furthermore the economics risks, which may happen during every single cycle life phase of project are analysed. Preventive measures must be determined before and after the investment.

This research is limited to the social economical risks.

Research questions were aimed at the economic efficiency of the construction investment projects for the investors and for the society and the risks related to this investment with the aim of completing a risk register related to the construction investment in the manufacturing and warehouse facility projects.

The research questions were determined as follows:

- **Do the investments in construction of manufacturing and warehouse facilities bear specific risks?**
- **Can a risk register be created specifically for manufacturing and warehouse construction investment projects?**

The answers were looked for in x-ante phase of construction project investment of manufacturing and warehouse facility in Žďár nad Sázavou, in the research projects of 12 manufacturing and warehouse facilities located in Europe and 26 global countermeasure projects for eliminating the environmental risk from manufacturing and warehouse facilities in the post-construction phase and in survey of expected risks from investors (CEO's) around the world. The risk register was created after considering the above-mentioned research samples and surveys.

2 STATE OF THE ART ANALYSIS

The author is engaged in ongoing research, in researching professional literature and at the same time he is a global manager responsible for managing the manufacturing and warehouse facilities including capital investment and risk management. Furthermore, the author is a doctoral student at the Institute of Construction Economics and Management, Faculty of Civil Engineering at Brno University of Technology and regularly participates in professional seminars and conferences. The author analysed professional literature dealing with the dissertation topic in preparation for the dissertation. It can be stated that there is currently no literature in the Czech Republic dealing in detail with the subject of risk management in ex-ante phase of construction investment projects. Similarly, the scientific literature in the field of project management development is limited, especially in the Czech Republic.

The research can serve as a supplementary resource to the management of investment project in general or the companies and organisations in general. The extensive range of resources as different sample projects, literature and work experience were used within the project.

Project

The Project Management Institute (PMI) a widely recognized authority on project management and its Project Management Body of Knowledge (PMBOK) provides a widely accepted framework for defining and managing projects. They define a project as a temporary endeavour undertaken to create a unique product, service, or result.

A project is a temporary and unique endeavour that is designed to achieve a specific goal or objective, typically defined by a set of requirements, constraints, and parameters. Projects are characterized by a defined beginning and end, with a series of tasks and activities that are planned, executed, and monitored to achieve the desired outcome within a specified timeframe and budget. Projects may involve creation of new products, services, processes, or systems, and may require the collaboration of multiple stakeholders with different expertise and roles. Effective project management is critical to ensure that projects are completed on time, within budget, and to the required quality standards, the planned input and output may differ from the reality (Svozilová, 2006).

The term project can be most generally and simply interpreted as an intention to make a significant change, for which, however, other characteristic conditions apply. This determines that the preparation and implementation of the project is an acyclic event (unique, unrepeatable). The assessment of a change as extensive or significant is understood from the point of view of the person (entity) who orders or conceives the implementation of such a change (Matějka, 2001).

Cleland (2002) identifies four typical features that characterize a project. The project should be:

1. **Unique** – a project is a unique endeavour that is designed to achieve a specific goal. It is not a routine operation or a repetitive task. It has a specific beginning and end, and the outcome of the project is intended to be different from what existed before.

2. **Temporary** – a project has a defined duration, which may range from a few weeks to several years, but it is not an ongoing activity. Once the project is completed, the team disbands, and the project is no longer active.
3. **Multidisciplinary** – a project requires a team of people with different skills and expertise to work together to achieve the project's objectives. This team may include people from different departments or even different organizations.
4. **Risky** – a project is inherently risky because it involves uncertainty and the unknown. Projects require managers to manage risks proactively and mitigate them to ensure that the project is delivered on time, within budget and to the required quality standards.

2.1.1 Project Management

According to PMBOK (2008) project management is the application of knowledge, skills, tools, and techniques to project activities in order to meet the project requirements. Project management is accomplished through the appropriate application and integration of 42 logically grouped project management processes comprising 5 process groups.

These 5 process groups are:

- Initiating,
- Planning,
- Executing,
- Controlling and monitoring,
- Closing.

Managing the project typically includes:

- Identifying requirements,
- Addressing the needs, concerns and expectation of the project planned and carried out,
- Balancing the competing project constraints including, but not limited to:
    - Scope
    - Quality
    - Schedule
    - Resource
    - Risk

The Project Management Triangle or the Iron Triangle which represents three fundamental factors that must be balanced and managed effectively in any project. These three constraints are explained in the figure and text below:

Scope: refers to the work that needs to be done to deliver the project's product, service, or result with specified features and functions. It defines what is included and excluded from the project. Changes to the project scope can significantly impact the project's time and cost

Time: Time, or schedule, represents the project's timeline, including the start date, end date, and milestones. Managing the project within the specified time frame is crucial to meet deadlines and project objectives. Changes to the schedule can affect scope and cost.

Cost: Cost involves the budget or financial resources allocated to the project. It includes all expenses, such as labour, materials, equipment, and overhead. Managing costs within the approved budget is essential to ensure that the project remains financially viable. Changes to cost can impact scope and schedule.

The picture below shows how these three constraints are interconnected, and how the changes to one constraint can impact the others. This relationship is often illustrated as a triangle, where each constraint represents one of the triangle's corners.

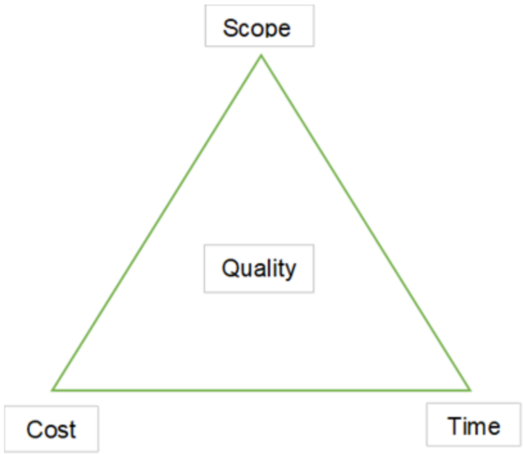


Figure 1: The project management triangle, edited by author (PBMOK, 2008)

PMBOK (2008) also offered more advanced model based on the triple constraint with 6 factors to be monitored and managed. These factors were organized into two triangles: the Input-Output Triangle and the Process Triangle. Here's a breakdown of these six factors:

Input-Output Triangle which represents the traditional triple constraint:

- Scope
- Cost
- Time

Process Triangle which is a balancing act:

- Risk
- Quality
- Resources

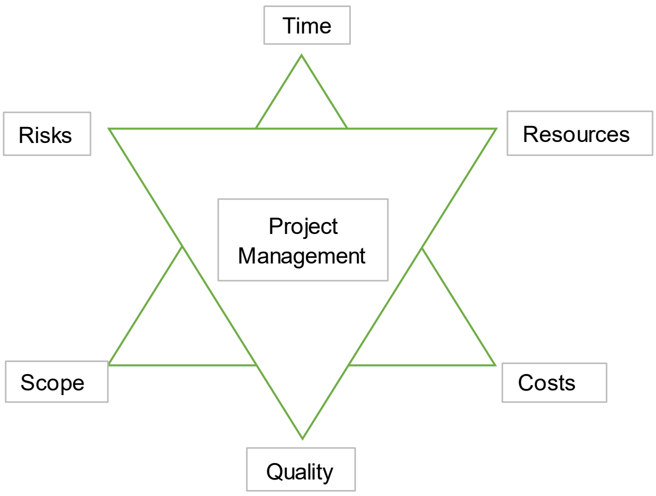


Figure 2: Project Management Star, edited by author (PMBOK, 2008)

Toor and Ogunlana (2010) state that in complex evaluation of projects, a three-level assessment of objectives is not sufficient. They introduces an extended model of the triple imperative that includes additional variables to examine. The authors call the model Iron Triangle KPIs (Key Performance Indicators).

Iron Triangle model includes additional variables to examine. These are key performance indicators to the mix. KPIs are metrics that help organizations track their progress toward specific goals and objectives. The organizations can gain a more comprehensive understanding of their project's performance by measuring KPIs related to the Iron Triangle constraints (min. time, min. resources, max. results).

The possible KPIs that could be added to the Iron Triangle model are as follows:

1. **Quality –** the quality of the project's deliverables can have a significant impact on its success. KPIs related to quality could include defect rates, customer satisfaction ratings, and adherence to industry standards.
2. **Risk –** every project carries some level of risk, whether it's related to technical issues, resource availability, or other factors. KPIs related to risk could include the number of identified risks, the severity of those risks, or the success rate of risk mitigation efforts.
3. **Stakeholder satisfaction** – the satisfaction of stakeholders, including clients, customers, and team members, can also have impact on the success of a project. KPIs related to stakeholder satisfaction could include feedback surveys, retention rates, or the number of complaints or escalations.
4. **Innovation –** in some cases, organizations may seek to innovate or disrupt their industry with a new project. KPIs related to innovation could include patents filed, market share gained, or the number of new features or capabilities introduced.

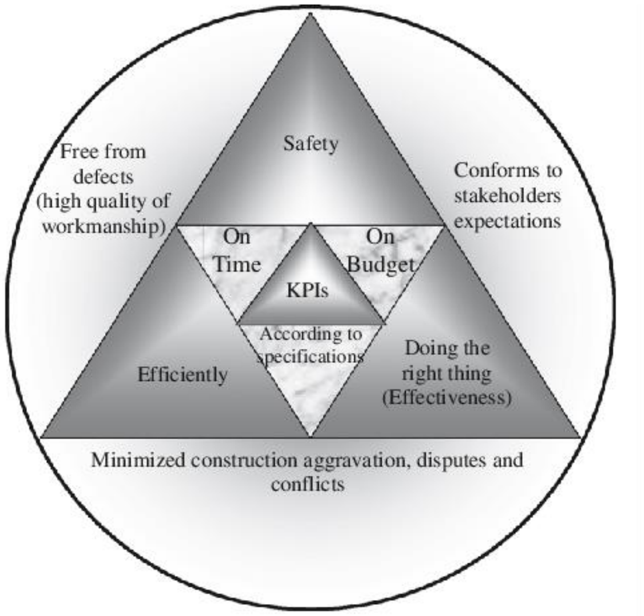


Figure 3: Iron Triangle (Toor and Ogunlana, 2010)

Through KPIs, organizations can gain a more comprehensive view of their project's performance and make more informed decisions about how to optimize their resources and achieve their goals.

Projects can be divided into the following commonly known categories:

- **Investment projects** involve the allocation of resources with the aim of generating future returns. Examples of investment projects include construction of new facilities, expansion of existing facilities, and acquisition of new manufacturing and warehouse facilities.
- **Research projects** are focused on the investigation and discovery of new knowledge or insights in a specific field. Examples of research projects include scientific studies, market research, and development of new technologies.
- **Construction projects** involve design, construction, and maintenance of physical structures such as buildings, roads, bridges, and other infrastructure. Examples of construction projects include the building of a new manufacturing facility or a warehouse.
- **Organizational projects** are aimed at improving the efficiency and effectiveness of organization's operations. Examples of organizational projects include the implementation of a new management system, the introduction of new policies and procedures, and the development of new training programmes.
- **Combined projects** involve a combination of two or more of the above categories. For example, a construction project that involves the development of a new technology or the implementation of a new management system.

It becomes easier to manage and prioritize the projects by dividing them into these categories based on their objectives, resource requirements, and expected outcomes. It also helps to ensure that projects are aligned with the overall goals of the organization and properly coordinated and monitored throughout their lifecycle.

2.1.2 Investment projects

The subject of the dissertation research is construction investment projects; therefore, the thesis further focuses on this area. The topic under investigation is based on a research sample that includes investment in constructing new facilities or extending manufacturing and warehouse facilities.

Investment decision-making is a critical aspect of long-term development and planning for organizations. This process involves evaluating various investment opportunities and deciding which ones to pursue based on factors such as financial returns, risk, and alignment with the organization's strategic objectives. Investment decisions can have significant implications for the organization's future, both in terms of its financial performance and its ability to achieve its long-term goals.

Investment decision-making is also the basis of any development strategy. Economic growth and wealth depend on productive capital, infrastructure, human resources, knowledge, total factor productivity and the quality of institutions. All of these fundamental components of development require complex decisions about drawing economic resources at present, in the hope of achieving desirable benefits in the distant and uncertain future (European Commission, 2008).

Effective investment decision-making requires a systematic approach that includes:

- **Identification of investment opportunities** which involves identifying potential investment opportunities based on the organization's strategic objectives, market trends, and competitive landscape.

- **Evaluation of investment opportunities** which involves conducting a thorough analysis of each investment opportunity to assess its financial viability, risk profile, and alignment with the organization's objectives.
- **Prioritization of investment opportunities** which involves ranking investment opportunities based on their potential financial returns, risk, and strategic importance to the organization.
- **Allocation of resources** which involves determining the amount of resources for allocating each investment opportunity and establishing a timeline for their implementation.
- **Monitoring and evaluation** which involve tracking the progress of each investment opportunity, measuring its financial performance, and adjusting the necessities to ensure that the organization's long-term objectives are being achieved.

Effective investment decision-making is critical for organizations that seek to grow and achieve their long-term goals. It requires a deep understanding of the organization's strategic objectives, as well as a thorough analysis of market trends and competitive dynamics. By making informed investment decisions, organizations can position themselves for long-term success and ensure that they allocate their resources in a way that maximizes their financial returns and supports their strategic objectives.

2.1.3 Construction investment projects

Construction investment project requires a careful project management. Every individual involved in the process of planning, designing, financing, constructing, and operating physical facilities related to the project under consideration, gain different perspective on project management of construction.

The contribution of proficient knowledge can be beneficial, mainly when it comes to large and complicated projects, since experts in various specialties can offer valuable services. On the other hand, it is very important and advantageous to understand how different parts of the process match together.

The poor coordination and communication between the specialists can result in waste, excessive cost, and delays. It is important to follow the requirement of the business and society to assure that such flaws do not happen between them. And it owes all participants involved in the project to regard the interests of business and society, as at the end, it is the investors who provide the resources and make the decisions to protect the overall business and society need.

Implementation of business and society requirement will help the participants to focus on the completion of the project by having proper attention in the process of project management for constructed facilities. This would minimize the old concept of bringing decisions based on the historical roles of specialists involved in the project.

The project team can align their efforts towards meeting specific requirements by considering the investors goals and objectives. This approach can minimize the reliance on historical roles and traditional decision-making processes that may not be applicable or effective in the current project context.

Involving the business and society requirement in the project management process can also help to ensure that the project is in progress and that any issues or concerns are addressed in a timely manner. This can help to minimize the risk of delays or cost overruns and can ultimately lead to a more successful project outcome.

Furthermore, by incorporating the above-described approach, the project team can gain valuable insights into the end-user's perspective, which can inform decisions related to design, functionality, and overall project scope. This can result in a more user-cantered approach to project management, which can lead to increased satisfaction and better overall outcomes.

Specialists mentioned are planners, architects, engineering designers, constructors, fabricators, material suppliers, financial analysts, and others. It can be said that each specialist individually contributes to the advances seen in the construction field.

Understanding the entire process of project management make them respond more effectively to the investor desires. They can contribute to their proficiency through opinions in improving the productivity and quality of their work.

Enhancement of project management boosts the construction industry which in turn facilitates the development of national and world economy. The knowledge of the construction industry, its working environment and the institutional constraints affecting its activities as well as the nature of project management leads to significant improvements (The constructor, 2022).

2.1.4 Construction project life cycle

The life cycle of a construction project represents a period in years starting with the development of the investment plan, its implementation, operation, and disposal upon completion of the construction project.

The below table shows the construction project life cycle and the construction life cycle.

Table 1: Construction Project Life Cycle (Korytárová et al., 2011) edited by author.

Construction Project Life Cycle			
Pre-Investment Phase	Investment Phase	Operational Phase	Disposal Phase

Construction Life Cycle		
Investment Phase	Operational Phase	Disposal Phase

The purchase of a constructed facility is a major capital investment. The investor can be an individual, a private corporation, or a public sector institution.

As the commitment of resources for the investment is stimulated by market demands or real needs, the facility is likely to satisfy certain objectives. These requirements fall within the constraints of the specified owner and applicable policies.

Managing construction-related projects requires both knowledge of modern management and understanding of the design and construction process.

Construction projects have a specific set of goals and constraints, such as a required time frame for construction completion. Although the relevant technology, institutional arrangements, or processes differentiate, the management of such projects has much in common with the management of similar types of projects from other specializations or technology domains such as aerospace, pharmaceutical and energy industries (Hendrickson, 2008).

Most of the constructed facilities are custom made in consultation with the owners, with the exception of the residential units that may be sold as built by the real estate developer.

Developer is regarded as the sponsor of construction projects, so far as public sector institution may be the sponsor of a public project and turns it over to another government unit upon its completion.

For project management, the terms “owner” and “sponsor” mean the same because both have the ultimate power to make all important decisions. It is crucial for any owner to have a clear understanding of the acquisition process to sustain firm control of the quality, timeliness, and cost of the completed facility, as he is essentially acquiring a facility on a promise in some form of agreement.

A project meets market demands or requirements on a timely basis and a variety of possibilities may be taken into consideration in the conceptual planning stage.

However, the technological, as well as the economic feasibility of each option, must be assessed and compared to select the best possible project.

The financing strategies for the proposed options and ideas should undergo a throughout examination, which is later programmed with respect to the project completion timing and based on the cash flow availability.

Once the scope of the project is clearly explained and defined**,** thorough engineering design provides the blueprint for construction, and the definitive cost estimate provides the baseline for the cost control.

Careful planning and control during the procurement and construction stages, the delivery of materials and the implementation of the project on the site must be maintained.

Certain specific stages require iteration, and the others can be carried out in parallel or in overlapping time frames. This decision mainly depends on the nature, size, and urgency of the project.

Analysis of the project life cycle from an owner’s perspective could help to focus on the proper roles of various activities and participants in all stages apart from the contractual engagements for different types of work.

Each phase of the construction project life cycle is critical to the success of the manufacturing and warehouse facility investment project, and careful planning and management is required throughout the entire construction project life cycle.

2.1.4.1 Pre-investment phase of a construction project

The pre-investment phase of a construction investment project is a preliminary phase that occurs before actual investment is made into the project. It is a very important phase from the overall project success point of view. The goal of the phase is to process the business plan in the details necessary to help decision making of its implementation.

By selecting the right method for assessing the economical-technical indicator, the economic efficiency and economical and financial feasibility are evaluated.

This phase is critical in ensuring that the project is feasible, viable, and aligned with the goals of the stakeholders. In this phase the project objective or need is identified; this can be a business problem or opportunity.

A suitable response to the need is documented in a business case with recommended solution options. A feasibility study is conducted to assess technical, financial, and economic viability of the project and determining whether it is feasible to proceed with the project and whether each option clearly identifies the project objective, and if a final recommended solution is determined.

When a solution is approved, a project investment phase is initiated to implement the approved solution., A project manager is appointed for this purpose. At this stage, the major deliverables and the participating work groups are identified. This is the time when the project team begins to take shape. Approval is subsequently required by the project manager to move onto the detailed planning phase.

2.1.4.2 Investment phase

Investment phase includes planning, execution, performance, and monitoring phases.

The planning phase involves further development of the project in detail to meet the project's objective. The team identifies all the work to be done. The project's tasks and resource requirements are identified, along with the strategy for developing them.

In a broader sense, identification of each activity as well as their resource allocation is carried out. A project plan outlining activities, tasks, dependencies, and timeframes are created.

The project manager is the one who coordinates the preparation of a project budget by providing cost estimates for the labour, equipment, and materials costs. This is mainly carried out by project scheduling software like MS project.

The budget of the project already estimated is used and controlled as follows:

- Monitoring and controlling cost expenditures during project implementation,
- Processing the documentation for tender to the contractor,
- Selection of the contractor,
- Signature of the contract,
- Trial of the construction,
- Acceptance of the building,
- Utilization of the building after the building permit is granted.

2.1.4.3 Operational phase

The operational phase of a construction investment project begins after the completion of the construction phase and the project is ready to be put into operation. All the construction investment activities of the project such as marketing, management, technical and technological procedures, management of human resources, management of working capital, impact on the environment are the most demanding from the point of view of the visibility study for the operational phase.

The operational phase needs to be assessed from a short-term and long-term points of view. All potential shortcomings, risks and uncertainties that could arise in the operational phase should be modelled again in the pre-investment phase in the form of a well-prepared feasibility study.

During this phase, the project is handed over to the client, who is responsible for operating and maintaining the facility.

The operation phase involves the following activities:

- **Commissioning** which involves testing all the systems and components of the facility to ensure that they are functioning properly and meet the design specifications,

- **Occupancy** which involves moving into the facility and using it for its intended purpose,
- **Operations and Maintenance** which involves the ongoing management and maintenance of the facility to ensure that it continues to function effectively and efficiently. This includes routine maintenance, repairs, and upgrades as necessary,
- **Monitoring and Evaluation** which involves tracking the performance of the facility over time and adjusting necessary processes to improve its efficiency and effectiveness,
- **End of Life** which involves decommissioning and dismantling the facility when it is no longer needed.

Overall, the operational phase is critical to the success of a construction investment project. Effective management and maintenance during this phase can help ensure that the facility remains functional and efficient for many years to come.

2.1.4.4 Disposal phase

The disposal phase is the phase in which the project is no longer running, however, the building may generate the last income or expenses by removing it.

At this stage the removal of building is being processed, the procedure for the removal of the building is under way and disposal can be carried out after obtaining the permission to its removal.

2.1.5 General risks associated with the construction project.

The feasibility study is carried out during the previous investment phase which shows the basic data for taking investment decision to manage the risk associated with the construction of large projects such as construction of manufacturing and warehouse facilities. The manual for preparing the feasibility study was developed by the UNIDO (United Nations Industrial Development Organisation) – UN organization for industrial development (Behrens, Hawranek, UNIDO, 1993)

In 1978 UNIDO has published a manual for the preparation of industrial feasibility study which is tailored to the requirement of specific projects.

The outline of the feasibility study for the construction of the manufacturing and warehouse facility follows the general outline of feasibility studies for construction projects and consists of the following chapters:

1. Executive summary,
2. Project background and history,
3. Marketing and facility capacity,
4. Materials and inputs,
5. Location and site,
6. Operation including engineering,
7. Facility organization and operating costs,
8. Manpower,
9. Implementing planning,

10. Financial and Economic Analysis,

11. Summary and evaluation of the project.

A feasibility study needs to be project specific, therefore in the context of construction investments in the manufacturing and warehouse facilities. A feasibility study usually includes the following steps – market, site, technical, financial, legal, and regulatory analyses.

- **Market analysis** involves analysing the demand and supply for the manufacturing and warehouse facilities in the area and assessing the competition,
- **Site analysis** involves assessing the suitability of potential sites for the manufacturing and warehouse facilities, considering factors such as accessibility, zoning, and environmental regulations,
- **Technical analysis** involves evaluating the technical feasibility of the project, including the design of the manufacturing and warehouse facilities, the construction process, and the potential risks and challenges,
- **Financial analysis** involves assessing the financial viability of the project, including estimated costs of construction, operation, and maintenance, and projecting the expected revenues and profitability of the project,
- **Legal and regulatory analysis** involves assessing the legal and regulatory requirements for the construction and operation of the manufacturing and warehouse facilities, including permits, licenses, and compliance with local, state, and federal regulations.

Based on the results of the feasibility study, the investors can determine whether the project is financially, technically, legally and regulatory feasible. If the project is found to be feasible, the investors can proceed with the project, while taking steps to mitigate any risks and challenges identified in the study.

There are several general risks associated with construction projects. Some common examples are:

- **Safety risks:** Construction sites can be hazardous, and accidents can occur, causing injury or even death to workers or bystanders,
- **Cost overruns**: Construction projects can be costly, and unexpected expenses can arise due to unforeseen circumstances, such as changes in the scope of work, material shortages, or delays,
- **Schedule delays:** Construction projects often involve several different teams and activities, making it challenging to coordinate and manage effectively. Delays can occur due to various reasons, such as weather conditions, contractor or supplier delays, or unexpected site conditions,
- **Design or quality issues**: If the design or specifications of a project are not properly planned or executed, it can result in issues such as defects, structural failures, or operational problems,
- **Contractual or legal disputes**: Disagreements or disputes can arise between different parties involved in a construction project, such as owners, contractors, subcontractors, or suppliers. These disputes can lead to legal action, delays, or added costs,
- **Environmental risks**: Construction activities can have a significant impact on the environment, including pollution, erosion, or damage to natural habitats,

- **Political or regulatory risks**: Changes in government regulations, permits, or zoning laws can impact the timeline, cost, or feasibility of a construction project.

It's important to note that the risks associated with a construction project may vary depending on the size, complexity, location, and type of the project. Therefore, it's essential to identify and assess specific risks that may apply to each project and develop strategies to mitigate or manage them.

Current approaches to risk management

Management is one of the most important human activities. Since humans began to form groups to achieve goals they could not achieve as individuals, management has become essential to ensure the coordination of individual efforts. Society started to rely more on group effort and the number of organized groups was constantly increasing and the importance of managers and management was increasing (Hálek, 2006).

Definition of risks and its clarification is a big deal that depends on problem solving. This dissertation research addresses the business risk. Business risk is generally defined as a deviation from the planned financial result with risk of lost / increase in cost or profit / reduction of costs (Korytárová et al., 2011).

According to Smejkal & Rais (2006), risk management issues depend on the focus of companies and their projects.

Risk management is a process in which the management entity tries to prevent the effects of existing and future factors of uncertainty and proposes solutions that help eliminate the effect of undesirable influences and, on the contrary, enable the use of opportunities for positive influence.

Part of the risk management process is a decision-making process based on risk analysis. After considering other factors, especially economic, technical, social and political, risk management develops, analyses, and compares possible preventive and regulatory measures.

Dissemination of risk information and risk perception are also understood as part of risk management (Smejkal & Rais, 2006).

Due to the existence of a large number of influences that affect the project, it is necessary to select the most fundamental ones for the given situation. Risk classifications have been created for the purpose of identification and subsequent classification, which enables more efficient work with risks.

There are several types of risk classifications that differ in concept or have different aspects of classification. Some risks can be classified into several categories, as appropriate and meet several criteria at the same time. The following types of risks are most often mentioned in the scientific literature depending on different principles of division. They are for example:

- **Business and pure risk**
  - **Pure risk** refers to the risk of loss or damage without any possibility of gain on the other hand,
  - **Business risk** refers to the risk of loss or damage that arises from the operations or activities of a business.
- **Systematic and unsystematic risk**

- **Systematic risk** refers to the overall risk inherent in the entire market or economy. This type of risk is also known as market risk and is not specific to any company or industry,
- **Unsystematic risk** is specific to a particular company or industry and is also known as idiosyncratic risk. Examples of unsystematic risk include poor management, labour strikes, lawsuits, and supply chain disruptions. Unsystematic risk can be diversified away by investing in a diverse range of companies across different industries and geographic regions.

- **External and internal risk**
  - **External risk** refers to risk that comes from outside the organization and is largely beyond its control. These risks include factors such as changes in government regulations, economic downturns, natural disasters, and geopolitical risks. External risk can have a significant impact on the operations and profitability of a business and can be difficult to predict or mitigate,
  - **Internal risk** refers to risk that arises from within the organization itself. This risk includes factors such as inadequate financial management, poor operational processes, and employee fraud. Internal risk can be managed and mitigated through effective risk management strategies such as internal checks, regular audits, and staff training.
- **Controllable and uncontrollable risk**
  - **Controllable risk** refers to risk that the business can control or mitigate through its actions. This risk includes factors such as operational risk, credit risk, and reputational risk. Examples of controllable risk include implementing effective risk management practices, diversifying the product and service offerings, and strengthening the internal control environment,
  - **Uncontrollable risk** refers to risk that is largely beyond the control of the business. This risk includes factors such as natural disasters, political instability, and changes in regulations. Examples of uncontrollable risks include earthquakes, floods, and pandemics. This risk can have a significant impact on the business and is often difficult to predict or mitigate.

- **Primary and secondary risk**
    - **Primary risk** refers to the initial risk that arises from a particular event or situation. For example, a fire in a manufacturing facility would be considered a primary risk as it directly impacts the business's operations and may cause damage to the facility, equipment, and inventory,
    - **Secondary risk** refers to the additional risk that arises as a result of the primary risk. This risk may be indirect and may not be initially apparent but can have significant impact on the business. For example, if the fire in the manufacturing facility results in a delay in production, this may lead to missed orders, loss of revenue, and reputational damage.

Hnilica & Fotr (2009) distinguish the following risks according to their content

- Technical-technological,
- Manufacturing (operational),
- Economic, market, sales, price,
- Financial, credit,
- Legislative, political, environmental,
- Associated with the human factor (management risks, employee losses, etc.),
- Informative,
- Force majeure interventions (accidents, natural disasters, terrorist attacks, etc.)

Other types of risks that affect business include: (Korecký & Trkovský, 2011)

- Corporate governance risk, business risk, reputation risk,
- Business continuity risk, strategic risk,
- Risk of information security, fraud,
- Health and safety risk,
- Project risk.

Speculative and non-financial risks also fall within the frequently mentioned types of risks. Risks can be further divided into static and dynamic.

The above-mentioned risks do not represent all the possible uncertainties of the investment project development. There are many other situations in the investment process that represent obstacles and may cause complications during the investment plan implementation. Most of these adverse events can be prevented by implementing risk management. Own risk management consists of several stages that help prevent and mitigate the impact of risks on the assessed project.

There are several other authors who have written about risk management. Some of the notable ones are:

- Nassim Nicholas Taleb - Author of "The Black Swan. Taleb in his work The Impact of the Highly Improbable" and "Antifragile: Things That Gain from Disorder focuses on the concept of “black swan events," which are rare and unpredictable events that can have a significant impact on investments.

- Peter L. Bernstein - Author of "Against the Gods", In his work The Remarkable Story of Risk Bernstein focuses on a historical perspective on the development of risk management and the mathematics of probability.
- David M. Rowe - Author of "Risk Management and Insurance." Rowe provides a comprehensive overview of the principles and practices of risk management, including risk classification.
- John Hull - Author of "Risk Management and Financial Institutions." Hull provides an in-depth analysis of the risks faced by financial institutions, including credit risk, market risk, and operational risk.
- Kevin Dowd - Author of "Measuring Market Risk." Dowd provides a detailed explanation of how to measure market risk using Value at Risk (VaR) and other techniques.

These authors have made significant contributions to the field of risk management and have provided valuable insights into the different types of risks that investors face.

Here are some authors who have written about risk classifications specifically in the context of construction investment:

- Odeyinka, H.A. and Yusif, A. (2007) focus on risk management in construction projects in the Journal of Financial Management of Property and Construction, Vol. 12 No. 2, pp. 63-71. This paper provides an overview of the risk management process in construction projects, including the classification of risks based on their likelihood and impact.
- Flanagan, R. and Norman, G. (1993) focus on risk management and construction in Blackwell Publishing. This book provides a comprehensive overview of risk management in construction, including the identification, assessment, and classification of risks.
- Holt, G.D. and Edwards, P.J. (1994) focus on the identification and classification of risks in construction projects in international Journal of Project Management, Vol. 12 No. 3, pp. 139-145. This paper provides a framework for the identification and classification of risks in construction projects, based on the categories of financial, technical, managerial, and environmental risks.
- Wang, X. and Li, Q. (2011) focus on risk identification and classification of building construction projects in Procedia Engineering, Vol. 15, pp. 389-395. This paper presents a risk identification and classification model for building construction projects based on the categories of design, construction, management, and external risks.
- Zhang, Y., Lu, W. and Shan, M. (2019) focus on risk identification and classification of construction projects based on system dynamics in Journal of Civil Engineering and Management, Vol. 25 No. 5, pp. 409-424. This paper proposes a system dynamics-based risk identification and classification method for construction projects, which considers the interdependencies between risks.

According to Odeyinka and Yusif (2007), risks in construction projects can be classified based on their likelihood and impact as follows:

- High likelihood, high impact risks: These are risks that are very likely to occur and, if they do, they will have a significant impact on the project. Examples include natural disasters, such as floods or earthquakes, and major design errors.
- High likelihood, low impact risks: These are risks that are very likely to occur but, if they do, they will have a relatively minor impact on the project. Examples include minor design errors, delay in material delivery, or minor changes in the scope.

- Low likelihood, high impact risks: These are risks that are unlikely to occur, but if they do, they will have a significant impact on the project. Examples include strikes, legal disputes, and major equipment breakdowns.
- Low likelihood, low impact risks: These are risks that are unlikely to occur and, if they do, they will have a relatively minor impact on the project. Examples include minor weather disturbances, small changes in the project scope, or minor equipment breakdowns.

The classification of risks based on likelihood and impact helps project managers to prioritize their risk management efforts and allocate resources accordingly. High likelihood, high impact risks require the most attention and resources, while low likelihood, low impact risks can be managed with relatively fewer resources.

According to Flanagan and Norman (1993), risks in construction projects can be classified into the following categories:

- Physical risks: These are risks related to the physical environment in which construction takes place, such as weather conditions, geological hazards, and natural disasters,
- Financial risks: These are risks related to the financial aspects of the project, such as cost overruns, budget constraints, and fluctuations in currency exchange rates,
- Legal risks: These are risks related to the legal framework in which construction takes place, such as contractual disputes, regulatory compliance, and liability issues,
- Social risks: These are risks related to the social environment in which construction takes place, such as public opposition, community relations, and stakeholder conflicts,
- Political risks: These are risks related to the political environment in which construction takes place, such as changes in government policies, political instability, and geopolitical risks,
- Technological risks: These are risks related to the use of technology in construction, such as failure of new or untested technologies, software malfunctions, and cyber-attacks,
- Management risks: These are risks related to the management of the project, such as inadequate planning, poor communication, and ineffective project controls.

The classification of risks based on these categories helps project managers to identify and assess various types of risks associated with a construction project. This, in turn, enables them to develop effective risk management strategies to minimize the impact of risks on the project.

According to Holt and Edwards (1994), risks in construction projects can be classified into the following categories:

- Financial risks: These are risks related to the financial aspects of the project, such as cost overruns, budget constraints, and financing issues,
- Technical risks: These are risks related to the technical aspects of the project, such as design errors, construction defects, and failure of equipment,
- Managerial risks: These are risks related to the management of the project, such as inadequate planning, poor communication, and ineffective project controls,
- Environmental risks: These are risks related to the natural and built environment in which the construction takes place, such as weather conditions, geological hazards, and pollution.

The classification of risks based on these categories helps project managers to systematically identify and assess the various types of risks associated with a construction project. This enables them to develop effective risk management strategies to minimize the impact of risks on the project. The framework proposed by Holt and Edwards provides a structured approach to risk identification and classification in construction projects.

According to Wang and Li (2011), the classification of construction investment risks can be divided into four main categories:

- Design risks: These risks are associated with the design phase of the project and include risks such as design errors, incomplete or inaccurate specifications, inadequate design documentation, and changes in design requirements,
- Construction risks: These risks are associated with the construction phase of the project and include risks such as poor workmanship, delays, poor quality materials, equipment breakdown, safety hazards, and environmental risks,
- Management risks: These risks are associated with the overall management of the project and include risks such as poor project planning, inadequate resource allocation, poor project control, poor communication, and poor financial management,
- External risks: These risks are associated with external factors that are beyond the control of the project team, such as changes in market conditions, political instability, natural disasters, and legal and regulatory risks.

By identifying and categorizing risks in these four main areas, project managers can develop effective risk management strategies to mitigate the impact of potential risks on the project.

According to Zhang et al. (2019) system dynamics-based risk identification and classification method, construction investment risks can be classified into six categories, considering the interdependencies between risks:

- Technology risks: These risks are related to the application of new or untested technologies, which can lead to project delays, cost overruns, and quality issues,
- Management risks: These risks are associated with planning, organization, and coordination of project activities, including risks such as inadequate resource allocation, poor communication, and lack of experience,
- Financial risks: These risks are associated with the financial aspects of the project, such as insufficient funding, unexpected expenses, and exchange rate fluctuations,
- Environmental risks: These risks are associated with the impact of the project on the environment, such as pollution, resource depletion, and habitat destruction,
- Political risks: These risks are associated with political instability, policy changes, and legal issues, which can affect the project's progress and outcome,
- Social risks: These risks are associated with the impact of the project on the community and stakeholders, such as public opposition, protests, and conflicts.

The system dynamics-based approach can provide a more comprehensive and realistic assessment of construction investment risks by considering the interdependencies between risks. This can help project managers to develop effective risk management strategies that consider the complex interactions between risks and their potential impact on the project.

According to the CTP annual report (2021), the company that builds and owns multiple warehouses in Europe mentioned that climate change-related risks can be split into three types from the risk management perspective:

- Environment risk under the category Strategic risk / ESG (Environmental, social, and governance), this captures the ethical element of doing the right thing to help mitigate an environmental catastrophe as a company responsibility,
- Climate risk category under operational risk is designed to capture the potential physical damage to the property that could result due to extreme weather phenomena related to climate change,
- Climate change related to risks in other risks category, examples include customer behaviour change risk, pandemic/acts - of force majeure risks, reputation risk, business continuity risk, regulatory noncompliance risk and regulator change risk.

The risks should be quantified and ranked by expected loss.

The company should perform a high-level analysis of the climate-related risk impact on the company's business and operation in the longer term and on the accounting of the current financial statement.

The above-stated risks affect both the final amount of investment and operating costs, the length of the construction period and the expected amount of revenue during the operational phase of the project (Pilger et al., 2020). It emphasizes that errors in the project are usually transformed into price adjustments (overrun of planned costs) and extended duration of the construction phase. According to Kennedy et al. (2018) uncertainty in cost estimation evolves over the project life cycle and arises from the difficulties in estimating construction, maintenance, operation, and financing costs. Therefore, environmental risk should be included in the risk management for the whole life cycle of the warehouse and manufacturing facility projects.

The classification of risks depends on projects in question, time when the project is being planned and the region. Each time period and each region run their risks, which are reviewed in the CEO survey of expected risks.

According to Korytárová et al. (2013) the business risks which may happen during the construction of projects are:

- Risk on project documentation,
- Risk on construction and other permits,
- Risk of cost change,
- Finance risk,
- Legal risk.

Risks in the phase of project preparation and implementation

Risks during the phase of project preparation and implementation can be technical, financial, resource-related, schedule-related, or legal/regulatory in nature. Effective risk management strategies, such as risk identification, risk assessment, risk mitigation, and contingency planning, can help businesses to address these risks and ensure the success of their projects.

Risks in the operational phase of a business can be operational, financial, reputational, legal/regulatory, or cybersecurity in nature. Effective risk management strategies, such as regular monitoring and evaluation, contingency planning, and employee training, can help businesses to address these risks and ensure their long-term success. (Hnilica & Fotr, 2009)

Risk related to the project documentation for a construction investment project.

The project documentation is an essential component of any construction investment project, ensuring its accuracy and completeness which is crucial to minimize the risks.

The Czech Act No. 183/2006 Coll. on urban planning and construction council (Czech Construction Law) states in §150 that; the builder is obliged to carefully prepare the execution of the construction. In doing so, he must consider, in particular, the protection of life and health of people or animals, the protection of the environment and properties well as respect for the neighbourhood. The constructor is obliged to provide the prescribed documentation for the purpose of discussing the intention according to that law. If the law requires development of the project documentation by a person authorized to do so, the builder is obliged to ensure the development of the project documentation by such a person, if he does not have the necessary authorization himself.

If the construction project documentation is developed by a person without an authorisation, the construction project shall be stopped by department of construction.

Some potential risks associated with inadequate project documentation are listed below:

- Legal risks: Incomplete or inaccurate documentation can lead to legal disputes between project stakeholders. This can result in costly litigation, damage to the project's reputation, and delay in project completion,
- Financial risks: Inaccurate project documentation can lead to misallocation of funds, incorrect cost estimation, and ultimately, project cost overruns,
- Safety risks: Incomplete or inaccurate documentation can lead to safety hazards on the construction site. For example, if safety guidelines and procedures are not properly documented, workers may be in danger, leading to injuries or fatalities,
- Schedule risks: Incomplete or inaccurate project documentation can result in delays in project completion. if a contractor is provided with incorrect or incomplete drawings or specifications, they may need to be redeveloped, resulting in additional time and cost.

It is important to ensure that project documentation is developed by a person who has enough experience and authorization to develop the construction project documentation to mitigate these risks.

Risk related to the construction permits and other authorisations.

It is necessary to ensure that all documents, permits, and authorisation are available on time and in good quality before starting the construction and later the operation.

It mainly requires the approval from all concerned authorities to grant the zoning decision and later the construction permit.

According to the Building Act and the relevant implementing regulation, which in the Czech Republic is currently Act No. 503/2006 Coll., containing a decree on detailed regulation of spatial management, public law contracts and spatial measures.

In order to apply for the issue of a zoning decision, it is necessary to submit, in addition to the drawing documentation, other documents and statements from the relevant authority, for example an extract from the real estate cadastre documenting the investor's relationship to the land, a statement from the administrators of the network for the establishment of connections to electricity, water, pipes and sewerage, a statement from the Department of Transport, memorial ovens, environment, technical administration of communication and many others. The required documents and statements regarding applications for spatial planning always depend on the project in question.

One of the key documents is the issue of resolving requirements related to the land on which the building is to be built. It is necessary to submit the ownership document of the land or contracts for future contracts ensuring, for example, the rental of the land for the required period.

If investor does not get the required construction permits, he cannot carry on with the construction project.

These risks appear to be very serious, especially where a fixed construction schedule is floated in accordance with the start of the construction operation, and any delay after that means the cancellation of the cost or the postponement of the revenues of the project for which the construction have been carried out.

Risk related to the cost change.

Investing in a construction project involves various risks and changes in the cost of the project are one of them. The cost of a construction project can change due to various factors such as changes in the price of construction materials, labour costs, design changes, or unforeseen events such as natural disasters or regulatory changes. These cost changes can have a significant impact on the profitability of the project and the return on investment.

One of the monitored parameters of buildings is the estimated cost. Both the investor and the contractor are interested in meeting the estimated cost.

The investor needs to observe the construction cost of the building, which directly affects the expected efficiency of the investment.

The contractor needs to observe the negotiated price, which includes the cost of constructing the building and ensure the generation of profit, that manages well the efficiency of the building activities.

The following chart shows the relation implicating investor, constructor and local community in evaluating risks and price.

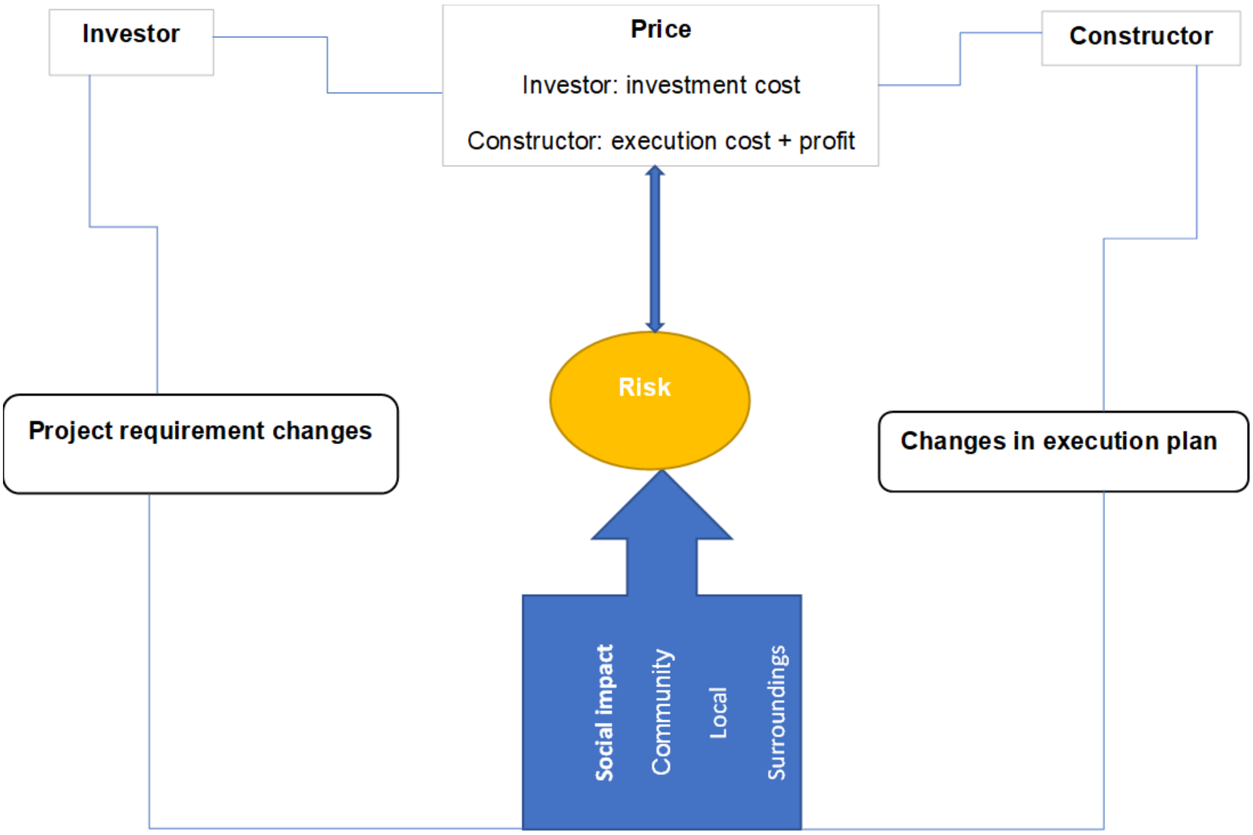


Figure 4 Relation implicating investor, constructor, local community, and price (Korytárová et al., 2013), (edited by author).

Due to the fact that the construction process is influenced by several factors which can negatively affect the costs, it is the common interest of both investor and contractor to assess the impacting factors in advance with the respect to the content, scope and consequently manage them.

Investor is the party providing financial resources to fund the construction project. He is motivated by the potential for returns on their investment through rental income (in the case of leasing the facilities) or eventual sale of the completed property.

Constructor (Contractor): The constructor is responsible for executing the construction project. He is hired by the investor to physically build the manufacturing and warehouse facilities according to the approved plans and specifications.

Price: The price represents the cost associated with the construction of the manufacturing and warehouse facilities. It includes labour, materials, equipment, permits, subcontractors, overhead costs, and profit for the constructor.

Risk: Risk is an essential aspect of any construction project. Various risks need to be assessed and managed to ensure the success of the investment. These risks can include market demand risk, construction cost overruns, project delays, regulatory compliance risk, environmental risks and tenant risks (if the facilities are intended to be leased).

Local Community: The local community plays a crucial role in any construction project. It consists of the neighbours, businesses, and stakeholders in the vicinity of the project site. The construction project can have significant impacts on the local community, such as traffic congestion, noise, environmental effects, and changes in property values.

The relationships between these elements can be described as follows:

- Investor and Constructor: The investor and the constructor have a contractual relationship. The investor hires the constructor to carry out the construction work under agreed-upon terms, including the scope of work, price, and timeline. Effective communication and collaboration are necessary for the successful completion of the project,
- Price and Risk: The price of the construction project is influenced by the assessment of various risks involved. For instance, if the constructor identifies potential risks during the project, such as site-specific challenges or regulatory compliance issues, the price may be adjusted to account for the additional work required to mitigate those risks,
- Local Community and Investor/Constructor: The local community can have both positive and negative impact on the construction project. The investor and constructor need to consider the concerns of local community and engage it in the dialogue to address potential issues. Building positive relationships with the local community can lead to smoother project execution and potentially reduced opposition or delays,
- Local Community and Risk: The local community can also present certain risks to the construction project. Community opposition, legal challenges, or public protests can delay the project and increase costs. Engaging with the local community and addressing their concerns proactively can help mitigate these risks.

Investing in a manufacturing and warehouse construction project involves a web of relationships and considerations, including the investor, constructor, price, risk assessment, and the local community. Effective risk management and stakeholder engagement are essential to navigate these relationships and ensure a successful and sustainable project.

it is important for constructor to efficiently exploit the resources and to deliver the construction to the investor in good quality and time.

To control a possible risk, it is necessary to prioritize the risk-sharing process for long-term risk, its allocation, determination of probability of occurrence at predefined values and the expression of rate in monetary value.

According to Kennedy et al. (2018), uncertainty in cost estimation evolves over the project life cycle and arises from the difficulties in estimating construction, maintenance, operation, and financing costs. The above-stated risks affect both the final amount of investment and operating costs, the length of the construction period and the expected amount of revenue during the project operational phase. Pilger et al. (2020) emphasizes that errors in the project are usually transformed into price adjustments and extended duration of the construction phase. The author focused on the study of risks associated with projects of warehouses and production halls located in industrial zones.

In recent years, a number of new approaches to risk management have appeared, such as Enterprise Risk Management (ERM). ERM is a new direction of portfolio management that covers the identification, assessment, and management of risks across the entire company. COSO (Committee of Sponsoring Organizations of the Treadway Commission) defines ERM as a process influenced by the company's governing body, its management, and other experts, which is strategically applied across the entire organization. It is designed to identify potential events that may affect the planned results and manage risks with respect to their characteristics in order to achieve a reasonable certainty achieving meeting the set goals. Volatility of international markets, correlation individual types of risks and the need for a comprehensive approach to risk management is leading to widespread adoption of ERM worldwide.

Characteristics of a construction object in the phase of preparation for implementation

To be able to set the procedure to evaluate the ensemble of construction object in the phase of preparation for implementation, it is important to:

- Limit the construction object,
- Classify the cost where there may be the deviations.

The construction objects can be identified according to the classification of professional organization such as national statistics office or verified professional international organizations.

The project team must carry out the analysis in terms of construction implementation process during the preparation for implementation. The production factor can be limited to:

- Construction with own team,
- Outsourcing with subcontractor.

Outsourcing activities is common practice. Several hiring processes are open and closed, and they have different sizes and schedules during the project cycle. They have to be wisely managed to avoid losses and liabilities, and the selection must follow a structured methodology, considering that there are a great variety of types of activities, risks, and contract size during this cycle. There are contracts that require more attention during its conduction, and others that do not, due to their simplicity.

Financial risk

Investing in a construction project involves various financial risks. It is important to understand them before making an investment decision. Some of the financial risks associated with investing in a construction project are as follows:

- Market risks: The success of a construction project depends on the market demand for the property. If the market demand decreases, the project may not generate the expected returns. This can happen due to changes in economic conditions, regulatory changes or other factors,
- Interest Rate Risks: Interest rates can impact the financing cost of the project. If interest rates increase, the cost of borrowing increase which can negatively impact the profitability of the project. This risk can be mitigated by securing long-term financing with fixed interest rates. This type of risk has become very common in 2022 and 2023 because the interest rate increased very much which represents a significant risk for some construction project investment,
- Liquidity Risks: Construction investment requires a large investment and there is risk that investor may not be able to generate sufficient cash to meet its financial obligations in due term, the project may require significant upfront investment that cannot be recovered quickly, or there may be a delay in generating sufficient cash flows to cover ongoing expenses or debt repayments,
- Construction Risks: Construction projects are subject to various construction risks such as cost overruns, delays, and quality issues. These risks can impact the profitability of the project, and it is important to manage them effectively to ensure the success of the project,
- Currency Risks: when dealing with international construction project, there is a risk of currency fluctuations impacting the investment returns. This can happen when the

currency in which the project is denominated depreciates against the investor's national currency.

To mitigate liquidity risk, it is important to carefully evaluate the cash flow projections for the investment project and ensure that there is adequate funding available to cover any potential shortfalls. It may also be prudent to maintain a sufficient level of cash reserves to cover unexpected expenses or other contingencies that may arise. In addition, it is important to regularly monitor market conditions and adjust the investment strategy as necessary to minimize exposure to liquidity risk.

Legal risk

Investing in construction projects involves various legal risks that should be carefully evaluated and addressed before making any investment decisions. Some of the common legal risks associated with investing in construction projects include:

- Contractual risks: Construction projects involve complex contracts between multiple parties, including contractors, architects, engineers, and vendors. These contracts often contain terms and conditions that may increase the risk of disputes and litigation. Therefore, it is essential to review and negotiate these contracts carefully to mitigate the risk of legal disputes,
- Regulatory risks: Construction projects are subject to various federal, state, and local laws and regulations, including zoning laws, building codes, environmental regulations, and labour laws. Failure to comply with these regulations may lead to legal and financial liabilities. Therefore, it is important to ensure that the project is in compliance with all applicable laws and regulations,
- Liability risks: Construction projects involve various risks that may result in property damage, personal injury, or other types of liability. These risks may include accidents, defects, and design errors. Therefore, it is important to have adequate insurance coverage and to ensure that all parties involved in the project are properly insured,
- Intellectual property risks: Construction projects may involve the use of patented or copyrighted technology, designs, or products. Therefore, it is important to ensure that all necessary licenses and permissions have been obtained to avoid potential legal disputes.

To mitigate these risks, it is important to work with experienced legal counsellor who can review and advise on the various legal issues associated with investing in a construction project. Additionally, thorough due diligence and risk assessments should be conducted before making any investment decisions.

According to the author’s point of view, the risks in construction project investment such as manufacturing, and warehouse facilities can be viewed at every phase of construction investment as can be seen below.

In the pre-investment phase, the following risks can happen:

- Legal risks, for example contractual or process risk,
- Financial risks, for example profitability risks,
- Social risks, for example public opposition, conflict, or protest,
- Design risks; for example, errors in the design, inaccurate specification, poor documentation,
- Regulatory risks: for example, change of policies and authorisation risks.

In the investment phase the following risks can happen:

- External risks: as environmental risk or global pandemic,
- Construction risks: for example, delay, over cost, poor quality,
- Management risks; for example, poor communication or poor project management and control.

In the operational phase the following risks can happen:

- Environmental risks: for example, air pollution, water pollution, energy consumption and greenhouse gas emission, soil contamination or waste generation,
- Financial risk: for example, cost increase or revenue decrease,
- Technical risks: for example, construction defects.

In the disposal phase the following risk can happen:

- Financial risk: for example, high cost connected to the disposal of construction,
- Regulatory or political risk: for example, authorisation risk,
- Environmental risk: for example, landfill contamination, air pollution.

The following figure shows the risks in construction project investment in every stage of the construction project cycle.

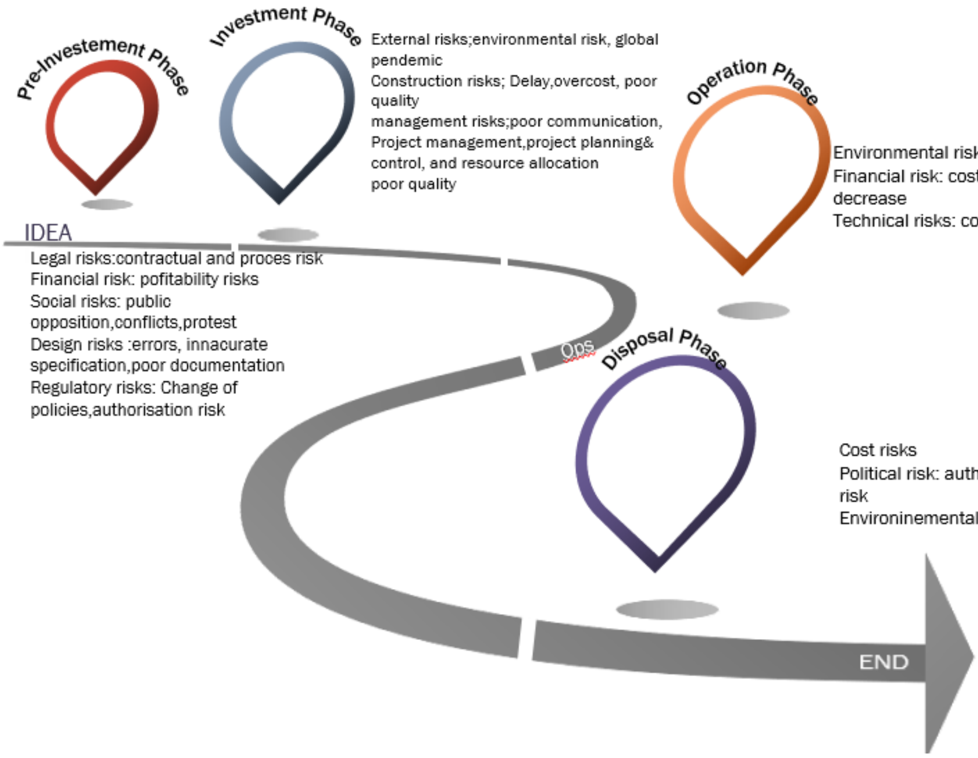


Figure 5 Investment risks in the construction project cycle (author's own work)

2.1.6 Risk analysis

Risk analysis increases the team and the managers confidence level in dealing with risks and includes two sub tasks - qualitative risk analysis and quantitative risk analysis. Risk analysis is not a onetime activity. It is repetitive, and it can be sent for further analysis from both the respond to risks process as well as the monitor and control risks process. Risk analysis and risk management represent an integral part of project risk management.

Qualitative risk analysis

Qualitative risk analysis is a risk management process that involves identifying, evaluating, and prioritizing risks based on their impact and likelihood of occurrence. This process uses qualitative data and expert judgment to assess the potential risks that may affect a project, organization, or system. Unlike quantitative risk analysis, which relies on numerical data and statistical models, qualitative risk analysis is a subjective approach that does not involve assigning numerical values to the risks. Instead, it relies on the experience and knowledge of the stakeholders involved in the project to identify and evaluate potential risks. The purpose of qualitative risk analysis is to provide decision-makers with a better understanding of the potential risks and to develop appropriate strategies to mitigate or manage those risks.

Qualitative risk analysis is an essential part of the risk management process in any investment project, including construction projects. Qualitative risk analysis involves identification, assessment, and prioritization of risks based on their impact and likelihood of occurrence. Some key steps to consider when conducting qualitative risk analyses in construction project investment follows:

- Identify potential risks: The first step is to identify potential risks that may affect the construction project. These may include project delays, cost overruns, quality issues, safety hazards, environmental concerns, regulatory compliance, and contract disputes,
- Assess the likelihood and impact of risks: Once the risks have been identified, the next step is to assess the likelihood and impact of each risk. Likelihood refers to the probability that the risk will occur, while impact refers to the consequences if the risk really occurs,
- Prioritize risks: After assessing the likelihood and impact of each risk, prioritize them based on their severity. This can be done by assigning a risk score or ranking the risks according to their potential impact on the project,
- Develop risk mitigation strategies: Based on the prioritized risks, develop risk mitigation strategies to minimize the impact of the identified risks. These strategies may include risk transfer, risk avoidance, risk reduction, or risk acceptance,
- Monitor and review risks: Finally, monitor and review the risks regularly to ensure that the risk mitigation strategies work effectively. This will help to identify new risks that may arise during the construction project and adjust the risk management plan accordingly.

By following these steps, investors can effectively manage risks in construction projects and ensure that they make informed investment decisions. It is important to note that qualitative risk analysis is just one part of the overall risk management process, and investors should also consider quantitative risk analysis and other risk management techniques to ensure project success.

Purpose of qualitative risk analysis

The purpose of this process is to prioritize risks to determine which risks require additional analysis. This helps the risk management team to focus on the higher priority risks.

The Qualitative Risk Analysis process asks questions like:

- What is the probability of the risk occurrence?
- What is the impact to the project objectives if this risk occurs?
- How much time is needed to respond to this risk?
- Where should our effort be focused?

The Qualitative Risk Analysis process uses the definition of Probability and Impact we set in the Risk Management Plan.

The need to further analyse a few of the selected high priority risks may be necessary at the end of qualitative risk analysis. These risks are further analysed in the quantitative risk analysis process. The information below summarizes the steps in qualitative risk analysis:

Performing qualitative risk analysis

Qualitative Analysis is the first step towards analysing the risks that have been identified in the risk identification process. The qualitative analysis process is quick and cheap. It can provide some idea about the risks, and determine which risks need to be analysed further by using quantitative analysis.

Input into qualitative risk analysis

The Risk Register is a default input into this process. Apart from the risk register, the other inputs into this process are:

Project scope statement - when the qualitative risk analysis is performed, it is necessary to know what kinds of risks must be dealt with. For example, if you are already familiar with these risks or if your project is similar to previous projects, it might have well-understood risks. If it is a new and complex project, it might involve risks that are not well understood in your organization. So, how do you know what kind of project you are dealing with? Simply put, you must look at the project scope statement and search for uncertainties.

Risk management plan - to generate the output of qualitative risk analysis, it is necessary to follow the elements of the risk management plan:

- Roles and responsibilities for performing risk management,
- Budgeting,
- Definitions of probabilities and impacts,
- The probability and impact matrices,
- Risk categories,
- Risk timing and scheduling,
- Stakeholders' risk tolerances.

If any of these input items were not developed during risk management planning, they can be developed during qualitative analysis.

Risk register - The Risk register contains the list of identified risks that are the key input to the qualitative risk analysis. Updated risk categories and causes of risks can also be useful elements of the risk register, which can be used in the qualitative risk analysis.

Organizational process assets - While analysing risks, project manager makes use of the risk-related components of the knowledge base from previous projects, such as data about risks and lessons learned. The project manager can also investigate risk databases that may be available from industry organizations and proprietary sources.

Tools and techniques for qualitative risk analysis

Prioritizing risks based on their probability of occurrence and their impact in case of occurrence is the central goal of qualitative risk analysis. Accordingly, most of the tools and techniques used involve estimating the probability and impact. Risk probability and impact assessment - risk probability refers to the likelihood that a risk occurs, and impact refers to the effect that the risk has on a project objective if it occurs. The probability for each risk and the impact of each risk on project objectives, such as cost, quality, scope, and time, must be assessed. Probability and impact should be assessed for each identified risk.

Methods used in the probability and impact assessment include holding meetings, interviewing, considering expert judgment, and using the information database from the previous projects.

A risk with a high probability might have a very low impact, and a risk with a low probability might have a very high impact. To prioritize the risks, it is necessary to look at both probability and impact.

Assessment of the risk data quality - Qualitative risk analysis is performed to analyse the risk data to prioritize risks. However, before it is done, it is necessary to examine the risk data for its quality, which is crucial because the credibility of the results of qualitative risk analysis depends upon the quality of the risk data. If the quality of the risk data is found to be unacceptable, it might be decided to gather better quality data. The technique of assessing the risk data quality involves examining the accuracy, reliability, and integrity of the data and examining how that data is relevant to the specific risk and project for which it is being used.

Risk urgency assessment - This is a risk prioritization technique based on time urgency. For example, a risk that is going to occur now is more urgent to be addressed than a risk that might occur a few months from now.

Probability and impact matrix - Risks need to be prioritized for quantitative analysis, response planning, or both. The prioritization can be performed by using a probability and impact matrix; a lookup table that can be used to rate a risk based on where it falls both on the probability scale and on the impact scale.

Risk mapping

Risk mapping is the process of identifying and assessing potential risks within a specific geographic area or location. The manufacturing and warehouse projects can bear risk within their geographic area or location. Risk mapping involves the use of scientific data and methodologies to create maps that visually represent the likelihood and potential impact of various hazards and vulnerabilities.

Risk mapping typically involves several key steps, as follows:

- Hazard identification: Identifying potential natural or man-made hazards that could pose a risk to a particular area or location,
- Vulnerability assessment: Assessing the degree to which a given area or population is vulnerable to the identified hazards,
- Risk assessment: Combining hazard and vulnerability data to determine the likelihood and potential impact of specific risks,
- Mapping and visualization: Creating maps that illustrate the results of the risk assessment, often using colours or shading to represent the likelihood and potential impact of different hazards and vulnerabilities.

Risk matrix

The risk matrix graphically illustrates risks according to probability of occurrence and their importance for the development project. It is typically a matrix or grid that categorizes risks based on their likelihood and potential impact.

The scientific definition of a risk matrix involves the following steps:

- Identifying potential risks: This involves identifying and listing all the potential risks that may affect an organization or project,
- Assessing the likelihood of each risk: This step involves assessing the probability of each identified risk occurring. This could be done by analysing historical data, conducting surveys or expert interviews, or using statistical models,
- Assessing the potential impact of each risk: This step involves assessing the severity of each identified risk and the potential damage it could cause. The impact could be financial, reputational, legal, or physical.
- Categorizing risks: Based on the likelihood and potential impact, the risks are categorized into different levels or zones within the matrix. For example, a low likelihood and low impact risk could be placed in the green zone, while a high likelihood and high impact risk could be placed in the red zone,

- Developing risk mitigation strategies: Based on the results of the risk matrix, appropriate risk mitigation strategies can be developed for each risk category or zone,

The risk impact on a project risk matrix helps the manufacturing and warehouse facility construction investment managers to prioritize and allocate resources to manage risks that are likely to have a high impact on the project. By identifying and prioritizing high-impact risks, project managers can take appropriate measures to mitigate or avoid those risks, reducing the potential negative impact on the project's success.

Table 2 The risk impact on a project risk matrix

Severity of risk	**Impact on the project**
Insignificant	it does not fundamentally impact the project
Negligible	it affects the project minimally
Moderate	it impacts the project with a significant impact on the cost or revenue
Extensive	it is necessary to use the project reserves
Significant	it has a fundamental impact on cost or revenue and project is not eligible to continue

For the manufacturing and warehouse facility construction project investments, the occurrence of the risk on a project refers to the likelihood or the probability of event happening during the project course or after. Manufacturing and warehouse facility project manager use it to identify and prioritize risks based on their likelihood of occurrence.

The occurrence of risk on warehouse and manufacturing facility projects can be influenced by various factors such as project complexity, project size, project duration, stakeholder involvement, and external factors such as economic and politic conditions, market trends, global pandemic, and regulatory changes.

Overall, the occurrence of risk on a project is an important aspect of project risk assessment and management, as it helps project managers to anticipate and manage potential risks that could impact the project's success.

Table 3 The occurrence of risks on the projects

Likelihood	**Chance**	**Probability**
Rare	It may occur only in exceptional circumstances	< 10%
Unlikely	It could occur at some time	< 35%
Possible	It might occur at some time	> 35%
Likely	It will probably occur in most circumstances	> 65%
Almost certain	It Is expected to occur in most circumstances	> 95%

Risk matrix

Overall, the risk matrix is a useful tool for the manufacturing and warehouse facility construction investment projects to prioritize and manage potential risks based on their likelihood and potential impact. The table below shows the risk elimination measures classification by visual representation of the likelihood and severity of potential risks. This matrix categorizes risks based on their likelihood and potential impact.

Table 4 The risk elimination measures classification.

		Impact				
		Insignificant	Negligible	Moderate	Extensive	Significant
Likelihood	Rare	No risk	No risk	Low risk	Common risk	Common risk
	Unlikely	No risk	Low risk	Common risk	Common risk	Increased risk
	Possible	Low risk	Common risk	Common risk	Increased risk	High risk
	Likely	Common risk	Common risk	Increased risk	High risk	High risk
	Almost certain	Common risk	Increased risk	High risk	High risk	High risk

Risk elimination measures are strategies used to completely remove the possibility of a risk event occurring. These measures are typically used when a risk is deemed too high to be managed through risk mitigation or avoidance strategies alone.

Table 5 The risk elimination measures classification.

Code	**Classification**	**Action/ Measures**
NR	No risk	No action necessary
LR	Low risk	Must be taken in account and monitored
CR	Common risk	Common measures
IR	Increased risk	Quick intervention needed
HR	High risk	Without immediate intervention has critical impact

It is important to note that risk elimination measures are not always practical or feasible, as they may be too costly or disruptive to the project. In such cases, risk mitigation or avoidance strategies may be used to manage the risk instead. Nonetheless, when possible, risk elimination measures are often the most effective way to reduce the likelihood and impact of a high-risk event.

SWOT analysis

SWOT analysis is a strategic planning tool that is widely used in business and organizational settings to identify and evaluate the strengths, weaknesses, opportunities, and threats of the manufacturing and warehouse facility construction projects. It is a simple yet effective framework that provides a comprehensive overview of the internal and external factors that can have impact on the success of a project and investor's organization.

Scientifically speaking, SWOT analysis is a structured approach to strategic planning that involves four main steps:

- **Strengths**: Identifying the internal strengths of the project or organization. This involves evaluating the resources, capabilities, and competitive advantages that the project or organization possesses.
- **Weaknesses**: Identifying the internal weaknesses of the project or organization. This involves evaluating the areas where the project or organization is lacking, such as skill gaps, operational inefficiencies, or limited resources.
- **Opportunities**: Identifying the external opportunities that the project or organization can capitalize on. This involves evaluating the market trends, emerging technologies, or changing consumer behaviour that can create new business opportunities.
- **Threats**: Identifying the external threats that the project or organization may face. This involves evaluating the competition, economic conditions, regulatory changes, or other factors that can affect the project or organization negatively.

Once SWOT analysis is complete, the information gathered can be used to develop a strategic plan that leverages the strengths, addresses the weaknesses, capitalizes on the opportunities, and mitigates the threats of the project or organization. This plan can help to guide decision-making, resource allocation, and prioritization of activities to maximize the chances of success.

The table below is the SWOT analysis table that shows how is the SWOT analysis composed.

Table 6 SWOT Analysis (edited by author)

	Helpful to achieving the objective	**Harmful** to achieving the objective
Internal origin Attributes of the project	STRENGTHS	WEAKNESSES
External origin Attributes of the project	OPPORTUNITIES	THREATS

2.1.7 Quantitative risk analyses

Quantitative risk analysis is a risk assessment technique that involves using numerical data and statistical models to evaluate the likelihood and potential impact of risks. This process involves identifying and analysing risks, determining the probability of their occurrence, estimating the potential impact of the risks, and using mathematical models to evaluate the overall risk exposure.

Quantitative risk analysis often involves collecting and analysing large amounts of data, such as historical project data, financial data, and performance metrics. It also uses probability distributions and statistical models to quantify the risks and to estimate the likelihood of specific events occurring.

The purpose of quantitative risk analysis is to provide decision-makers with a more precise and accurate understanding of the potential risks associated with a project, system, or organization. This information can help decision-makers to make informed decisions and to develop effective risk management strategies.

Quantitative risk analysis is commonly used in industries such as finance, insurance, engineering, and project management. It is an important tool for assessing and managing risks in complex projects, systems, or organizations.

Quantitative Analysis is usually performed on a sub-set of the identified risks that are of high impact / priority, while Qualitative Analysis is quick and cost effective, Quantitative analysis can be more time consuming and costly. In smaller projects, this step may be ignored whereas for large projects, quantitative analysis is extremely valuable. Quantitative analysis is repetitive and may occur multiple times throughout the life of the project.

Performing quantitative risk analysis

Quantitative risk analysis is generally performed on risks that have been prioritized by using the qualitative risk analysis. However, depending upon the experience of the team and their familiarity with the risk, it is possible to skip the qualitative risk analysis and, after the risk identification, move directly to the quantitative risk analysis. The quantitative risk analysis has three major goals:

- Assess the probabilities of achieving specific project objective,
- Quantify the effect of the risks on the overall project objectives,
- Prioritize risks by their contributions to the overall project risk.

Input into quantitative analysis

All the items that represented input for the qualitative risk analysis also represent input for the quantitative risk analysis. In addition, the quantitative risk analysis generally requires more information than its qualitative counterpart.

Risk register - The key input items from the risk register are the following:

- List of identified risks and their description,
- Priority and occurrence list of risks if the qualitative risk analysis performed,
- Risks with categories assigned to them,
- Mitigation measures to manage the risks.

The following plan must be considered to perform quantitative risk analysis: the risk management, plan, cost management plan, and schedule management plan and to generate the output of the quantitative risk analysis, the following elements of the risk management plan should be considered:

- Budgeting,
- Definitions of probabilities and impacts,
- Probability and impact matrix,
- Risk categories,
- Risk timing and scheduling.

Schedule and the project cost must be known to analyse the effect of risks on the project objectives. These can be found in the cost management plan and schedule management plan. The approaches taken by these plans can affect quantitative risk analysis.

Organizational process assets - The following organizational process assets might be useful in the quantitative analysis:

- Information on previously performed similar projects,
- Studies performed by risk specialists on similar projects,
- Proprietary risk databases or risk databases available from the industry.

The methodology to assist the risk management in ex-ante phase of construction project is used on investment project of constructing a manufacturing and warehouse facilities.

2.1.8 Input information into the construction project risk analysis

Input information is defined by the conditions of the degree of processing in the stage of preparation of the construction work for implementation.

The technical parts of construction are defined in the project documentation.

The documentation:

- Technical report,
- Drawing,
- Documents,
- Technical specifications,
- Assessment reports and budget.

This documentation provides information for establishing the cost from the budget according to technical solution of the construction with defined quality.

Risk of extending the cost out of planned limits can be due to technical change in construction or economic change in the price entry.

Evaluation of the risk is done according to the selected indicators (Korytárová et al., 2011).

2.1.9 Risk assessment

Investing in a construction project for manufacturing and warehouse facilities involves several risks that should be carefully assessed before proceeding.

Risk assessment procedure

During the preparation of the construction work for implementation, the risk of no-compliance with cost is the determined in the following individual steps:

- Determining the location of the risk,
- Defining root causes – technical and economical,
- Defining the conditions, according to the original location of the risk, that may cause deviations of the actual costs from the planned costs,
- Determining the probability of change in given conditions,
- Calculation of the change range in the individual cost.

- Determining the extent of the partial changes effect on total costs.
- Defining the change extent in total on the basis of the conditions defined in the sections.
- Evaluating the result in terms of feasible costs and determining the range of the final value.

In the case of construction costs, it is necessary to look for a place of possible risk. Usually these are increased costs arising as a result of the performance of the activity, or costs related to production resources.

To determine the degree of risk due to non-compliance with the cost of construction work, simulations can be performed in advance with the definition of the input conditions for which they apply.

Based on the selected entry conditions, the calculation of the future price is calculated expressed as the interval of the minimum and maximum possible price.

The input data expressed as an interval of minimal and maximal values can be inserted into the budget as output conditions.

Output data that may affect future costs of the construction are mainly:

- Costs of building materials in unit prices,
- Costs of production labour in wage tariffs,
- Costs of production machines, especially their time and capacity utilization and operating mass prices.

The influence of risk factors on the overall efficiency of the construction project

The risk analysis of construction project means analysing the relative risk factor on the efficiency of the overall project.

In general, efficiency can be characterized as an effort to minimize the cost or maximize the utility in terms of input and output to define the term efficiency of project. Based on the concept of the evaluation of economic efficiency, it is possible to distinguish two most important approaches to its assessment. The first approach is to compare the general benefits and general costs that arise as a result of the implementation of the construction project. Necessary condition is that all benefits and expenses are expressed in the form of cash flow, thus in monetary units. If the condition of the financial form of the benefits and costs associated with the assessed project is met, it is possible to use standard criteria for evaluating the effectiveness of the project, as they are for example Net Present Value (NPV) and/or Internal Rate of Return (IRR).

However, if the project is designed with an emphasis on the fixed benefits of the property ownership and the possibility of using the property as transport construction, technical infrastructure, or, for example the company's headquarters, it is more advantageous to use a second alternative approach, which is to assess the Life Cycle Cost (LCC).

In this case, the benefit from realization and operation of the project is not quantified and the project is evaluated only based on an analysis of the costs that arise during the life cycle of the project.

Project risk assessment can be performed by doing the following steps:

- Determination of the evaluation criteria which is relevant with regard to the required business success of the project,

- Determination of the model of dependence of the evaluation criteria on the influencing variables,
- Definition of risk factors from the group of influencing variables,
- Determining the probability of distribution for risk factors,
- Determining the risk of the project by calculating the basic statistical characteristics of the established evaluation criteria.

Definition of risk factors and their significance

Definition of risk factors and their significance are the basic steps for risk management of the project. Risk factor can be characterized as a variable, e.g., its future development can have negative or positive impact on the success of the project. The success of project can be seen from different perspectives according to the character of evaluated projected. The commercial project has characters that are based on the profits and cash flow, in the case of a non-commercial project, the criteria may be based on the cost of the project or the evaluation of the utility.

Significant simplification of the identification of risk factors helps the division of construction project into phases of its life cycle (pre-investment, investment, operational and liquidation).

Economic efficiency of the construction projects

Economic efficiency of the construction project is an important indicator for investors and other stakeholder as it shows the ability of the project to generate the desired returns on investment while minimizing costs and risks.

It is possible to agree with Synek's (2011) opinion that for the evaluation of effectiveness there must exist a criterion according to which the investment is judged. Since investment projects in general are implemented with certain goals, the criteria for their evaluation must be the degree of these objectives' achievement.

Key factors considered to improve investment efficiency of a construction project may be:

- Project planning: A well-planned project can reduce the risk of cost overruns and delays; therefore, it is very important that investment efficiency indicators are well studied during the project planning,
- Use of technology: Technology such as Building Information Modelling (BIM) can help improve collaboration, reduce errors, and minimize the risk of rework, all of which can increase efficiency and reduce costs,
- Resource optimization: Optimize the use of resources, such as labour and materials, to reduce waste and improve productivity. This can be achieved by using lean construction techniques, pre-fabrication, and off-site construction,
- Contract management: Effective contract management can help minimize disputes and ensure that contractors and suppliers deliver work to agreed-upon standards, timelines, and costs,
- Stakeholder engagement: Engagement of stakeholders, including investors, contractors, and end-users, to ensure that their expectations are met, and their needs are considered. This can help improve project outcomes and increase the likelihood of repeated investment.

Efficiency should consider the time value of money. The time period gives the results of the calculating a real value of earnings. Discounting is not applied to short-term projects, here the time value of money can be neglected. Therefore, it is also possible to divide the methods of assessing the effectiveness of the project in time-static and dynamic.

Time-static methods, unlike dynamic ones, do not consider the time value of money.

Cash flow indicator shows how the money that flows in and out of project throughout a given period according to the author of the publication Managerial Economics and other professional literature. The general effect of investments is in cashflow (Synek, 2011).

2.1.10 Time-static methods

There are several time-static methods that can be used for economic efficiency evaluation of construction investment project. The most common methods used are return on investment, the return on equity method and payback periods.

Return on investment.

Return on Investment (ROI) is the method that assesses the percentage excess of costs over revenues. It is a measure of the return earned on an investment relative to the cost of that investment.

ROI is a useful tool for investors to compare the profitability of different investments and to determine if an investment is worth the cost. A high ROI indicates that the investment is generating a significant return relative to the cost, while a low ROI indicates that the investment may not be generating enough profit to justify the expense.

According to the publication *Managerial Economics*, the effect of the project is considered profit. It is because both changes in production volume and changes in costs caused by the investment are reflected in the profit, which sufficiently characterizes the benefit of the investment.

$$ROI = \left(\frac{TR}{TC} - 1\right) * 100$$

Where:

TR is Total Revenue,

TC is Total Cost,

ROI is Return on Investment.

ROI is expressed as a percentage and is calculated by dividing the net profit (or revenue) of an investment by the cost of that investment.

Return on Equity

Return on Equity (ROE) is a useful indicator to evaluate the profitability of a construction investment project. This is also a simple method as the ROI method, but in the numerator is the profit instead the taxation, in the denominator is the invested (or required by the bank) equity.

According to the authors of the publication *Investment decision-making and project management*, equity profitability is determined as the ratio of profit after tax (or profit before tax) to the equity capital invested in projects, and therefore expresses the degree of appreciation of the own resources used by the investor to finance the project (Fotr & Souček, 2011).

$$ROE = \frac{EBT}{EQ} 100$$

Where:

EBT is Earning Before Tax,

EQ is Equity,

Payback period

Another time-static method is the undiscounted payback period in years. The payback period is also commonly used in construction investment projects to evaluate the financial feasibility of the project. In this context, the payback period is calculated by dividing the initial construction cost by the estimated annual cash flows generated by the project.

According to the publication *Managerial Economics*, the payback period is the period during which the net Cashflow brings a value equal to the original investment costs.

If the income in each year of the investment life is the same, then the payback period is the investment costs divided by the annual amount of expected net cash flow.

$$PP = \frac{IC}{CF}$$

In practice, most of the projects have different cash flow each year, therefore the following formula is more suitable (Korytárová & Hromádka, 2022)

$$0 = -TC + \sum_{t=1}^{pp} CF_t$$

Where:

TC is total cost of investment,

CFt is Cashflow for a total period *t*,

PP is Payback Period.

The payback period is an important metric for construction projects because it provides an indication of how long it will take to recover the initial investment and start generating profits. This information can help investors and project managers make informed decisions about whether to pursue a construction project or not.

2.1.11 Time-dynamic methods

The time-dynamic methods are used to account for the changing value of money over time. They are more telling from an investment point of view than undiscounted ones.

In this dissertation thesis, the method of discounted payback period, the internal rate of return, the net present value method and the economic added value method are subjected to further investigation as part of the time-dynamic methods.

Weighted Average Cost of Capital

The Weighted Average Cost of Capital WACC is a financial metric used to measure the time required to recover the initial investment in a project, taking into account the time value of money and the cost of capital. Here are the steps to calculate it:

- Determination of the initial investment in the project,

- Calculation of the annual cash inflows from the project for each year of the project's life,
- Calculation of the present value of each annual cash inflow using the WACC as the discount rate. The formula to calculate the present value is: $PV = CF / (1 + WACC)^t$, where *PV* is the present value, *CF* is the cash flow, *WACC* is the weighted average cost of capital, and *t* is the number of years from the present,
- Adding up the present values of the annual cash inflows until they equal the initial investment.

Formula for discounted payback period

$$0 = -TC + \sum_{t=1}^{DPP} DCFt$$

Where:

TCF is Total Cost of investment,

DCFt discounted cashflow in time t,

DPP is discounted payback period.

The discounted payback period allows investors and project managers to assess the feasibility of a construction project investment by determining how long it will take for the project to recover its initial investment, taking into account the present value of future cash flows. This helps to identify the risks and uncertainties associated with the project, as well as the potential for a long-term profitability.

In the construction industry, discounted payback period can be used to evaluate the efficiency of projects such as building new structures, developing infrastructure, or upgrading existing facilities. By using DPP, investors and project managers can compare different construction projects investment to determine which ones are the most financially feasible and offer the greatest return on investment.

Weighted average cost of capital (WACC)

The Weighted Average Cost of Capital (WACC) is a financial metric that measures the cost of capital for a company or a project.

When calculating the WACC for a construction investment project, the process is similar to that for any investment project, but there are a few specific factors that need to be taken into account. Here are the steps to follow:

- Estimating the market value of the project's equity and debt. In the case of a construction project, this may involve estimating the total cost of the project, including land, materials, labour, and any other expenses. This estimate should be discounted to its present value using an appropriate discount rate.
- Determining the cost of equity for the project. This may involve estimating the project's beta, or its sensitivity to market risk, and using the Capital Asset Pricing Model (CAPM) to calculate the required rate of return for equity investors. In the case of a construction project, the riskiness of the project may be higher than for other types of projects, due to uncertainties such as construction delays, cost overruns, and regulatory issues.
- Determining the cost of debt for the project. This may involve estimating the interest rate that the project would need to pay to borrow money, based on its creditworthiness and the prevailing market interest rates. In the case of a construction project, the cost of debt

may be higher than for other types of projects, due to the greater risks associated with construction.

Calculate the WACC for the project using the formula:

WACC = (E/V x Re) + (D/V x Rd x (1-Tc))

Where:

E = Market value of the project's equity,

V = Total market value of the project (equity + debt),

D = Market value of the project's debt,

Re = Cost of equity for the project,

Rd = Cost of debt for the project,

Tc = Corporate tax rate (if applicable).

Use the WACC as the discount rate to calculate the present value of the project's future cash flows. This will provide an estimate of the project's net present value (NPV), which can be used to evaluate whether the project is a good investment. In the case of a construction project, it is important to account for the fact that cash flows are likely to be negative during the construction phase, and positive after the project is completed.

Overall, when calculating the WACC for a construction investment project, it is important to take into account the specific risks and uncertainties associated with construction, and to carefully estimate the costs and cash flows of the project.

Net present value

Net Present Value (NPV) is a useful financial metric in construction investment projects. It is often used to determine the economic feasibility of a construction project by estimating the present value of future cash flows generated by the project and comparing it to the initial cost of investment.

In construction projects, the initial investment cost includes the cost of land acquisition, construction materials, labour costs, and other expenses. The expected cash flows generated by the project include revenues from sales or rentals, savings on operational costs, and salvage value at the end of the project's life.

The method algebraically adds discounted income and expenses. In the case of a positive sum, the investment is feasible, as there is a positive balance (profit) at the end of the project's life. In the case of a negative result, the project is not profitable.

As stated by the authors in the book *Theory and Practice of Finance Firms*, the concept of net present value enables the effective separation of ownership and management of a corporation, in our case a project.

A manager who invests only in assets with a positive net present value best serves the interest of all owners of the company (in our case, the project) – regardless of their differences in wealth and taste. A financial manager cannot influence the interest rate, but he can increase the wealth of the owners. The way to do this is by investing in assets with positive net present value (Brealey, 2011).

Formula to calculate NPV is:

$$NPV = -IC + \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t}$$

Where:

IC = Total investment cost in Year 0,

CFt = The cash flow in *t* period year,

t = The lifetime of project in years,

NPV = Net Present Value.

If the NPV is positive, the project is expected to generate a profit, while a negative NPV indicates that the project is expected to generate a loss. An NPV of zero indicates that the project will break even.

NPV is a useful tool for construction project managers and investors to evaluate the profitability of a project and make informed investment decisions. However, it is important to note the accuracy of the NPV calculation.

Economic literature most often refers to the use of the NPV method in the evaluation of investment projects. The key parameter of this method is the length of the evaluated period and the chosen discount rate. However, many companies still use other methods for investment decisions. For example, a study conducted on the Helsinki Stock Market showed that Finnish companies still lag behind the United States and Sweden in the use of NPV and IRR indicators (Liljeblom & Vaihekoski, 2004).

Discounted payback period

The discounted payback period (DPP) is a useful tool in evaluating the investment efficiency of a construction project. The DPP considers the time value of money, which is important in construction projects that require large initial investments and generate cash flows over a long period of time.

As stated in the publication Investment decision-making and project management, one of the shortcomings of the payback period is not respecting the time value of money, when income and expenses of the project in the nearer or more distant years of the project's life have the same weight (Fotr & Souček, 2011).

Internal rate of return

Calculating the IRR for a construction investment project involves estimating the expected cash inflows and outflows over the construction period and the subsequent operating period.

Formula to calculate IRR is

$$0 = \sum_{t=o}^{n} \frac{CFt}{(1+IRR)^t}$$

Where:

CFt is the Cash flow in the specific time,

n is the project lifetime is years,

IRR Internal rate of return in percentage.

In other words, the IRR is the rate at which the present value of the expected cash inflows from the investment equals the present value of the expected cash outflows.

3 METHODOLOGY

During the scientific research it is necessary to select the suitable and appropriate methods and the procedures used to conduct the research. This chapter explains how the research was conducted and how the data was collected and analysed. The methods of analysing the risk in ex-ante phase of construction investment project as well as the evaluating of its economic efficiency can be numerous.

In this dissertation thesis, the author focuses on risk management in the ex-ante phase of construction investment projects. The key components that are included in the methods and procedures used to conduct the research are as follows:

- **Research design:** The research approach used to assess the risks of projects in the ex-ante phase of their life cycle is based on a mix of qualitative and quantitative risk management methods.
- **Sampling:** The research consists of:
  - The manufacturing and warehouse facility construction projects in Ždár nad Sázavou,
  - 12 manufacturing and warehouse projects in Central and Eastern Europe,
  - 26 initiative projects to eliminate the environmental risk in the manufacturing and warehouse projects from 3 continents (Europe, America, and Asia).
- **Data collection**: The data was collected through archival data and quality of data was ensured by double checking the data with the specific project investor.
- **Focus:** The author focuses on risk management in the manufacturing and warehouse facility construction project investments and limit on risk impacting the economic investment efficiency.
- **Strengths:** Evaluation of the suitability of individual methods and usefulness of the results that each chosen method provide.

3.1 Risk analysis

There are several common risks associated with investing in manufacturing and warehouse facility construction projects. Some of these risks include:

- **Construction delays:** One of the biggest risks is construction delays, which can occur due to a variety of factors such as unforeseen site conditions, labour shortages, or adverse weather conditions.
- **Cost overruns:** They can occur due to changes in the design, unexpected expenses, or inflation. Construction projects are notorious for going over budget.
- **Regulatory and Compliance Risks**: There are numerous regulations and compliance standards that must be met when constructing a manufacturing and warehouse facility. Failure to comply with these standards can lead to fines and legal action.
- **Design and Engineering Risks**: There are errors in the design or engineering of the project that can lead to construction delays, cost overruns, and safety issues.
- **Safety Risks**: Construction sites are inherently dangerous, and safety risks can result in injuries to workers, property damage, or even fatalities.

- **Environmental Risks**: Environmental risks such as soil contamination, air pollution, and hazardous waste disposal can have significant legal and financial implications.
- **Market Demand Risks:** Manufacturing and warehouse facilities are often built to meet specific market demands. If the market demand changes, the facility may become obsolete or unprofitable.
- **Economic Risks:** Economic factors such as interest rates, inflation, and market conditions can impact the profitability of the project.

3.1.1 The most common risks associated with investing in manufacturing and warehouse construction projects.

A research sample of 12 projects implemented in Central and Eastern Europe, listed in the table below, was examined as part of the dissertation thesis. Most of the projects are already completed, 2 projects are in the pre-investment phase. The research showed that projects are particularly burdened by the following risks:

- Cost overruns 20% of the sample had cost overruns risk.
- Construction delays 30% of the sample had construction delay.
- Market demand risks 20% of the sample had market demand changes.
- Environmental risks 20% of the sample had environmental risks.

Table 7 common risk associated with investing in warehouse and manufacturing facility construction projects.

Project number	Project	Project phase	Cost overruns risk	Construction delays risk	Market demand risk	Environment risk
1	Žďár nad Sázavou Industrial Zone	Completed	YES	YES	YES	YES
2	Jičín Industrial Zone	Completed	NO	YES	NO	NO
3	Jindřichův Hradec Industrial Zone	Completed	YES	YES	YES	YES
4	Bucharest West	Completed	NO	NO	NO	NO
5	Bor B7	Completed	NO	NO	NO	NO
6	Brno	Completed	NO	NO	NO	NO
	Modřice	Completed	NO			
7	Budapest East	Completed	NO	N/A	NO	NO
8	Romania Sibiu	In Pre-investment phase	N/A	N/A	N/A	N/A
9	Poland Opole	Completed	NO	NO	NO	NO
10	Poland Opole	In Pre-investment phase	N/A	N/A	N/A	N/A
11	Bratislava	Completed	NO	NO	NO	NO
12	Belgrade	Completed	NO	NO	NO	NO

3.1.2 Risk mapping

The risk matrix was used for evaluating the risk. The following table defines the main risks of projects and the impact of these risks on the course of projects.

Table 8 Risk types and their impact

Risk	Explanation	Impact on the project
Cost overruns	Construction cost is exceeding the planned cost	The overall economic efficiency of the project
Construction delays	The project timeline is not being respected	It can impact the start of receiving the revenue expected
Market demand	Market demand drops down	The overall economic efficiency of the project
Environmental risk	Project harm or negative impact on the environment	Wellbeing of people and can impact the overall economic efficiency

The individual risks were included in the risk matrices, which visually show the evaluation of risks in the table below.

Table 9 Risk matrix

		Impact				
		Insignificant	Negligible	Moderate	Extensive	Significant
Likelihood	Rare	No risk	No risk	Low risk	Common risk	Common risk
	Unlikely	No risk	Low risk	Common risk	Common risk	Increased risk
	Possible	Low risk	Common risk	Common risk	Increased risk	High risk
	Likely	Common risk	Common risk	Increased risk	High risk	High risk
	Almost certain	Common risk	Increased risk	High risk	High risk	High risk

The impact on project profit is calculated according to the formula below.

$$RI = \sum_{n=1}^{R} A_n x\, L_n$$

Where:

RI is Risk Impact on the profit before tax,

A is evaluation of occurrence of the risk,

L is evaluation of risk level.

Table 10 Calculation of Semiquantitative risks

		Impact				
		1	2	4	8	16
Likelihood	1	No risk	No risk	Low risk	Common risk	Common risk
	2	No risk	Low risk	Common risk	Common risk	Increased risk
	3	Low risk	Common risk	Common risk	Increased risk	High risk
	4	Common risk	Common risk	Increased risk	High risk	High risk
	5	Common risk	Increased risk	High risk	High risk	High risk

3.1.3 Sensitivity analysis

Scenarios based on sensitivity analysis are well used in decision making.

A hypothetical situation was created by varying key input variables in the financial models to evaluate how they affect the project's financial outcomes.

3.1.4 Sensitivity analysis scenarios

Sensitivity analysis scenarios in the context of investing in construction projects follow:

Table 6 Scenario for sensitivity analysis

Risk factor	SENSITIVE ANALYSIS OF REVENUE REDUCTION		
	Pessimistic	Realistic	Optimistic
Market demand (revenue)	Decrease in demand (revenue)	As expected,	Increase in demand (Revenue)
Cost of investment	Increase in investment cost	As expected,	Decrease in cost of investment
Pay back in years	Longer Pay Back Period	As expected,	Shorter Payback Period
Return on investment	Lower ROI	As expected,	Higher ROI

Investors can identify the key variables that have the most significant impact on the project's financial outcomes by analysing different sensitivity analysis scenarios. This information can help investors make informed decisions about how to manage risks and optimize returns.

4 CASE STUDIES

The methodology to assist the risk management in ex-ante phase of construction project is applied at investment projects of manufacturing and warehouse facility constructions.

Case studies comprise:

- Construction of warehouse and manufacturing facility in Žďár nad Sázavou,
- Analysis of 12 manufacturing and warehouse facilities from different countries in Central and Eastern Europe,
- Analysis of 26 countermeasures of environmental risks of manufacturing and warehouse facilities.

Case study 1: Construction of manufacturing and warehouse facility in Žďár nad Sázavou

The investor is the Hettich group which is one of the world's leading manufacturers of furniture fitting. It is a family-owned company based in the eastern Westphalian town of Kirchlengern. Hettich group has 38 subsidiaries worldwide. Hettich group has had a manufacturing facility in the Czech Republic since 1993, where they make production.

Hettich Czech Republic is the competence centre for zinc die casting production and, as a component manufacturer, an important partner in the Hettich production network. Product portfolio ranges from hinges to extensions, connecting fittings and technology for sliding and folding systems which has an indispensable position in the Hettich group.

Hettich Czech Republic is based in Žďár nad Sázavou located in an industrial area where other companies with experience in furniture fitting were already based, therefore there was a guarantee there would be employees in local area with required know how. This area is also near the railway station and the main road. The local authorities of Žďár nad Sázavou have had an interest in extending the businesses in the industrial zone as it creates more job opportunities for local community.

Hettich Czech Republic has overgrown its manufacturing size, which is a risk to the further grow by getting more share of the market and additionally to that, the company uses external warehouse for storing the components needed for production which represents additional logistics cost. As risk reduction and strategy for growth, the company decided to invest in additional manufacturing and warehouse facility.

4.1.1 Ex-ante project phase

Projects definition

The investor had a goal of investing in manufacturing and warehouse facility construction project, next to the already existing facility that has 16,420 m^{2,} the new facility would have 3,239 m^2 that should be used for warehousing and manufacturing for additional projects to facilitate the growth of production and reduction in logistics cost. The investment cost for investing in manufacturing and warehouse construction was planned to be EUR 3,11 million that is the cost connected to the facility construction.

Currently the Hettich logistics orders from external warehouse one delivery of needed production components in the morning and another delivery in the afternoon, each delivery transport costs EUR 79, which is EUR 158 per day and EUR 82,000 per year. The company also pays the cost for renting the space in the external warehouse EUR 145,000 per year. The project of investing in the manufacturing and warehouse construction facility would eliminate this cost therefore they are counted as saving. Additional saving would come from improvement of material flow in the new facility which would reduce the operation cost in the facility, that is estimated at EUR 26,000 and with the new facility there will be no need to pallet manipulation and their transportation inside the existing facility. This means saving on less transportation by EUR 77,000. In total the saving on this project is counted to be EUR 332,000.

The project planned since 2017 and it was executed between 2019 and 2020, the project therefore went through different risks including the global pandemic of Covid-19.

This case study is conducted to assist the risk from the perspective of changes to the plan both from financial and time point of view.

The Figure 6 below shows the location of the existing facility in green and the new facility in grey.

Figure 6 First draft of Žďár nad Sázavou layout

Construction investment decision

The investor's strategy was to gain a higher market share in order to increase the company's profit, and therefore increase the manufacturing and warehouse capacities. This could be carried out by investing in the construction of another manufacturing and warehouse facility or outsource some of the existing production or build only new manufacturing facility without a warehouse. All those variants were assessed to help make the investment decision.

The following 3 variants were analysed and discussed during the pre-investment project phase:

- Variant 1 “Without building with support outsourcing”. It meant investment costs of approx. EUR 0.569 million, these are cost related to finding new suppliers to outsource the production too and the investment in new equipment and transport of current ones to the new suppliers, they would be annual savings which would come from the price reduction from the new supplier that is estimated to be EUR 0.166 million with the variant payback of approx. 3.4 years. The disadvantage of this variant is a risk of know-how loss, and it does not allow continuous growth. Cost and saving explanation.
- Variant 2 “New warehouse and manufacturing facility” which offered annual savings of approx. EUR 0.332 million, investment costs of EUR 3,110,000 with the variant payback of approx. 9.4 years. In addition to the gained savings, the factory output could be doubled.
- Variant 3 “New assembly facility” offered annual savings of approx. EUR 0.332 million, investment costs of EUR 3,965 million with the variant payback of approx. 11.9 years.

The variant chosen was the variant of investing in manufacturing and warehouse facility because it can allow the company to double the capacity with a payback period of 9.4 years.

The investment costs of this variant were planned to be EUR 3.11 million which is cost for building the new facility and its related costs.

The project was planned to have annual savings of EUR 0.332 million. This saving comes from the logistics cost which are saving of annual rental cost of external warehouse, saving of transportation cost between external manufacturing and warehouse facility.

Evaluation of economic efficiency

The return on investment was calculated using the simple payback period method which is total cost of investment divided by saving from the project. The calculation of payback period for the selected variant 2 can be seen below.

The saving will come from the logistics cost reduction and operation cost reduction after the execution of the project.

The invest cost of building the new manufacturing and warehouse was calculated by constructor to be EUR 3.10 million.

The saving is calculated from estimated reduction of existing external warehouse cost and transportation and efficiency improvement that would lead to reduction of internal logistics cost.

The process of saving calculation can be seen below:

- Saving in annual rental costs EUR 0.145
- Saving in annual transportation costs EUR 0.082
- Less internal transportation EUR 0.077

- Improved material flow EUR 0.026
- Total EUR 0.332

Planned Investment EUR 3.110 million.

$$PB = \frac{3.11}{0.332}$$

Return on investment is 9.4 years.

The table below shows the cash flow situation of the project.

Table 7 The cash flow situation of the project

CF position in Years	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Total
Cost	3.100													3.100
Revenue														
Saving in annual rental costs		0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.000
Saving in annual transportation costs		0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	
Less internal transportation		0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	
Improved material flow		0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	
Total Revenue		0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	3.300
CF position in years		(3.100)	(2.770)	(2.440)	(2.110)	(1.780)	(1.450)	(1.120)	(0.790)	(0.460)	(0.130)	0.200	0.530	
Discounted Cash Flow rate of 5.3%		(3.102)	(2.771)	(2.441)	(2.111)	(1.781)	(1.451)	(1.121)	(0.790)	(0.460)	(0.130)	0.200	0.530	

Return on Equity

The return on Equity ROE was used to measure the profitability of invested Equity in the project.

Data used for calculation:

- EBT is Earning Before Tax which is EUR 330,000
- Equity EQ is 3,100,000 * 30% of investor = EUR 930,000

Earning Before Tax used in the calculation is the earning from the project saving and the Equity accounts for 30% of project cost as 70% comes from the bank loan

$$ROE = \frac{330,000}{930,000} 100 = 33\%$$

The return on equity at 33% is exceptional as any ROE above 20% is considered to be positive.

Payback period

The simple method of payback period is used to calculate when the project pays back the investment.

The table with input for calculation can be seen below.

- *TC* is total cost of investment,
- *CFt* is Cashflow at specific period *t,*
- *PP* is Payback Period.

$$0 = -TC + \sum_{t=1}^{pp} CF_t$$

$0 = -3{,}100{,}000$ +3,300,000-(33,000-130,000)

Payback Period is 9.4 Years, this means that the investments will be paid back in less than 10 years and after that it will only be generating the profit. This is considered positive because the project lifetime is planned to be above 30 years.

Discounted payback period

The total cost of investment is covered partially by the investor and other part is covered by external capital. The ratio is 30:70 as 30% of capital investment comes from the investor, which is used to calculate the Weighted average cost of capital WACC.

$$WACC = r_e * \frac{E}{C} + r_d * \frac{D}{C} * (1 - t)$$

Where:

Re is Cost of equity, the investor is expecting a *Re* of 8%,

E is Market value of the company's Equity,

C is sum of all Capital (Total market value of the company (equity + debt)),

Rd is cost of debt,

D is Debt (Market value of the company's debt),

t is income tax rate (tax shield).

- Return on Equity *Re*: The investor is expecting a return of 8% on their investment to compensate them for the risk they are taking by investing in the manufacturing and warehouse construction project,
- Equity *E*: The investor planned to invest 30% of the total cost capital needed for the investment. Which is 30% times 3.1 million that is equal to EUR 0.930 million,
- Debt *D* is 70% of EUR 3.1 million total cost of construction, which is equal to EUR 2.17 million,
- Capital *C*: Sum of equity + Debt that is EUR 3.1 million,
- Cost of Debt *Rd* = the cost of debt is 3% which was the interest rate that was agreed between the bank and the investor,
- Income tax *t* = tax rate is 19%.

  WACC is Weighted average cost of capital.

$$WACC = 8\% \times \frac{0.930}{3.100} + 3\% \times \frac{2.170}{3.100} \times (1 - 19\%) = 4.1\%$$

Formula for discounted payback period

The input below was used in the calculation:

- *TCF* is Total Cost of investment,
- *DCFt* discounted cashflow in time *t,*
- *DPP* is discounted payback period.

Table 8 Discounted payback period.

CF position in Years	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
Cost	3.100												
Revenue													
Saving in annual rental costs		0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145
Saving in annual transportation costs		0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082
Less internal transportation		0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.077
Improved material flow		0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
Total Revenue		0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330
CF position in years		(3.100)	(2.770)	(2.440)	(2.110)	(1.780)	(1.450)	(1.120)	(0.790)	(0.460)	(0.130)	0.200	0.530
Discounted Cash Flow rate of 5.3%		(3.102)	(2.771)	(2.441)	(2.111)	(1.781)	(1.451)	(1.121)	(0.790)	(0.460)	(0.130)	0.200	0.530

$$0 = -TC + \sum_{t=1}^{DPP} DCFt$$

$$0 = -3{,}100{,}000 + 3{,}300{,}000 - (330{,}000 - 130{,}069)$$

Payback period is 9.4 years.

In this case the discount payback period is not essentially different from undiscounted period because both future expenses and future income are discount and the discount rate is not having an effect.

Internal rate of return

Calculating the Internal Rate of Return (IRR) for an investment in a construction project involves determining the discount rate that equates the present value of the cash inflows with the initial investment.

Data used in the calculation:

- *CFt* is the Cash flow in the specific time,
- *n* is the project lifetime is years,
- *IRR* Internal rate of return in percentage.

Table 9 Internal rate of return

CF position in Years	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
Cost	3,100,000											
Revenue												
Saving in annual rental costs	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000
Saving in annual transportation costs	82,000	82,000	82,000	82,000	82,000	82,000	82,000	82,000	82,000	82,000	82,000	82,000
Less internal transportation	77,000	77,000	77,000	77,000	77,000	77,000	77,000	77,000	77,000	77,000	77,000	77,000
Improved material flow	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000
Total Revenue	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000
NCF	-2,770,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000
Discounted Cash Flow rate of 4.1 %	-2,771,136	330,135	330,135	330,135	330,135	330,135	330,135	330,135	330,135	330,135	330,135	330,135
IRR	4.8%											

$$IRR = 4.8\%$$

The internal rate of return is 4.8% for the desired payback period of 12 years.

Net present value

The following input is used in the table below to measure the present value of expected cash inflows and outflows over time of the project:

- *IC* is the investment cost (total investment in year 0),
- *CFt* is cashflow in year *t,*
- *R* is discounted rate,
- *t is the project lifetime,*

- *NPV* is the net present value.

Table 10 Net present value

CF position in Years	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
Cost	3,100,000											
Revenue												
Saving in annual rental costs	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000
Saving in annual transportation costs	82,000	82,000	82,000	82,000	82,000	82,000	82,000	82,000	82,000	82,000	82,000	82,000
Less internal transportation	77,000	77,000	77,000	77,000	77,000	77,000	77,000	77,000	77,000	77,000	77,000	77,000
Improved material flow	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000
Total Revenue	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000
NCF	-2,770,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000	330,000
Discounted Cash Flow rate of 4.1 %	-2,771,136	330,135	330,135	330,135	330,135	330,135	330,135	330,135	330,135	330,135	330,135	330,135
IRR	4.8%											
Equity, own Capital is 30% of total cost	€ 930,000											
Debt, 70% of total cost	€ 2,170,000											
Capital, sum of Equity and Debt	€ 3,100,000											
Return on Equity re	8%											
Cost of debt rd	3%											
Income tax rate t	19%											
WACC %=re*E/C+rd*D/C*(1-t)	4.1%											
Net Present Value	€ 101,126											

$$\boldsymbol{NPV} = -\boldsymbol{IC} + \sum_{t=o}^{n} \frac{CFt}{(1+IRR)^t} = 110\ 126\ EUR$$

Net Present Value over 12 years is EUR 110,126, NPV is positive which means that the project is expected to generate more cash inflows than outflows and therefore is likely to be profitable.

Risk mapping

Risk mapping during the time of decision making is done according to the information available during that time.

Demand

Demand that is considered in the project is already an existing demand, it will be transferred from expensive facilities in Germany to cheaper new facility in the Czech Republic, according to the historical data it is rare that the demand is reduced, it can however increase impact in that case to be more positive than projected.

Suppliers

The suppliers can have significant impact on the investment in manufacturing and warehouse facility construction, if they do not perform their task on time and according to the quality standard that is expected. During the preparation phase of this project the team has planned enough time for suppliers and worked out with them a realistic plan, therefore it would be unusual for this risk to occur.

Preparation

It can normally happen that during the overall preparation, some important factor is forgotten. To mitigate that risk on this project, enough time was given and consultation with the stakeholder was planned to happen before and after the preparation phase, therefore the risk will be insignificant.

Increase in cost

Increase in cost of construction is unfortunately a very common thing and it can have a significant impact on the project, the scenario of cost increase was studied to analyse the overall impact.

Execution time

Construction time usually is not respected during the construction, because of various reasons, enough time was given for this project.

Semiquantitative analysis

Semiquantitative analysis evaluates the risk occurrence and importance / impact on the profit from the demand change, risks with suppliers, risks in preparation, risk due the increase in cost and risk during the execution time.

Table 11 Semiquantitative analysis

	IMPORTANCE IMPACT ON THE PROFIT				
OCCURRENCE	Negligible	Insignificant	Medium	Significant	Essential
Rarely			Demand		
Unusual				Suppliers	
Ordinary		Preparation			
Usual			Execution time		
Very common				Increase in cost	

The impact on project profit was calculated according to the formula below.

$$RI = \sum_{n=1}^{R} A_n x\, L_n$$

Where:

RI is Risk Impact on the profit before tax,

A is evaluation of occurrence of the risk,

L is evaluation of risk level.

Table 12 Calculation of semiquantitative risks

	IMPORTANCE/IMPACT ON THE PROFIT				
OCCURRENCE	1	2	4	8	16
1			Demand		
2				Suppliers	
3		Preparation			
4			Execution time		
5				Increase of cost	

$$RI = 1x4 + 2x8 + 3x2 + 4x4 + 5x8 = 82$$

Considering that the minimum total rating of 5 different risks would be together 5 x 1 x 1 = 5 and the maximum value by reaching 5 x 5 x 16 = 400, we find an overall rating of 82 in the first quarter of the overall possible risk.

SWOT analysis

The table below shows the Žďár nad Sázavou manufacturing and warehouse facility construction project SWOT analysis.

Table 13 SWOT Analysis Žďár nad Sázavou manufacturing and warehouse facility project

STRENGTHS	WEAKNESSES
Well thought-out business plan	Difficult land for construction
Support the company growth	Availability of suppliers
Combination of current production with new warehouse and production	Limitation from current manufacturing facility
Potential improvement of products and customer portfolio	
Stable management team	
Continuous training for management team	
Financially stable corporation	
Well positioned location	
Ownership of machines and know how	
OPPORTUNITIES	THREATS
Expansion of construction investment in the locality	Potential economic crises
Up skilling current and new employees	Global pandemic
Innovate the products and production	Unavailability of employees
Improve the logistics flow	Non-fulfilment of contractual obligations by suppliers
Increase of revenue	Damage caused by employees
Increase of job opportunities by 50 employees	

Sensitivity analysis – reduction of the revenue

The risk of revenue reduction can be caused by many factors such as project delay, customer demand reduction etc. The table below looks at the different scenarios of reduction and their impact on revenue and payback period in years as well as impact on Return on investment.

Table 14 Sensitivity analysis of the revenue reduction

	Sensitivity analysis of revenue reduction					
Reduction of revenue	0%	20%	40%	50%	60%	70%
Revenue €	330,000	264,000	198,000	165,000	132,000	99,000
Cost of investment €	3,100,000	3,100,000	3,100,000	3,100,000	3,100,000	3,100,000
Pay back in years	9.4	11.7	15.7	18.8	23.5	31.3
Return on investment	11%	9%	6%	5%	4%	3%

Calculation of switching value

The desired return on investment from the investor was 8% or 12 years of payback period, therefore any return on investment that is lower or closer to that rate is not interesting for the investment. In this case, the scenario where the revenue is reduced by more than 20% would mean that the project is not profitable, that means that the switching value represents a revenue of EUR 264,000 per year.

Sensitivity analysis – increase of investment cost.

Unfortunately, the increase in construction cost is one of very likely risks, that is because of rough calculation of cost that is used before the full project study. If the scenario where the investment cost rise by more than 20%, the project would be unprofitable as it would represent the payback of more than 12 years, that is the desired payback period from the investors and the return of investment desired is 8%. If the project cost increases by more than 20%, that would make the return on investment lower than target return on investment from the investor.

The table below shows sensitivity analysis of cost increase.

Table 15 Sensitivity analysis of cost increase

	Sensitivity analysis of cost increase in €						
Cost increase	0%	10%	20%	50%	100%	200%	220%
Revenue	330,000	330,000	330,000	330,000	330,000	330,000	330,000
Cost of investment	3,100,000	3,410,000	3,720,000	4,650,000	6,200,000	9,300,000	9,920,000
Pay back in years	9.4	10.3	11.3	14.1	18.8	28.2	30.1
Return on investment	11%	10%	9%	7%	5%	4%	3%

The switching value of investment cost is EUR 3,720,000, if the cost increases more, this value, the project is not profitable anymore.

Sensitivity analysis of the scenarios

Looking at different scenarios, the project is unprofitable if the revenue reduces by 70% and that is very unlikely because the revenue is driven by the demand that is controlled within the investor's sister companies.

The cost of investment sensitive analysis shows that the project will be unprofitable if the cost increases by 220%.

4.1.2 Project post-audit

In the initial project plan, the project was expected to be completed within 12 months, however, it was completed within 14 months due to complications caused by the Covid-19 pandemic.

A comparison of the key items of the plan and the reality is given in the following table.

Table 16 Project post-audit

Key figures	Planned savings in million EUR	Reality in million EUR	Absolute deviation
Saving in external warehouse annual rental costs	0.145	0.072	100%
Saving in annual transportation to external warehouse costs	0.082	0.041	100%
Less internal transportation due to increase in process efficiency	0.077	0.069	11%
Improved internal material flow due to a new warehouse	0.025	0.024	5%
Saving from new projects/opportunities		0.230	100%
Total savings	0.332	0.439	24%
Rough total investments	3.110	3.260	5%
Payback period in years	9.4	7.4	26%

Total saving increased by 24% from EUR 0.332 million to EUR 0.439 million, that is EUR 0.107 million per year and the total investment cost increased by 5%, that is EUR 0.15 million increase on the project which had good improvement to the payback period from 9.4 years to 7.4 years, so the project investment will be paid back 2 years earlier than it was planned.

Analysis of the deviation from the plan

The project investment cost was expected at EUR 3.11 million, however, it ended up being EUR 3.26 million. The increase in cost resulted from excavation, as the soil contained rocks that were more expensive to dig through than planned which increased the cost of the project by 5%.

The total saving was expected at EUR 0.33 million, however, in reality, the company saving was EUR 0.44 million. An additional saving opportunity was the increased manufacturing and warehouse facility capacity together with the planned saving in rental cost and transport to the external warehouse which did not happen as planned to result in a total annual saving of about 24% more than planned.

The planned return on investment was 9.4 years during the project initial phase, however, thanks to the increase in saving, the planned return on investment was improved to 7.4 years which represented a 26% improvement.

The project was delayed by 2 months due to Covid-19 pandemic which was not planned in the project design.

Creation of jobs

The project planned to create 100 jobs. In fact, 124 jobs were created, so the project overachieved the job creation plan by 24%.

The construction of manufacturing and warehouse facility in Žďár nad Sázavou had a positive financial impact on the people living close to the industrial area by creating 124 jobs and bringing the investor saving of EUR 0.44 million per year.

Furthermore, the external suppliers in this area gained more business in, for example catering, cleaning, security, indirect and direct material deliveries as the investors increased the revenue and number of employees, the external suppliers increased their number of employees too.

4.1.3 Summary of manufacturing and warehouse facility construction project in Žďár nad Sázavou

The industrial zone development is important for unifying the local government strategy with the country strategy to attract more investors and create job opportunities.

Investment in the construction of a manufacturing and warehouse facility requires a well-thought project, good risk management and good cooperation between the project stakeholders, mainly between investors, architect, and constructor. One of the main goals of the stakeholders in the construction of a warehouse and a production hall is to create profit and provide better life quality for people. When all parts cooperate well together, they can better manage risks and optimise the opportunities, which can be seen on one research sample project.

However, both the investors and the project team need to keep in mind the possible uncertainty that the project team or the global world can face, for example the Covid-19 pandemic.

The research sample project has shown that the industrial area development by constructing a manufacturing and warehouse facility brings good opportunities to local people and businesses, as can be seen in the case study of a manufacturing and warehouse facility construction in Žďár nad Sázavou industrial area, where the project created 124 job opportunities and operation cost saving of EUR 0.440 million every year.

Case study 2: 12 Manufacturing and warehouse facility construction projects in industrial zones

Manufacturing and warehouse facilities are situated in the industrial zones which are areas representing the concentrated location of the production facilities specialised in a particular industrial field, strategic services, or technological centres. Both services and industry are the main engines of the economy of both the Czech Republic and the European Union with services accounting for 60.8% (2017 est.) of Gross Domestic Product (GDP) and industry for 36.9% (2017 est.), and 59.2% of the Czech labour force working in the sector of services, while 38% work in the industrial sector (2016 est.). GDP in the European Union by sector is composed of 70.7% representing services and 24.5% industry, the share of the labour force in the service sector accounts for 73.1% and in the industry for 21.9% (The world factbook, 2017) Construction of manufacturing and warehouse facilities in terms of economic improvement has a positive impact due to new jobs that are created which is beneficial especially for the areas with a high unemployment rate. Industrial zones are usually situated in abandoned overgrown areas that are not used in any way. Declaration of territory as an industrial zone requires cooperation with the Ministry of Industry and Trade, the CzechInvest agency and the local government representatives on the Czech Republic side.

Industrial zones have developed a lot in recent years representing a part of the innovation strategy of the Czech Republic 2019-2030 (Council for Research, Development, and Innovation, 2019).

The government in its strategical plans for future development has the ambition to become one of the innovation leaders in Europe and a country with the technological future - Czech Republic: The Country for the Future. Implementing this strategy means that the country develops industrial zones, areas where industry and services or technology centres are concentrated and implements the following sub-strategies for the Czech Republic:

The Country for R&D: Funding and Evaluation of R&D,

The Country for Technology: Polytechnic Education,

The Country for Startups: National Start-up and Spin-off Environment,

The Country for Digitalization: Digital State, Manufacturing and Services,

The Country for Excellence: Centres for Innovation and Research,

The Country for Investment: Smart Investment,

The Country for Patents: Intellectual Property Protection,

The Country for Smart Infrastructure: Mobility and Construction Environment,

The Country for Smart People: Smart Marketing.

This is beneficial both for private investors and local people since it creates investment opportunities and increases employment in the area. However, the investor must analyse the project well in the initial phase of the project life cycle before implementing it. Investment projects related to the implementation of industrial zones are accompanied by several uncertainties and risks during their life cycle.

There is a large number of risks related to investing in the manufacturing and warehouse facilities in the industrial zones. Focusing on the business risk which is generally defined as the deviation between the planned and actual economic result (outcome) of the investment project. Risks that may occur during each stage of the investment project life cycle according to Ministry of Transport of the Czech Republic are as follows:

Demand-related risks (different development of demand than expected),

Risks related to the project design,

Administration and public procurement risks (building permit),

Risks related to the purchase of the land (land price),

Risks related to the construction process (exceeding investment costs),

Operational risks,

Regulatory risks (change in environmental regulations),

Other risks (public opposition).

(Ministry of Transport of the Czech Republic (MoT CZ). Departmental Guideline for the Evaluation of Economic Effectiveness of Transport Construction Projects, 2017).

The risks of investment projects of manufacturing and warehouse facilities were examined from two perspectives. Firstly, a separate SWOT analysis was performed for each research sample project and a summary SWOT analysis was carried out showing the expected project strengths, weaknesses, opportunities, and threats in the current societal situation.

Furthermore, the research on the 12 projects regarding the changes in the plans and reality was examined, it is the manufacturing and warehouse facilities placed in industrial zones, located in different countries of Central and Eastern Europe – the Czech Republic, Slovakia, Poland, Hungary, and Romania. The basic description of the zones where they are placed in the industrial areas can be seen in the table below.

Table 17 Selected industrial zones and manufacturing and warehouse facility projects.

Industrial area	**Advantages of the location**
Žďár nad Sázavou, Czech Republic	Land attached to the production facility that will use it.
Jičín, Czech Republic	Land in the industrial area where it is needed.
Jindřichův Hradec, Czech Republic	Land attached to the production facility that will use it.
Bucharest West, Romania	5 km from the city centre. Strategic location. Proximity to the Budapest M0 highway.
Bor, Czech Republic	Strategically located in Western Bohemia, 50 km from Plzeň city centre, with excellent highway connectivity and only 15 km from the Czech/German border. The routes and important trade paths lead through Germany further to Italy.
Brno Modřice, Czech Republic	5 km south of Brno/D1 junction. 13 universities in the city/region. Skilled labour force available. Lower operational costs. Proximity to the Brno international airport. Onsite public transport. 1-hour drive to Vienna.
Budapest East, Hungary	8 km to the south-east of Budapest at the intersection of M0 ring road and motorway M4. Budapest International Airport is very close. Located on the busiest transit route to and from Budapest.
Sibiu, Romania	Located in the vicinity of two European routes E68 and E81, and just off the A1 motorway which runs from Sibiu city all the way to the Romanian/Hungarian border. Located in the area which has the longest industrial tradition in Romania. Sibiu is home to 148,000 inhabitants, 40% of whom are employed in industrial activities.
Opole, Poland	Strategically located between two strong agglomerations: Katowice and Wroclaw. 56 km from the Polish/Czech border, 250 km to the German border. 6 universities in close vicinity.
Bratislava, Slovakia	Direct highway connection. Well-developed infrastructure, highway, railway, naval and cargo port and international airport. Directly adjacent to VW automotive plant.
Belgrade, Serbia	Direct highway access. Ideal for e-commerce, first-mile logistic, distribution, manufacturing. Prime location between two biggest cities in Serbia Belgrade and Novi Sad 20 minutes away from the city centre with excellent transport access to Zagreb, Budapest, and Timisoara.

The tables below show the SWOT analysis for all above-mentioned constructions of manufacturing and warehouse facility project.

Table 18 Žďár nad Sázavou – Manufacturing and warehouse construction project

Industrial Zone – Ždár nad Sázavou, Czech Republic	
STRENGTHS	**WEAKNESSES**
Well thought-out business plan	Difficult land for construction
Support the company grown	Availability of suppliers
Combination of current production with new manufacturing and warehouse facility	Limitation from current manufacturing facility
Potential improvement of products and customer portfolio	
Stable management team	
Continuous training of management team	
Financially stable corporation	
Well positioned location	
Ownership of machines and know how	
OPPORTUNITIES	**THREATS**
Expansion of construction investment in the locality.	Potential economic crises
Up skilling current and new employees	Global pandemic
Innovate the products and production	Unavailability of employees
Improve the logistics flow	Non-fulfilment of contractual obligations by suppliers
Increase in revenue	Damage caused by employees
Increase in job opportunities	

Table 19 Jičín, Czech Republic– Warehouse construction project

Jičín, Czech Republic Warehouse	
STRENGTHS	**WEAKNESSES**
Well thought-out business plan	Availability of suppliers
Support for company grown	Limitation from current manufacturing facility
Combination of current production with new warehouse	Untrained employees
Potential improvement of products and customer portfolio	
Financially stable family company	
Well positioned location	
Ownership of machines and know how	
OPPORTUNITIES	**THREATS**
Expansion of construction investment in the locality	Potential economic crises
Innovate the products and production	Global pandemic
Improve the logistics flow	Unavailability of employees
Increase in revenue	Non-fulfilment of contractual obligations by suppliers
Increase in job opportunities in the region	Damage caused by employees
Increase in job opportunities by 12 employees	Unstable management

Table 20 Jindřichův Hradec, Czech Republic – Manufacturing and warehouse construction project

Jindřichův Hradec, Czech Republic	
STRENGTHS	**WEAKNESSES**
Well thought-out business plan	Availability of suppliers
Support for company grown	Limitation from current manufacturing facility
Combination of current production with new warehouse and production	Untrained employees
Potential improvement of products and customer portfolio	
Stable management team	
Well positioned location	
Ownership of machines and know how	
OPPORTUNITIES	**THREATS**
Expansion of construction investment in the locality	Potential economic crises
Innovate the products and production	Global pandemic
Improve the logistics flow	Unavailability of employees
Increase in revenue	Non-fulfilment of contractual obligations by suppliers
Increase in job opportunities in the region	Damage caused by employees
Increase in job opportunities by 4 employees	Unstable management

Table 21 Bor, Czech Republic – Manufacturing and warehouse construction project

Bor, Czech Republic	
STRENGTHS	**WEAKNESSES**
Excellent highway connectivity	Availability of suppliers
Highly skilled workforce	Limitation from current production hall
50 km from Plzeň city	
Potential customer portfolio	
Onsite public transport	
OPPORTUNITIES	**THREATS**
Expansion of construction investment in the locality	Potential economic crises
Innovate the product and improve the customers portfolio	Global pandemic
	Unavailability of employees
	Non-fulfilment of contractual obligations by suppliers

Table 22 Bucharest, West Romania – Manufacturing and warehouse construction project

Bucharest, West Romania	
STRENGTHS	**WEAKNESSES**
Premier destination ideal for large logistics operators	Availability of suppliers
No property tax location	Limitation from current manufacturing facility
Medical point and canteen nearby (10 km)	Untrained employees
Potential customer portfolio	
Employee shuttle bus from the city centre	
OPPORTUNITIES	**THREATS**
Expansion of construction investment in the locality	Potential economic crises
Innovate the product and improve the customers portfolio	Global pandemic
	Unavailability of employees
	Non-fulfilment of contractual obligations by suppliers

Table 23 Budapest, East Hungary – Manufacturing and warehouse construction project

Budapest, East Hungary	
STRENGTHS	**WEAKNESSES**
Located in high-bay logistics warehouse with offices located in Üllő	Located on the busiest transit route to and out of Budapest
Few minutes' drive to the airport	Availability of tenants
OPPORTUNITIES	**THREATS**
Expansion of construction investment in the locality	Potential economic crises
Innovate the product and improve the customers portfolio	Global pandemic
	Unavailability of employees
	Non-fulfilment of contractual obligations by suppliers
	Damage caused by employees

Table 24 Bratislava, Slovakia – Manufacturing and warehouse construction project

Bratislava, Slovakia	
STRENGTHS	**WEAKNESSES**
Direct highway connection	Located on the busiest transit route to and out of Budapest
Well-developed infrastructure, highway, railway, a naval and cargo port, and international airport	Availability of tenants
Directly adjacent to VW automotive plant	
OPPORTUNITIES	**THREATS**
Expansion of construction investment in the locality	Potential economic crises
Innovate the product and improve the customers portfolio	Global pandemic
	Unavailability of employees
	Non-fulfilment of contractual obligations by suppliers
	Damage caused by employees

Table 25 Opole, Poland – Manufacturing and warehouse construction project

Opole, Poland	
STRENGTHS	**WEAKNESSES**
Strategically located between two strong agglomerations: Katowice and Wroclaw	Located on the busiest transit route to and out of Budapest
Investment incentives: 10-year property tax exemption	Availability of tenants
Near 6 universities	
Income tax exemptions available	
OPPORTUNITIES	**THREATS**
Expansion of construction investment in the locality	Potential economic crises
Innovate the product and improve the customers portfolio	Global pandemic
	Unavailability of employees
	Non-fulfilment of contractual obligations by suppliers

Table 26 Sibiu, Romania – Manufacturing and warehouse construction project

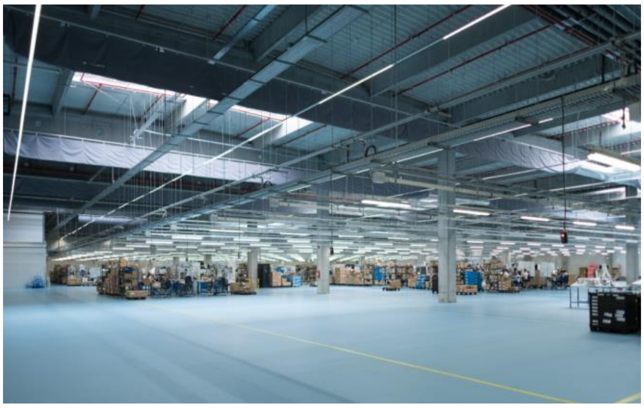
Sibiu, Romania	
STRENGTHS	**WEAKNESSES**
Multilingual region (German, Romanian, Hungarian, English)	Untrained employees
40% of regional population employed in industry	Availability of tenants
Modern airport with direct flights to various cities in Europe	The weakening of external demand from Europe
Ideally situated on the main road connecting the airport and Sibiu industrial zone	
OPPORTUNITIES	**THREATS**
Expansion of construction investment in the locality	Potential economic crises
Innovate the product and improve the customers portfolio	Global pandemic
	Non-fulfilment of contractual obligations by suppliers
	Damage caused by employees

Table 27 Brno - Modřice, Czech Republic – Manufacturing and warehouse construction project

Brno - Modřice, Czech Republic	
STRENGTHS	**WEAKNESSES**
5 km south of Brno / D1 junction	Challenges to find employees
13 Universities in the city / region	Availability of tenants
Available skilled labour	
Lower operational costs	
Onsite public transport	
OPPORTUNITIES	**THREATS**
Expansion of construction investment in the locality	Potential economic crises
Innovate the product and improve the customers portfolio	Global pandemic
Increase of job opportunities in the region	Unavailability of employees
	Non-fulfilment of contractual obligations by suppliers
	Damage caused by employees

Table 28 Prague - Ruzyně, Czech Republic – Manufacturing and warehouse construction project

Prague - Ruzyně, Czech Republic	
STRENGTHS	**WEAKNESSES**
Great accessibility (R7 highway)	Limitation around airport regulation
Only 1 km from the Prague International Airport	Availability of tenants
High floor loading	
CCTV security system	
24/7 security on-site	
OPPORTUNITIES	**THREATS**
Expansion of construction investment in the locality	Potential economic crises
Innovate the product and improve the customers portfolio	Global pandemic
Increase in job opportunities in the region	Unavailability of employees
	Non-fulfilment of contractual obligations by suppliers
	Damage caused by employees
	Terrorist attack risk

Table 29 Belgrade, North Serbia – Manufacturing and warehouse construction project

Belgrade, North Serbia	
STRENGTHS	**WEAKNESSES**
Direct highway access	Only one main construction partner
Ideal for e-commerce, first mile logistic, distribution, manufacturing	Availability of tenants
Prime location between two biggest cities in Serbia Belgrade and Novi Sad	Untrained employees
20 minutes away from the city centre, with excellent transport access to Zagreb, Budapest, and Timisoara	
OPPORTUNITIES	**THREATS**
Expansion of construction investment in the locality	Potential economic crises
Innovate the product and improve the customers portfolio	Global pandemic
Increase in job opportunities in the region	Country is debt equivalent to 56.7% of the projected 2020 GDP
Increase in job opportunities	Risk of state bankruptcy

The summary of SWOT analysis for 12 research projects was completed to identify strengths, weaknesses, opportunities, and threats of the investment projects identified in the table below. Emphasis was placed on the impact on the public area, such as employment, public transport, and the development of the locations among other things.

Based on the study of individual investment projects located in the analysed industrial zones, the predominant strengths and weaknesses, opportunities and threats identified are shown in the table below.

Table 30 Summary SWOT analysis of 12 warehouse and manufacturing facility projects

STRENGTHS	**WEAKNESSES**
Well-thought-out business plan	Availability of suppliers
Supporting the company growth	Limitation of current production hall / area
Well diversified customers	The complex requirement from the project
Customer-focused projects	
Stable management team	
Well-positioned location	
Know-how and infrastructure availability in place	
OPPORTUNITIES	**THREATS**
Expansion of construction investment in the location	Potential economic crises
Upskilling the employees	Global pandemic
Possibility to innovate the products and processes	Unavailability of employees
Income tax exemptions	Non-fulfilment of contractual obligations by suppliers
Increase in job opportunities	

The above-mentioned table shows the following facts.

Strengths of the majority of projects are very well-thought-out, have a mission to grow, the mission can be achieved by focusing on customers, developing the employee potential and placement in a good location, all of that is fulfilled when investing manufacturing and warehouse construction projects.

Weakness of these projects are that construction activity is a complex project; limitation comes from the current production area and limited capacity of suppliers which remained a weakness for the sample projects.

Opportunity for all these kinds of projects have the potential to create jobs for local people and new business for local suppliers. Investors make use of the income tax exemptions opportunity in some countries.

Threats are the global pandemics as the world has seen at the beginning of 2020 and economic crises as the one of 2008 to any businesses. On the other hand, if the economic growth is large, there is a threat of the lack of labour availability and suppliers as the Czech Republic experienced the in 2016-2018 period.

4.1.4 Risk assessment

Risks and opportunities for 12 manufacturing and warehouse facility constructions situated in Central and Eastern Europe were identified in the text below, these are mainly: risk related to construction (cost, time) and operational utilization. The following table shows the technical and economic data about these projects.

Table 31 Data on 12 sample projects of manufacturing and warehouse facilities

Project no.	Project name	Size of floor area / overall m²	Planned costs / real costs in million EUR	Planned time of implementation / real time of implementation in months	% of utilisation
1	Žďár nad Sázavou Industrial Zone	3,239 / 5,822	3.11 / 3.26	12 / 14	70
2	Jičín Industrial Zone	1,602 / 1,822	1.56 / 1.52	8 / 8	100
3	Jindřichův Hradec Industrial Zone	593 / 888	0.158 / 0.162	12 /12	70
4	Bucharest West	127,694	No deviation from the planned cost	On time	94
5	Bor B7	30,606 / 58,718	No deviation from the planned cost	On time	94
6	Brno Modřice MO13	10,413 / 12,322	No deviation from the planned cost	On time	94
7	Budapest East ULL2	11,200 / 36,531	No deviation from the planned cost	On time	94
8	Romania Sibiu SU1	15,403 / 18,401	In Pre-investment phase	In Pre-investment phase	In Pre-investment phase
9	Poland Opole	10,500 / 32,806	No deviation from the planned cost	On time	94
10	Poland Opole	5,900 / 11,851	In Pre-investment phase	In Pre-investment phase	In Pre-investment phase
11	Bratislava	5,340 / 5,670	No deviation from the planned cost	On time	94
12	Belgrade	15,000 / 20,000	No deviation from the planned cost	On time	94

Risk related to construction.

Risks identified in the sample projects were related to the change in the planned construction project cost price compared to the realised cost price.

Two projects exceeded investment costs and did not meet the expected investment costs. Project 1 had planned costs of EUR 3.11 million, however, the real costs were EUR 3.26 million which was by 5% more than the planned costs, project 3 had planned costs of EUR 0.158 million and the realised costs were EUR 0.162 million which was by 4% more than the planned costs.

Project 2 was completed with a cost saving of EUR 0.06 million, its planned costs were EUR 1.62 million and the realised costs EUR 1.56 million, which was by 4% less than the planned costs thanks to the cost saving agreed between the investor and the constructor.

Projects 4 to 12 met both the expected investment costs and the time of implementation.

Risk related to operational utilization.

Projects 2 and 3 achieved a utilisation rate of 70%, projects 4, 5, 6, 7, 8 and 10 achieved 94% of utilisation rate and project 2 achieved 100% of the utilization rate. The planned utilization rate of all the projects was around 90 - 95%. It means that the objective has been achieved.

The summary of risks investing in manufacturing and warehouse construction facility are completed in the risks register in the conclusion section of this dissertation work.

Case study 3: Environmental risk management of manufacturing and warehouse facility investment projects

4.1.5 Environmental risk

The environmental risks include the risk to human health and well-being such as pollution, radiation, noise, poor infrastructure, water quality worsening, diseases caused by the microbes and climate change. These risks are driven by policies in various sectors, such as energy, industry, agriculture, transport, and land planning.

According to the statistical data, emissions were very low prior to the industrial revolution. Growth in emission production was still relatively slow until the mid-20th century. In 1950 the world emitted 6 billion tonnes of CO_2.

By 1990 this amount had almost quadrupled, reaching more than 22 billion tonnes. Emissions have continued to grow rapidly, over 34 billion tonnes are currently emitted each year (Our World in Data, 2022). Reducing emissions applies for all buildings and it is applied at the industrial zone development in this thesis.

Industrial zones are areas where the manufacturing and warehouse facilities specialised in a particular industrial field, strategic services, or technological centres are located. Both services and industry represent the main economic engines of the Czech Republic and the world.

Industrial zones have developed a lot in recent years, this development is positive in terms of production capacities, on the other hand, it has negative effects in terms of increased emissions. Owners of manufacturing and warehouse facilities and investors should therefore participate in environmental risk management. If these risks are not addressed, they may result in secondary risks such as the social impact on the investment, sales risks such as loss of market share, product liability and product boycott, reputation risk on national and internal levels or equity risk as fall on the shared price.

The purpose of this thesis is to research environmental risk management. Risk assessment means simply identifying hazards, assessing risks and implementing and checking control mechanisms.

Manufacturing and warehouse facility projects were analysed in this research to find out whether projects include adequate provision for actions and determination of the costs necessary for preventing, controlling, and mitigating negative impacts on the environment as well as improving environmental quality. The list of initiatives to reduce environmental risk in manufacturing and warehouse facilities was identified. The cost and social impact of the environmental management system represent the output of this research.

4.1.6 Calculation of the equivalent of CO_2 emission by manufacturing and warehouse facilities

In the manufacturing and warehouse facilities, the equivalent CO_2 emission is generated during their operation when the items such as electricity, water, natural gas, and diesel engine are used.

Consumption of natural gas, electricity, and water creates CO_2 emissions during the production of these items, which pollute the atmosphere resulting in big consequences for the society.The carbon dioxide equivalent is used for CO_2 emission measurement in the facility.

The carbon dioxide equivalent or CO_2 equivalent, abbreviated as *CO_2-eq* is a metric measure used for comparing emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential (Eurostat, 2022).

It is calculated using the mass of a given greenhouse gas (GHG) multiplied by its global warming potential according to the International Organization for Standardization (ISO 14064-1, 2006).

The following table shows the calculation of CO_2 equivalent for the company operating 3 manufacturing and warehouse facilities in Brno, the Czech Republic. It has about 800 employees and a total area of 32,472 m².

The items mentioned in the table below are the items used during the operation of the manufacturing and warehouse facilities, their consumption has its *tCO_2 equivalent* according to the related emission factor.

Table 32 Emission factor related to the manufacturing facility consumption, Brno, Czech Republic

Item	**Consumption**	**Unit of measure**	**Emission factor**	**Unit of measure**	**tCO_2 equivalent**
Natural gas	40	MWh	0.20000	t CO_2/ MWh	8.0
Electricity	62	MWh	0.86000	kg CO_2/ kWh	53.3
Water	322	m^3	0.00038	t CO_2/ m^3	0.1
Heat	35	MWh	0.23200	t CO_2/ MWh	8.1
Diesel oil	6,000	l	0.00266	t CO_2/ l	16.0

During the operation of the warehouse and manufacturing facility, the emissions that pollute the climate are generated leading to climate change resulting in heatwaves, droughts, apocalyptic wildfires and floods as we have seen in recent years. Therefore, it is essential to reduce these emissions.

In order to reduce emissions, a number of actions have to be taken. The table below shows the actions leading to emission reduction in a different number of manufacturing and warehouse facilities around the world.

4.1.7 Economic efficiency evaluation for 12 initiatives to reduce the environmental risk in manufacturing and warehouse facilities.

A research sample was taken from 26 initiatives to reduce emissions in warehouse and manufacturing facilities has been collected and analysed. Only 12 top initiatives were selected to be presented in this work.

The sample research of countermeasures that should mitigate the environmental risks caused by the emission in the warehouse and manufacturing facility investment projects follows.

The top 12 initiatives to reduce emissions are shown below instead of all 26 initiatives that were analysed. The aim of these initiatives is to reduce the consumption of items that represent a source generating emission during their creation such as electricity, natural gas, and diesel engine oil.

The reduced consumption was transferred into the *tCO_2 equivalent* by multiplying the reduced consumption by its equivalent emission factor as in the above-stated table.

The table below is ordered from the largest $tCO_{2\,eq}$ emissions to the smallest.

The reduced consumptions represent the yearly reduction and its yearly equivalent of tCO_2 emissions.

Table 33 Top 12 initiatives to reduce emissions per year

Region	**Location**	**Initiatives**	**Reduced consumption**	**Unit of measure**	**$tCO_{2\,eq}$/year**
America	Colorado - USA	Update of roofing and installation of solar option	664	MWh	571
America	Queretaro - Mexico	Photovoltaic system (25% of the building)	455	MWh	391
Europe	Bielefeld - Germany	Installation of a photovoltaic system	362	MWh	311
Europe	Bielefeld - Germany	Elimination of vehicles with diesel consumption	63,910	tCO_2/l	170
Europe	Bielefeld - Germany	Completing LED conversion in the production	186	MWh	160
America	Rockford - USA	Converting the whole site to LED lighting	114	MWh	98
America	Queretaro - Mexico	KAIZEN for Energy Reduction	86	MWh	74

America	Queretaro - Mexico	5-day working week	65	MWh	56
Europe	Bielefeld - Germany	Reduction of sandblasting process	56	kg	48
Asia	Noida - India	Extension of solar power plant	35	MWh	30
Europe	Bielefeld - Germany	Modernisation of process water cooling	47,368	m^3	18

Initiatives to reduce electricity consumption are the most efficient as electricity represents the high emission emitter for manufacturing and warehouse facilities.

Saving in the operational costs from reduction in the *tCO_2* emissions

Savings are calculated by considering the reduction in the quantity of consumption of items creating emissions. The implementation of these environmental risk countermeasures results in the reduction of consumption such as energy consumption which leads to the reduction of costs that represent saving from these initiatives.

The following table shows the reduced consumption, reduced *tCO_2 equivalent* and related savings.

Table 34 Top 12 initiatives with a quantity of consumption reduced in technical units and in EUR

Region	**Location**	**Projects**	**Reduced consumption**	**Unit of measure**	**Reduced tCO_2**	**Savings (EUR)**
Europe	Bielefeld - Germany	Complete LED conversion in the production area	186	MWh	160	118,700
Europe	Bielefeld - Germany	Installation of a photovoltaic system	362	MWh	311	107,165
America	Queretaro - Mexico	Photovoltaic system 25% of the building)	455	MWh	391	96,682
Europe	Bielefeld - Germany	Replacement of old injection moulding with electrical drives	105	MWh	90	15,300
Europe	Bielefeld - Germany	Modernisation of process water cooling	47,368	l	18	15,000
Asia	Noida - India	Solar Panels - Install solar panels into the facility	8	MWh	7	7,300
Europe	Leeds – UK	Lighting - Replace T8	7	MWh	6	5,700

		lighting with LED system				
Asia	Noida - India	Extension of the solar power plant by 150KWp	35	MWh	30	5,388
Asia	Shanghai -China	Solar street lamps on the site	47	MWh	40	5,188
Asia	Shanghai -China	Install electricity meters to monitor key power consumption	3	MWh	3	5,000
Asia	Bielefeld - Germany	Replacement of HQL lights with LED lights	3	MWh	3	2,578
Asia	Leeds - UK	Compressors - compressor 75kW with 50 kW.	3	MWh	3	2,100

Payback period calculation for cost savings from the CO_2 emissions reduction initiatives

The simple payback period calculation method was used to assess the return on investment. The payback period is defined as the number of years required to recover the original cash investment. In other words, it is the period of time at the end of which the investment has produced sufficient net revenue to recover its investment costs.

Table 35 Payback Period calculation for the top 12 projects

Location	**Projects**	**Reduced consumption**	**Unit of measure**	**tCO2**	**Savings (EUR)**	**Investment (EUR)**	**Payback (Years)**
Bielefeld - Germany	Complete LED conversion in production area	186	MWh	160	118,700	317,797	3
Bielefeld - Germany	Installation of a photovoltaic system	362	MWh	311	107,165	586,000	6
Querétaro - México	photovoltaic system 25 % of the building)	455	MWh	391	96,682	325,000	3
Bielefeld - Germany	Replacement of old injection moulding with electrical drives	105	MWh	90	15,300	95,000	6

Bielefeld - Germany	Modernisation of process water cooling	47,368	l	18	15,000	75,000	5
Noida-India	Solar Panels installation	8	MWh	7	7,300	22,000	3
Leeds-UK	Lighting - Replace T8 lighting with LED system	7	MWh	6	5,700	17,000	3
Noida-India	Extension of solar power plant by 150KWp (50 KWp stagewise)	35	MWh	30	5,388	21,844	4
Shanghai-China	Solar street lamp in the site	47	MWh	40	5,188	32,000	6
Shanghai-China	Install electricity meters to monitor key power consumption	3	MWh	3	5,000	3,000	1
Bielefeld - Germany	Replacement of HQL lights with LED lights	3	MWh	3	2,578	4,100	2
Leeds-UK	Replace compressor 75kw with 50 kw.	3	MWh	3	2,100	10,000	5

The calculated payback period in years for 26 initiatives is 5.8 years, which is very good compared to the USA homeowners' solar panel payback which is 8 years according to the USA (ecowatch.com, 2022) that works with solar experts.

One way to determine whether the solar energy investment has a good return is the comparison with the entire lifespan of the analysed system. Most solar systems have a life time of 25 and 30 years (EcoWatch Solar, 2022). If the payback period is 5.8 years, the investment will be "making a profit" for 19.8 to 24.8 years.

The 26 addressed initiatives can reduce 3,435 tons of emissions and the total investment can reach 5.47 million EUR which can bring total savings of EUR 0.94 million. This is a very good investment financially and environmentally.

The effectiveness of the investment for investors is represented by determining the FNPV (Financial Net Present Value) at a 7% discount rate, which represents the average expected return on investment in the area of these manufacturing and warehouse and facilities.

ENPV Calculation – CO_2 reduction

On July 14, 2021, the European Commission adopted a series of legislative proposals to reduce the total volume of greenhouse gases that can be emitted by power plants, industrial plants and the aviation sector. The implementation of environment risk countermeasure initiatives should lead to the reduction of emission.

These reductions can be valued at the market price of the emission allowances, which current price (07th September 2022) is EUR 69.85/t (Trading economics EU Carbon Permits, 2022) .

The effectiveness of the investment for the public is shown by determining the ENPV (Economic Net Present Value) at a 5% discount rate currently used for projects affecting the public, in this case improving the environment in the Czech Republic. Table 41 shows the payback period, FNPV and ENPV of each project, calculated on the basis of the evaluated period of 10 years according to the procedures mentioned above.

The table below shows economic efficiency calculation and its cost-saving initiatives.

Table 36 Economic efficiency calculation cost-saving initiatives

Location	**Projects**	**Reduced consumption**	**Unit of measure**	***tCO_2***	**Savings (EUR)**	**Investment (EUR)**	**Payback period (Years)**	**FNPV (EUR)**	**ENPV (EUR)**
Bielefeld Germany	Complete LED conversion in the production area	186	MWh	160	118,700	317,797	3	482,152	122,584
Bielefeld Germany	Installation of a photovoltaic system	362	MWh	311	107,165	586,000	6	155,778	238,273
Querétaro México	photovoltaic system 25% of the building)	455	MWh	391	96,682	325,000	3	330,892	299,565
Bielefeld Germany	Replacement of old injection moulding with electrical drives	105	MWh	90	15,300	95,000	6	11,646	68,954
Bielefeld Germany	Modernisation of process water cooling	47,368	l	18	15,000	75,000	5	28,368	13,791
Noida India	Solar Panels installation	8	MWh	7	7,300	22,000	3	27,357	5,363
Leeds UK	Lighting - Replace T8 lighting with LED system	7	MWh	6	5,700	17,000	3	21,527	4,597
Noida India	Extension of the solar power plant by 150KWp	35	MWh	30	5,388	21,844	4	14,952	22,985
Shanghai China	Solar street lamps on the site	47	MWh	40	5,188	32,000	6	4,148	30,646
Shanghai China	Install electricity meters to monitor key power consumption	3	MWh	3	5,000	3,000	1	30,017	2,298
Bielefeld Germany	Replacement of HQL lights with LED lights	3	MWh	3	2,578	4,100	2	13,090	2,298
Leeds UK	Replace compressor 75kW with 50 kW.	3	MWh	3	2,100	10,000	5	4,439	2,298

Return on Equity - CO_2 reduction.

Table below shows Return on Equity (ROE) of the top 12 initiatives to eliminate the environmental risk in manufacturing and warehouse facilities.

Table 37 ROE of the top 12 initiatives to eliminate the environmental risk in manufacturing and warehouse facilities.

Region	Location	Projects	Reduced tCO2	Savings (EUR)/year	Saving in 7 Years	Investment (EUR)	Payback (Years)	ROE
Europe	Bielefeld - Germany	Complete LED conversion in production area	160	118,700	830,900	317,797	2.7	261%
Europe	Bielefeld - Germany	Installation of a photovoltaic system	311	107,165	750,155	586,000	5.5	128%
America	Querétaro - México	photovoltaic system 25 % of the building)	391	96,682	676,774	325,000	3.4	208%
Europe	Bielefeld - Germany	Replacement of old injection moulding with electrical drives	90	15,300	107,100	95,000	6.2	113%
Europe	Bielefeld - Germany	Modernisation of process water cooling	18	15,000	105,000	75,000	5	140%
Asia	Noida India	Solar Panels - Install solar panels into the facility	7	7,300	51,100	22,000	3	232%
Europe	Leeds - UK	Lighting - Replace T8 lighting with LED system	6	5,700	39,900	17,000	3	235%
Asia	Noida - India	Extension of solar power plant by 150KWp (50 KWp stagewise)	30	5,388	37,716	21,844	4.1	173%
Asia	Shanghai-China	Solar street lamp in the new site	40	5,188	36,316	32,000	6.2	113%
Asia	-China	Install electricity meters to monitor key power consumption	3	5,000	35,000	3,000	0.6	1167%
Asia	Bielefeld - Germany	Replacement of HQL lights with LED lights	3	2,578	18,046	4,100	1.6	440%
Asia	Leeds - UK	Compressors - compressor 75kw with 50 kw.	3	2,100	14,700	10,000	4.8	1.47

Summary and recommendation

Manufacturing and warehouse facilities have been causing the emissions growth rapidly since the mid-20th century. Globally, over 34 billion tonnes are emitted each year. Weather patterns are changing, sea levels are rising, and weather phenomena are becoming more extreme. It causes physical risk to the manufacturing and warehouse investment construction projects. According to the United Nations, this situation is disrupting national economies and affecting lives.

If the emissions continue to increase, they will cause global catastrophic risks to the world. All activities, especially commercial ones, need to focus on environmental protection. This also applies to manufacturing and warehouse facility projects. However, initiatives to reduce environmental risks need to be managed effectively in order to reach good social and economic impact. The effectiveness for investors was demonstrated on a research sample of 26 initiatives leading to the improvement of the living environment (impact on direct operating Cash Flow, saving of expenses). Furthermore, the initiatives reviewed as samples research can be used as baseline for the valuation of environmental improvement by reducing CO_2

emissions using the price of emission allowances and calculating the economic and social impact of the initiatives.

Global CEO's risk survey

The analysis of risks from companies CEO (the Chief Executive Officer) around the world and further creation of risk register according to the research made in the Žďár nad Sázavou, Central Europe manufacturing and warehouse facility investment and environment risk reduction initiatives from 3 continents Europe, America, and Asia.

Global CEOs of the large companies represent the majority of decision makers for construction investment in manufacturing and warehouse facilities. The collection of their risks survey has been made to analyse what they can see as a risk.

Climate change exemplifies a time-horizon challenge that comes into clearer focus when we look at a broader set of external threats to the global economy. Over the next 12 months, CEOs feel most exposed financially to inflation, economic volatility, and geopolitical risk. All three are immediate, headline-grabbing issues that can reinforce and compound one another, as, for example, the war in Ukraine pushes up prices, encouraging central banks worldwide to intervene through growth-dampening interest rate hikes. The picture changes for CEOs' medium-term (five-year) outlook. Over that time frame, cyber risks and climate change join inflation, macroeconomic volatility, and geopolitical conflict in the top tier of risk exposure.

In the survey, the CEOs were asked to bring their key business risks forward when investing and the question had 2 planning horizons of next 12 months and next 5 years.

Climate change is an example of risk that exemplifies a time-horizon challenge that comes into clearer focus when looking at a broader set of external threats to the global economy.

Question 1: How much do you believe your company will be exposed to the following key threats in next 12 months and next 5 years?

Data point underscores represent a dual imperative facing CEOs from 105 countries who responded to the survey.

The following figure shows what the CEOs replied to the question number 1.

Figure 7 Next 12 months global risks to the companies

Over the next 12 months, CEOs feel most exposed financially to inflation, macroeconomic volatility, and geopolitical risk. All three are immediate, important issues that can reinforce and compound one another.

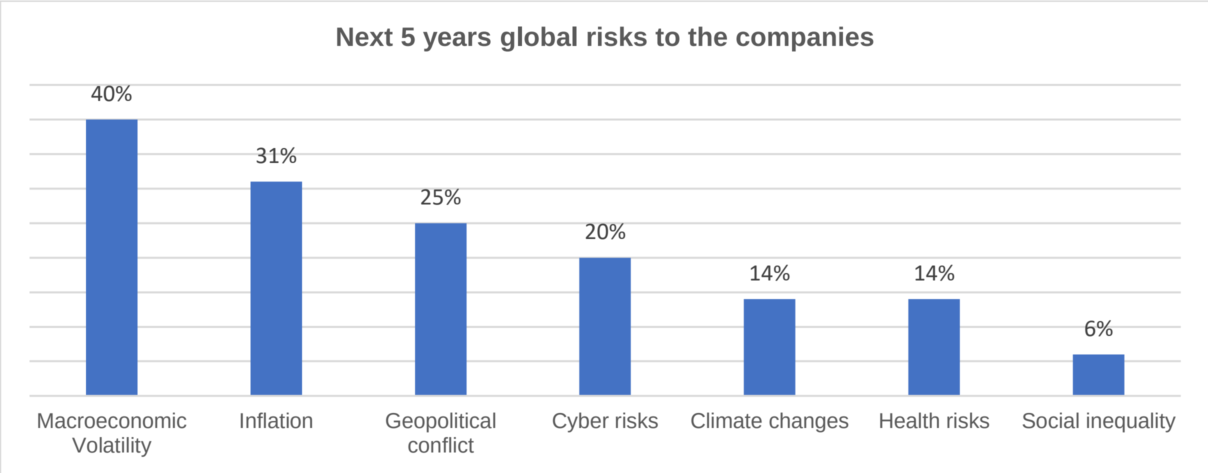


Figure 8 Next 5 years global risks to the companies

Inflation and macroeconomic volatility stand out more prominently than other key threats in the next 12 months than over next 5 years.

The misalignment between short time risks and long-time risks prediction show the CEOs run risk of being blindsided in near term as they focus on her-and-now risks.

Question 2: To what extent do you believe the following will impact (i.e., either increase or decrease) profitability in your industry over the next 10 years?

CEOs see multiple challenges to profitability in their industry, a chart below shows the top risks.

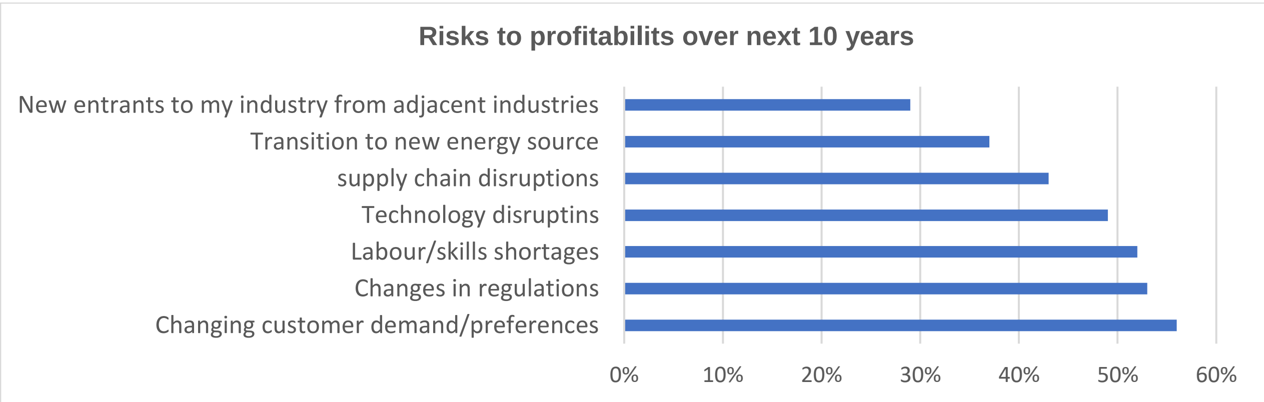


Figure 9 Risks to profitabilits over next 10 years

Today's leaders and investors are living through extraordinary times characterized by five broad megatrends:

- Climate change,
- Technology disruption,
- Demographic shifts,
- Fracturing world and social instability,
- Reshaping the business environment.

Although none of these forces is new, their scope, impact and interdependence are growing, with varied magnitude across industries and geographies.

CEOs in Japan (who have been buffeted by demographic headwinds for decades) and China (who are the front lines of uncertainties about the free-flowing global trade) were the most concerned about the long-term viability of their business models, while CEOs in the United States were the most optimistic.

Questions 3: Below is a list of actions companies may undertake to prepare for the risk of climate change. Which statement best characterises your company's level of progress on these actions?

Many companies are trying to decarbonise, innovate and craft climate strategy in parallel. Table below shows the list of actions they replied they are undertaking.

Table 38 list of actions companies may undertake to prepare for the risk of climate change.

	We do not plan to do this	Planned but not started	In progress	Complicated
Implement initiatives to reduce my company's emissions	17%	16%	39%	27%
Innovate new climate-friendly products or processes	19%	17%	36%	25%
Develop a data-driven, enterprise-level strategy for reducing emissions and mitigating climate risks	20%	19%	35%	23%
Implement initiatives to protect my company's physical assets and / or workforce from physical impacts of climate risks	36%	17%	27%	17%
Apply an internal price on carbon in decision-making	54%	17%	13%	11%

Moving with the right pace and priority to mitigate risks, generate opportunities and decarbonise are enormous strategic challenges. Many companies appear to be strategizing today without the information provided by an internal pricing mechanism for carbon. More than half of all CEOs in the survey (including 38% of those at the at the biggest companies and 70% of those at US companies) say that their company has no plans to apply an internal carbon price to decision-making, even though doing so could help them account for considerations like taxes and incentives and clarify strategic trade-offs.

Question 4: What new contingencies are you preparing for as geopolitical risks rise?

World events have elevated the importance of geopolitics, and have made themselves felt in myriad ways, including in influencing leaders' perspectives on the global economy itself. CEOs in Brazil, Canada, China, India, Japan, and the United States are more optimistic about the short-term growth prospects of their own countries than those of the world as a whole. The growing emphasis on national interests over global ones represents an acceleration of trends that have been underway for some time, as the post-Cold War consensus of open markets and frictionless global trade has broken down. An exception is major economies where the second-order effects of geopolitics are hitting home hardest. As CEOs in France, Germany and the UK prepared for a potentially dark, cold winter, they anticipated growth in their home markets would lag behind the global economy.

Question 5: How do you believe economic growth (i.e., gross domestic product) will change, if at all, over the next 12 months in the global economy / your country or territory?

CEOs in many majors' economies are more optimistic about the near-term growth prospects of their own countries than the global economy.

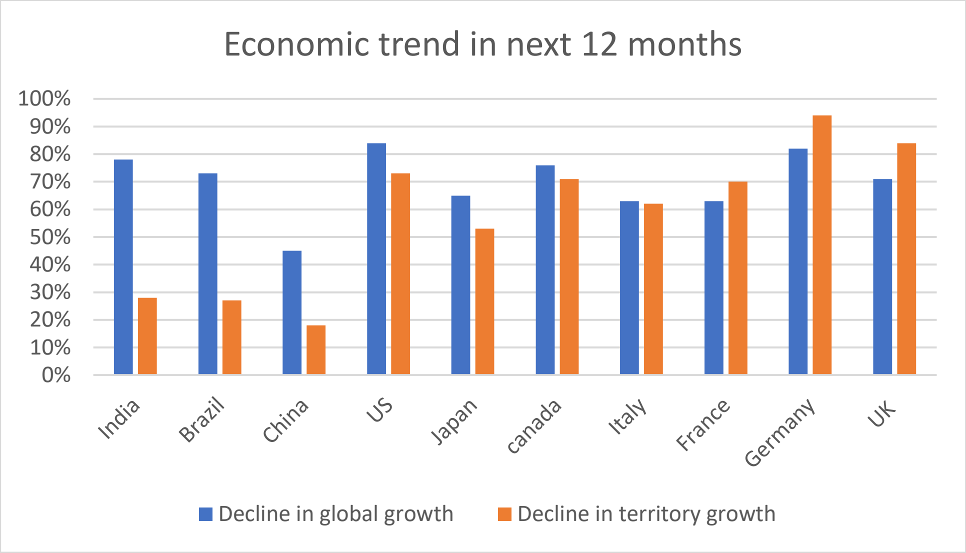


Figure 10 Economic trend in next 12 months

Question 6: Which of the following actions, if any, is your company considering mitigating against exposure to geopolitical conflict in the next 12 months?

The figure below shows the action that companies are taking to mitigate the geopolitical risk.

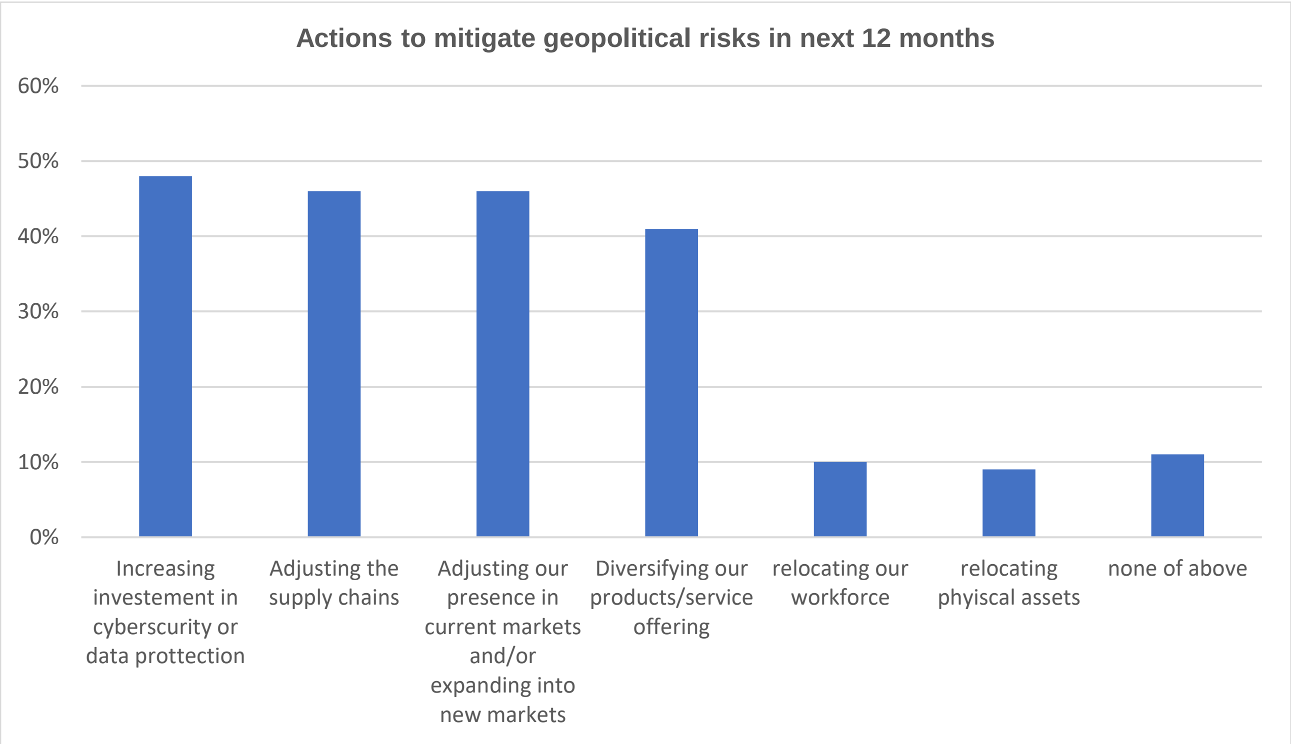


Figure 11 Actions to mitigate geopolitical risks in next 12 months.

CEOs are increasing cyber investments, adjusting supply chain, and changing their physical footprint in response to geopolitical conflict. Boosting supply chain resilience has been a growing priority for many organisations since 2020, when the covid-19 pandemic highlighted the fragility of many tightly wound systems.

Question 7A: Which of the following investments, if any, is your company making in the next 12 months?

Question 7B: For each of the investment areas selected, please indicate the percentage of investment allocated to preserve current business versus reinvest in the business for the future.

Table 39 Technology and reinvention-oriented investments for large companies' global CEOs

	Preserving the current business	Reinventing the business of future	Percentage of CEOs investing
Automation processes and systems	40%	60%	76%
Upskilling the company's workforce in priority areas	41%	59%	72%
Deploying technology	38%	62%	69%
Adjusting the company's supply chain (including reshoring/onshoring operations	47%	53%	41%
Adopting alternative energy sources	45%	55%	34%
Decarbonising the company's business model	42%	58%	31%
Exploring the metaverse	38%	62%	12%
Relocating the company's operations in response to climate change	43%	57%	7%

To reinvent the business while navigating near-term challenges, Chef Leader suite need the help of the employee. This survey suggests that companies are investing in process, people, and technology to prepare themselves to the future challenges.

The Czech Republic risks and threats according to CEO's survey.

The last 3 years can be commented as years of risks management, where managers were in crisis mode. In first quarter of 2020, the COVID-19 pandemic became a global health crisis, The virus was first identified in Wuhan, China in December 2019, and has since spread rapidly around the world, causing widespread illness, death, and significant social and economic disruption.

In the first quarter of year 2022, precisely on 24 February 2022, Russia invaded and occupied parts of Ukraine in a major escalation of the Russo-Ukrainian War, which had begun in 2014. The invasion has resulted in tens of thousands of deaths on both sides, and instigated Europe's largest refugee crisis since World War II.

According to Czech national statistic the average annual inflation rate for year 2022 was 15.1% – this is the value of the same indicator in December of the given year. This was the second highest inflation rate in the history of the Czech Republic after the one of year 1993 20.8%. This had negative consequences for businesses, including reduced purchasing power, increased costs, reduced consumer spending, uncertainty, and economic instability.

March 2023 had inflation rate of 15% and according to the CEO survey 2022 inflation rate is at the top of risk for year 2023.

Question 8: Which business risks and threats bother Czech CEOs the most and how has their perception changed in the last five years?

Table 40 Development of business risk perception since 2019

Risks and threats	2019	2020	2021	2022	2023
High inflation	15%	16%	48%	84%	90%
Growth in labour costs	87%	77%	48%	85%	85%
Volatility of energy prices			37%	67%	85%
Availability of qualified employees	88%	81%	71%	94%	85%
Geopolitical risks	46%	63%	41%	46%	77%
Raw material price volatility			46%	69%	77%
Uncertain or unstable economic growth	46%	60%	68%	60%	74%
Cyber threat		39%	49%	54%	71%
Increasing tax and levy burden	43%	65%	71%	55%	69%
Low-quality legislation or its hard-to-predict changes	51%	64%	81%	60%	65%
Too much regulation	59%	68%	77%	56%	65%
A permanent shift in consumer behaviour and their willingness to spend	31%	40%	45%	40%	64%
Uncertain political developments			64%	34%	63%
Supply chain security	29%	26%	37%	59%	61%
Disinformation			61%	48%	60%
Fluctuations in exchange rates	44%	45%	59%	51%	59%
Lack of energy	38%	35%	21%		55%
Unstable capital markets	49%	39%	42%	41%	54%
Rising interest rates and worsening availability of financing				34%	51%
Inability to finance further growth	11%	23%	19%	18%	39%
Social unrest	14%	24%	33%	22%	38%
Unemployment			28%	19%	23%
Speed of technological change		39%	32%	29%	22%
Pandemics and other crises related to the health of the population			78%	73%	20%

While last year the Chief Executive Officers of Czech companies were most troubled by the lack of qualified employees, this year they consider high inflation to be the biggest threat to their business. Also, other business risks following closely behind the rising inflation that is associated with the impact of the war in Ukraine - the imaginary second row for this year was equally occupied by the fear of fluctuating energy prices and rising labour costs. However, 81% of CEOs still deal intensively with the unavailability of labour.

A figure below illustrates the risks and threats over the last 5 years.

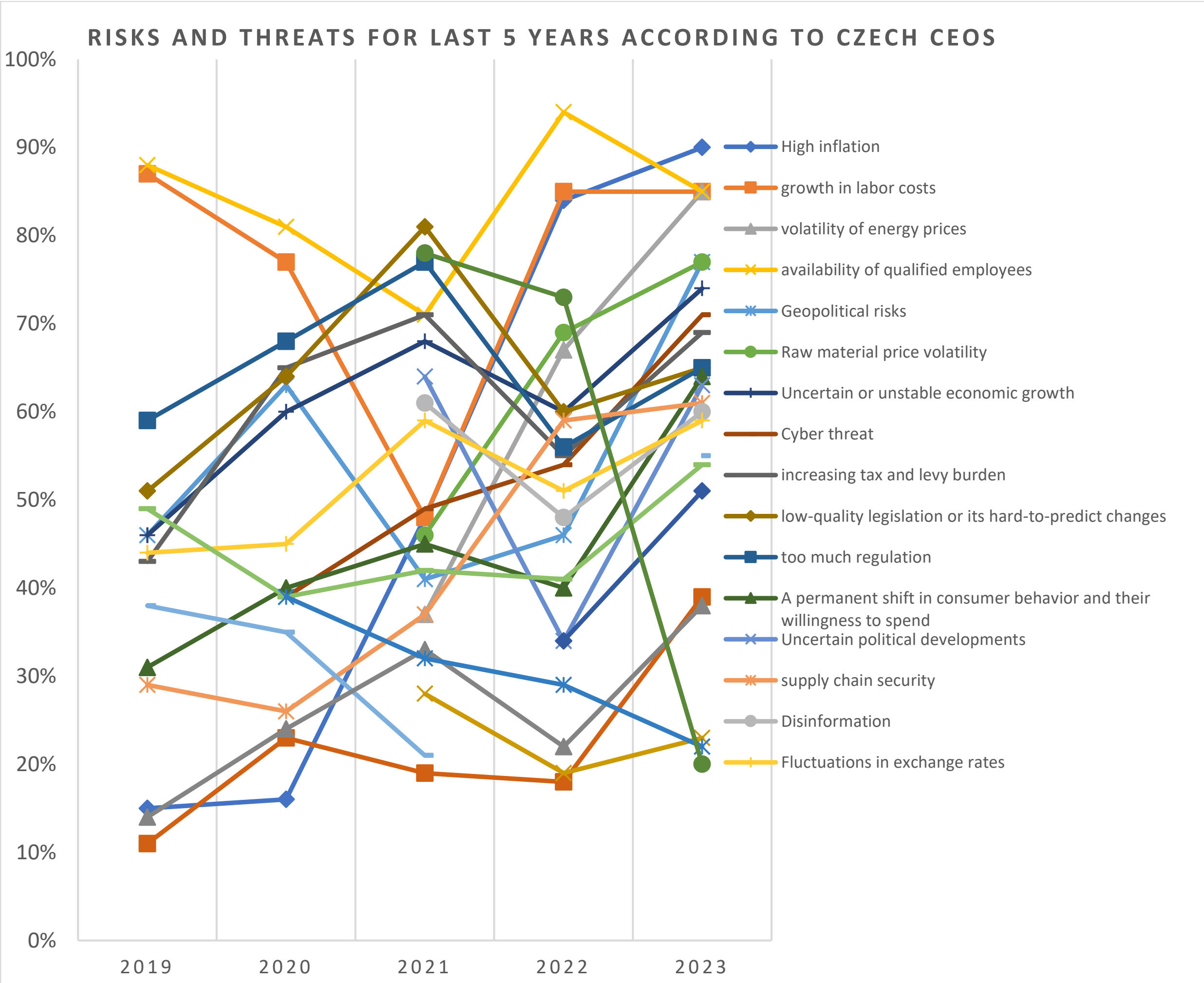


Figure 12 risks and threats for last 5 years according to Czech CEOs

The fear of the risks associated with inflation is logical, but it can be assumed that it disappears at the moment when inflation drops back to normal values.

Cyber security risk increased by 17% to 71% , this risk increases with time, there are more Czech CEO's who are aware of this risk and 33% of them plan to invest in cybersecurity in reaction to increase in the geopolitical risk.

Question 9: Which of the following measures is your company considering using to mitigate potential economic problems in the next 12 months?

The figure below shows the mitigation measures that companies consider.

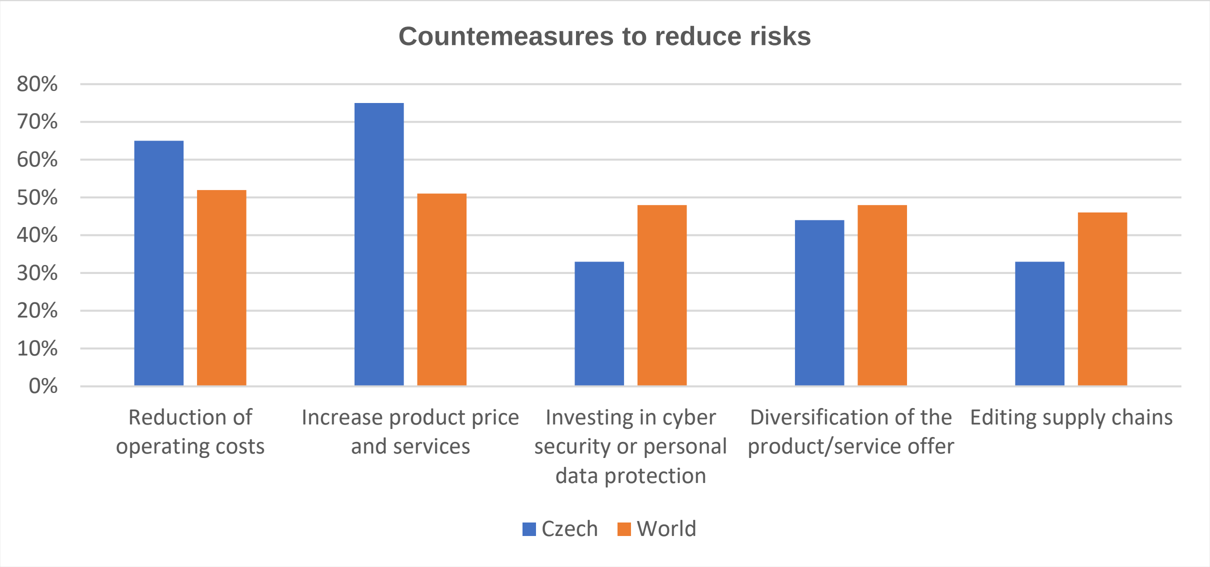


Figure 13 Countemeasure to reduce the risks.

It can be seen from the survey that most companies are flexible and are used to help themselves in difficult times.

Most activities can be seen in the measures taken. The Czech companies prefer quick fix, while directors are generally more strategic and prefer more complex solutions such as diversification of the portfolio of products and services or expansion into other markets.

Question 10: In which of the following areas is your company going to invest in the next 12 months?

The figure below shows the investments that the companies are planning in the next 12 months.

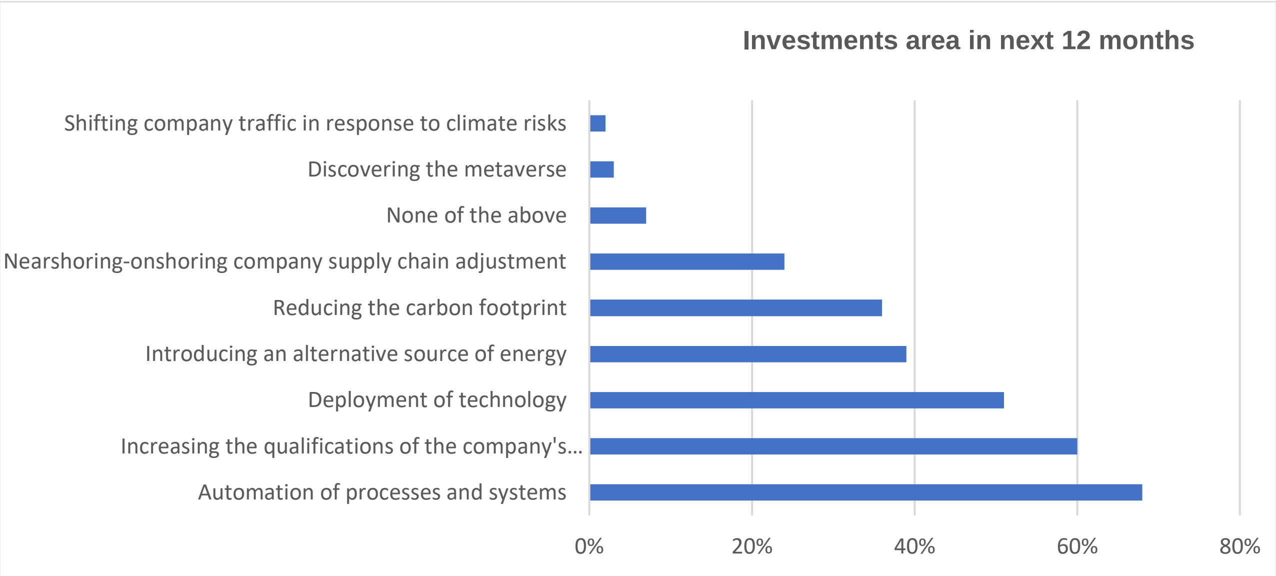


Figure 14 Investments area in next 12 months

5 RESULTS

5.1. Specific risks in investing in manufacturing and warehouse facilities construction project.

According to the author's perspective and facts studied in different phases of research and above-listed CEOs survey, the risks in investing in manufacturing and warehouse projects has the specific risks which can be split into two categories of external and internal risks. Further specific risks' categorisation for these types of projects are financials risks, legal risks, technological risks, political risks, supply chain and operation risks, social risks, project management risks and environmental risks. These categories can be seen in the risk register.

External and internal risks

External risks are mostly the risks that have an impact on investor and internal risks are most the risks carried by the constructor; therefore, the risk register that follows this sub section uses mitigation carrier instead of external and internal risks.

External:

- Global pandemic,
- Geopolitical risks,
- Climate change,
- Macroeconomic volatility.

Internal:

- Cost overruns,
- Delays,
- Quality,
- Poor projects management,

External risks

External risks in investing in manufacturing and warehouse construction project facilities are the risks that impact mainly the investors as they impact the sales revenue and the efficiency of financial return of the project.

The external risks with specific impact on manufacturing and warehouse facility construction investment projects are listed below:

Global pandemic

In year 2020 the world has witnessed the COVID-19 global pandemic which caused

- Disruptions in Manufacturing: Lockdowns and restrictions on movement in various countries led to factory closures and disruptions in manufacturing activities. This caused delays in the production and distribution of goods.

- Transportation and warehouse challenges: Border closures and reduced transportation capacity due to travel restrictions impacted the movement of goods across the globe, resulting in delays and lack of capacity in some warehouse and lack of demand in others.

- Reshoring and regionalization: The pandemic prompted some companies to reconsider their global supply chain strategies, leading to a trend of reshoring or regionalizing supply chains to reduce risks and improve resilience.

Geopolitical risks

Investors in construction project of manufacturing and warehouse facilities are generally global investors who play key role in the global supply chain.

Geopolitical risks bring the following specific risks to the investors:

- Trade Wars and tariffs: Geopolitical tensions and trade disputes between countries can lead to the imposition of tariffs and trade barriers. These measures can disrupt manufacturing and warehouse facility operation. and supply chains by increasing costs, reducing competitiveness, and limiting market access.
- Political instability: Political instability, such as civil unrest, government changes, or coups, can lead to disruptions in transportation, trade, and business operations, affecting the flow of goods and services by increasing costs, reducing competitiveness, and limiting market access.
- Sanctions and embargoes: The imposition of economic sanctions or embargoes by one country against another can restrict trade and lead to supply chain disruptions, particularly for goods with restricted origin or destination.
- Border Checks and Customs regulations: Changes in border controls, customs regulations, or import/export procedures can cause delays at borders and increase administrative burdens for businesses engaged in cross-border trade.
- Intellectual property and technology transfer issues: Geopolitical disputes related to intellectual property rights and technology transfer can impact supply chains by restricting access to critical technologies and components.
- Regional conflicts: Armed conflicts and territorial disputes in certain regions can disrupt transportation routes, ports, and infrastructure critical to the global supply chain.
- Economic blocs and alliances: The formation of economic blocs and trade alliances can impact supply chains by changing trading patterns and creating preferential trade agreements that may exclude certain countries or industries.

To mitigate geopolitical risks to the global supply chain, businesses often employ strategies such as diversifying suppliers and markets, implementing contingency plans, investing in technology and risk analysis tools, and maintaining open communication with stakeholders and authorities. Flexibility and adaptability are key traits for businesses seeking to navigate the complexities of the global supply chain under geopolitical uncertainties.

Environmental risks

Investing in manufacturing and warehouse facilities construction projects involves various environmental risks. These risks can impact the project's feasibility, regulatory compliance, and long-term sustainability. Some specific environmental risks to consider are:

- Site contamination: The chosen construction site may have historical contamination from previous land uses, such as industrial activities or hazardous materials storage. Conducting a thorough environmental site assessment is essential to identify potential contamination issues and assess the costs and feasibility of remediation.
- Environmental regulations: Construction projects are subject to numerous environmental regulations, including those related to air quality, water management, waste disposal, and habitat protection. Non-compliance with these regulations can lead to costly fines and delays.

- Natural resource impacts: The construction project may affect natural habitats, wetlands, or protected areas. Mitigation measures may be required to minimize impacts on wildlife and ecosystems.
- Water resources: The construction project's water use, and stormwater management can impact local water resources. Ensuring proper management of water runoff and the use of sustainable water practices is important to minimize environmental impacts.
- Climate change resilience: Construction of manufacturing and warehouse facilities generate carbon emissions which affect the environment. Implementing measures to control emissions is necessary to protect the environment. Considering the potential impacts of climate change, such as extreme weather events and sea-level rise, is critical to ensure the long-term resilience of the facilities and infrastructure.
- Waste management: Construction projects generate significant amounts of waste. Proper waste management practices, such as recycling and responsible disposal, are essential to minimize environmental impacts.
- Energy efficiency: Designing the facilities for energy efficiency and incorporating sustainable energy practices can reduce the project's carbon footprint and operational costs.
- Environmental permits: Securing necessary environmental permits is crucial for the construction project's compliance with regulations. Delays in obtaining permits can result in project delays and financial losses.

Managing environmental risks effectively, conducting comprehensive environmental assessments, engaging with environmental consultants, and developing environmental management plans are essential. Incorporating sustainable design practices and adhering to environmental regulations can both mitigate risks and contribute to the project's overall success and positive environmental impact. Additionally, communicating transparently with stakeholders and the local community about the project's environmental measures can build trust and support.

Macroeconomic volatility

Investing in a construction project of manufacturing and warehouse facilities can be influenced by various macroeconomic volatility risks, which are uncertainties arising from changes in broader economic conditions. These risks can impact the project's viability, costs, and returns on investment. Some key macroeconomic volatility risks to consider include:

- Economic downturn: During economic recessions or downturns, there is reduced consumer demand, which may affect the demand for warehouse space and manufacturing facilities. Occupancy rates could decline, leading to potential difficulties in leasing or selling the properties.
- Interest rate fluctuations: Changes in interest rates can impact the cost of financing for the construction project. Higher interest rates may increase borrowing costs and affect the overall profitability of the investment.
- Currency exchange rate risks: If the construction project involves international transactions or relies on foreign suppliers, fluctuations in exchange rates can impact costs and returns, especially if revenues are denominated in a different currency.
- Inflation: Rising inflation can lead to increased construction costs, including materials, labour, and overhead expenses, potentially impacting the project's budget and profitability.

- Labour market conditions: Labour market volatility, such as labour shortages or wage inflation, can affect construction costs and project timelines. Labour availability and skilled workforce shortages could lead to delays and increased labour expenses.

To mitigate macroeconomic volatility risks, investors should carry out market research, financial analysis, and stress testing scenarios. Implementing flexible financial models, considering conservative assumptions, and have contingency plans which can help to overcome economic uncertainties and enhance the resilience of the investment.

Internal risks

Internal risks in investing in manufacturing and warehouse construction projects are those that arise from factors within the control of the constructor or project stakeholders.

The most common risks are listed below:

- Cost overruns,
- Delays,
- Quality,
- Poor projects management.

5.2. Risk registers for manufacturing and warehouse construction facility investments

The survey of risks from companies' Chef Executive Officers (CEOs) who are the investors into the manufacturing and warehouse construction facilities around the world and the research carried out in the Central Europe manufacturing and warehouse facility construction investment projects and environment risk reduction initiatives from 3 continents Europe, America, and Asia were used to create the risk register descripting the risks, the occurrence from the survey of global inventors and the percentage which indicates the percentage of surveyed investors who believe that the specific risk is real. The risk categorization is sorted according to the category where the risk fits the most, considering the risk carrier as well. Control / mitigation was completed to show how risk can be eliminated or controlled when the action of risk control and mitigation is performed by its carrier.

Risk registers are sorted into the risks categories, and each categories contains both the risks and the mitigation countermeasures. The risks categories that were determined when investing in construction of manufacturing and warehouse facilities are listed below:

- Financials risks,
- Legal risks,
- Technological risks,
- Political risks,
- Supply chain and operation risks,
- Social risks,
- Project management risks,
- Environmental risks.

Financial risk registers for investing in the construction of manufacturing and warehouse facilities

The table below shows the financial risk register when investing in construction of manufacturing and warehouse facilities.

Table 41 Financial risk register for investing in the construction of manufacturing and warehouse facilities.

Risks description	Risk perception of investors %	Risk carrier	Controls / Mitigation	Controls / Mitigation Carrier
High inflation	90%	Investor	Reduce the operational cost Increase the product and service price	Investor
Growth in labour costs	85%	Investor/ Constructor	Increase the price of product and service price	Investor/ Constructor
Volatility of energy prices	85%	Investor	Increase the price product and service price, generate renewable energy onsite (PV)	Investor
Raw material price volatility	77%	Investor	Reduce the operational cost Increase the product and service price	Investor
Uncertain or unstable economic growth	74%	Investor	Evaluate the projects properly	Investor
A permanent shift in consumer behaviour and their willingness to spend	64%	Investor	Analyse different scenarios of prediction	Investor
Fluctuations in currency exchange rates	59%	Investor	Analyse different scenario of prediction	Investor
Unstable capital markets	54%	Investor	Pre agree the long-term exchange rate with the bank	Investor
Rising interest rates and worsening availability of financing	51%	Investor	Pre agree with the long interest rate with the bank	Investor
Inability to finance further growth	39%	Investor	Analyse different scenarios of prediction, sensitivity analysis	Investor
Overruns	20%	Constructor	Run and prepare for different scenarios	Constructor
Budget constraints	15%	Investor	Run and prepare for different scenarios	Investor
Risk of cost change	10%	Investor/ Constructor	Run and prepare for different scenarios	Investor/ Constructor

When investing in these types of projects, investors feel most exposed financially to the inflation, growth in the labour cost and volatility of energy and raw material prices as risk mitigation investors should increase operational efficiency and apply other above-mentioned mitigations.

Social risk register for investing in the construction of manufacturing and warehouse facilities.

Investing in the construction of manufacturing and warehouse facilities can offer significant opportunities for returns, but it also brings social risks that should be considered.

The risk register for such investments can be seen in the table below.

Table 42 Social risk register for investing in the construction of manufacturing and warehouse facilities.

Risks description	Risk perception of investors %	Controls / Mitigation	Controls / Mitigation Carrier(s)
Availability of qualified employees	85%	Invest in the training, support public local community education.	Investor/ Constructor
Disinformation	60%	Engage with local communities through transparency and communication.	Investor/ Constructor
Social unrest	38%	Diversification of the product / service offered.	Investor/ Constructor
Unemployment	23%	Conduct thorough social impact assessments and build ecosystem to attract employees and grow the relationship with the local community.	Investor/ Constructor
Public opposition	15%	Comply with all relevant regulations and permits and implement sustainable and responsible practices. Build strong relationships with local public, including community leaders, environmental groups, and labour unions.	Investor
Stakeholder's conflict	10%	Build strong relationships with local stakeholders and engage with local communities through transparency and communication.	Investor
Social inequality	9%	Address the inequality concerns and implement sustainable and responsible practices to reduce social inequality.	Investor

The biggest social risks that investors face when investing in the manufacturing and warehouse facilities are the lack of available qualified employees and disinformation. To mitigate these risks, investors, constructors and other stakeholders as government or location authorities should invest in the people training and support local community education and engage with local communities through transparency and communication.

Legal risk register for investing in the construction of manufacturing and warehouse facilities

Creating legal risks register for investing in the construction of manufacturing and warehouse facilities is an essential step in risk management. This register helps identify, assess, and manage potential legal challenges that could arise during the development and operation of the project. The table below shows legal risks register for investing in construction of manufacturing and warehouse facilities.

Table 43 Legal risk register for investing in the construction of manufacturing and warehouse facilities

Risks description	Risk perception – investors %	Controls / Mitigation	Controls / Mitigation Carrier(s)
Increasing tax and levy burden	69%	Analyse different scenarios of prediction and run sensitivity analysis.	Investor
Low-quality legislation or its hard-to-predict changes	65%	Analyse different scenarios of prediction and run sensitivity analysis.	Investor
Over - regulation	65%	Conduct thorough due diligence on regulatory requirements and possible scenario, engage with regulatory authorities early, and maintain compliance throughout the project.	Investor/ Constructor
Sub-constructor poor performance	30%	Outsource the risk to the sub-constructor.	Constructor
Liability issues	20%	Conduct thorough due diligence, engage legal experts when needed, maintain comprehensive insurance coverage, establish risk management protocols, and implement stringent safety and compliance measures.	Investor/ Constructor
Quality of construction	10%	Regular check of construction, outsource the risk to the constructor	Constructor
Labour disputes, wage and hour violations, or non-compliance with labour laws	9%	Ensure compliance with labour laws, maintain good labour relations, and have clear employment contracts.	Constructor

The investors when investing in discussed projects face the biggest legal risks of increasing tax and levy burden, low-quality legislation or its hard-to predict changes and over regulation. The mitigation measures should regularly update and review the projects' legal risks register throughout the project's lifecycle. Additionally, consultations with legal experts and seeking legal counsel to address specific legal challenges as they arise is needed.

Political risk register for investing in the construction of manufacturing and warehouse facilities

Creating political risks register for investing in the construction of the manufacturing and warehouse facilities is essential to identify, assess, and mitigate potential political risks that could affect this investment.

The table below shows the political risks register in investing in the construction of the manufacturing and warehouse construction facilities.

Table 44 Political risk register for investing in the construction of manufacturing and warehouse facilities.

Risks description	Risk perception - investors %	Mitigation measures	Mitigation Carrier
Geopolitical risks	77%	Change the supply base, create alternative duo sourcing. Relocate the workforce and tangible property and diversify investments across regions and stay informed about geopolitical developments.	Investor
Uncertain political developments	63%	Diversification of the product / service offer	Investor
Changes in government policies	30%	Stay updated on political developments through local experts and political risk analysis. Diversify investments across regions to reduce exposure.	Investor/ Constructor
Tariffs and trade barriers affecting product exports	29%	Diversify export markets, stay informed about trade policy changes, and engage in advocacy efforts if necessary.	Investor/ Constructor
Terrorism or political violence	10%	Enhance security measures, coordinate with local law enforcement, and have contingency plans for evacuations if needed.	Investor/ Constructor

Political risks can have big impact of these type of projects, therefore the mitigation measures as mentioned above are necessary for the project success, additionally, it is important to regularly review and update the mitigation plans to adapt to changing political conditions and evolving threats.

Technological risk register for investing in the construction of manufacturing and warehouse facilities.

Creating a technology risk register for investing in the construction of the manufacturing and warehouse facilities is essential to identify, assess, and mitigate potential technology-related challenges.

The table below shows the risk register for these projects and the related mitigation measures.

Table 45 Technological risk register for investing in the construction of manufacturing and warehouse facilities.

Risks description	Risk perception - investors %	Mitigation measures	Mitigation Carrier(s)
Cyber threat	71%	Invest in robust cybersecurity measures, including firewalls, intrusion detection systems, employee training on cybersecurity best practices, and regular security audits.	Investor/ Constructor
Lack of energy to run current technology	55%	Diversify suppliers, search for alternative suppliers.	Investor/ Constructor
Speed of technological change	22%	Invest in the technology ahead of time, innovate.	Investor/ Constructor
Failure of new or untested technology	15%	Run and prepare for different scenarios.	Constructor
Software malfunctions	10%	Run and prepare for different scenarios.	Constructor
Inadequate or inappropriate technology selection for warehouse and manufacturing processes	9%	Conduct a thorough technology assessment, engage with industry experts, and ensure that selected technologies align with the project's requirements and long-term goals.	Investor
Disruption in the supply chain for critical technological components	8%	Diversify suppliers, maintain safety stock for critical components, and implement supply chain risk management strategies, such as dual sourcing.	Investor

Technological risks can have impact when investing in the manufacturing and warehouse facilities therefore the above-mentioned mitigation measures should be integrated into the type of project risk management and consistently implemented throughout life cycle phases. Collaboration with technology experts and staying informed about emerging trends and potential risks are critical for successful risk mitigation in the technological domain.

Environmental risk register for investing in the construction of manufacturing and warehouse facilities.

Investing in the construction of manufacturing and warehouse facilities involves specific environmental risks that should be carefully assessed and managed to ensure compliance with regulations, minimize potential impacts, and mitigate potential environmental challenges.

The table below shows the risk register for these types of projects and related mitigation measures.

Table 51 Environmental risk register for investing in the construction of manufacturing and warehouse facilities.

Risks description	Risk perception-investors%	Mitigation measures	Mitigation Owner
Climate change	14%	Implement ESG initiatives.	Investor/ Constructor
Inadequate site selection and incomplete Environmental Impact Assessment (EIA) leading to unforeseen environmental issues	10%	Conduct a comprehensive EIA prior to construction. Select sites with minimal environmental impact and ensure compliance with all regulatory requirements.	Investor
Emissions and pollutants generated during manufacturing operations	10%	Install advanced pollution control technologies, conduct regular emissions monitoring, and adhere to emission standards and regulations.	Constructor
Negative impact on local ecosystems and biodiversity	9%	Conduct biodiversity assessments, implement habitat restoration plans, and practice responsible land use to minimize ecological impact.	Investor/ Constructor
Inadequate water management leading to water scarcity or contamination	8%	Utilize water conservation practices, including rainwater harvesting and wastewater treatment. Ensure compliance with water quality standards.	Investor/ Constructor
Vulnerability to climate change impacts, such as flooding or extreme weather events	7%	Incorporate climate-resilient design and construction techniques, such as flood-resistant infrastructure and energy-efficient building materials.	Investor/ Constructor
Improper handling and disposal of construction and manufacturing waste	6%	Develop a comprehensive waste management plan, emphasizing recycling and responsible disposal practices.	Investor/ Constructor
Deterioration of local air quality due to emissions.	5%	Invest in air quality monitoring systems, employ low-emission equipment, and adhere to emission reduction strategies.	Investor

Environmental risks are one of the challenges when investing in these types of projects and following the above-stated risk register and regularly review it throughout the project's lifecycle will help identify, assess, and manage environmental risk effectively. Engaging with environmental consultants, regulatory agencies, and stakeholders is crucial for successful risk mitigation and environmental compliance.

Construction project management risks register for investing in the construction of manufacturing and warehouse facilities.

Creating a comprehensive risk register is an essential part of project management when investing in warehouse and manufacturing construction facilities.

The table below shows the construction project management risk register for manufacturing and warehouse facilities projects.

Table 52 Construction project management risk register for manufacturing and warehouse facilities projects

Risks description	Risk perception-investors %	Mitigation measures	Mitigation Carrier
Risk on project documentation	5%	Work with authorised person	Investor
Inadequate planning	4%	Work with authorised person	Constructor
Poor communication	3%	Work with skilled and experienced management	Constructor
Ineffective project checks	2%	Work with skilled and experienced management	Constructor
Risk of construction and other permits	1%	Work with authorised person	Constructor

This risk register serves as a starting point for identifying and managing risks in a manufacturing and warehouse facility construction projects. Regularly reviewing and updating it throughout the project's lifecycle, active monitoring and addressing emerging risks ensures a successful and efficient project completion.

Supply chain and operational risk register for investing in the construction of manufacturing and warehouse facilities.

Creating a supply chain and operations risk register is crucial when investing in the construction of manufacturing and warehouse facilities.

The table below shows the supply chain and operational risk register when investing in manufacturing and warehouse facilities.

Table 53 Supply chain and operational risk register for investing in the construction of manufacturing and warehouse facilities

Risks description	Risk perception-investors %	Mitigation measures	Mitigation Carrier
Disruptions in the supply chain can lead to delays in construction and increased costs	61%	Develop contingency plans for supply chain disruptions. Maintain safety stock for critical components. Diversify suppliers and sources of raw materials.	Investor/ Constructor
Disruptions in energy supply can affect manufacturing operations	55%	Explore renewable energy options for sustainability and reliability. Optimize energy efficiency in facility design and operations. Invest in backup power systems or generators.	Investor/ Constructor
Equipment breakdowns can disrupt construction and operations	20%	Implement a robust equipment maintenance and inspection program. Maintain spare parts inventory and access to qualified technicians. Consider equipment warranties and service contracts.	Investor/ Constructor
Transportation delays can impact the timely delivery of materials and equipment.	15%	Communicate closely with logistics partners to ensure on-time delivery. Establish backup transportation options in case of disruptions. Optimize logistics and transportation routes to minimize delays.	Investor/ Constructor
Unreliable vendors may not meet delivery timelines.	10%	Monitor vendor performance and address issues promptly. Establish clear contractual agreements with performance expectations. Carefully choose and select reputable vendors with a history of reliability.	Investor/ Constructor

The above-stated register can help identify, assess, and mitigate potential risks associated with the sourcing of materials, equipment, and operational activities.

5.3. Answers to the research questions

Research questions were formulated in the introduction of the dissertation thesis. In this part they are confirmed or refuted. The following research questions were established in accordance with the defined research area in the dissertation research:

Main research question

- Do the investments in the construction of manufacturing and warehouse facility have specific risks?
- If so, how are they managed?

Sub-research question

The results of the scientific research concluded in this dissertation thesis are as follows:

Answers to the main questions

- The specific risk of investing in manufacturing and warehouse construction project facilities were collected using 12 sample research projects and investors survey, it was showed in the research sample projects that there are specific similar risks in this area of investment, the pre-investment analysis was compared to the post-investment analysis to assess the deviation from the plan. The summary of 12 projects proves that the investments in the construction of manufacturing and warehouse facility has specific risks.
- The way the risks are managed is different project to project, however, the methods used to evaluate the economic efficiency of the project and risk management can be the same as it is shown in economic efficiency evaluation that was elaborated for the researched project in this dissertation thesis.

Answers to sub-research question

- The necessary resources needed to achieve economic investment is shown in 12 manufacturing and warehouse projects studied in this dissertation.
- Global investors' (CEOs) survey was reviewed to analyse the risk that investors saw to analyse how to mitigate the risks and additional to that, sample projects research showed the risk found in investing in the manufacturing and warehouse construction projects and also the environment risk reduction initiatives were analysed to study how to mitigate the risk in the environment area, putting all these studies together in the risk register for investing in the manufacturing and warehouse facility was created.

6 CONCLUSION

The conclusion evaluates the results of the application of the methods in the case study and their comparison in the individual phases of the project. It tested the suitability of methods used and at the same time it evaluated recommendations for their use. Conclusion answers the research question formulated at the beginning of this thesis.

If the investor can timely identify, quantify, and relevantly incorporate the impact of the risks into the process of assessing investment plans, he is able to manage his investments maximally efficiently even in an uncertain economic environment. It will be possible in the future to use the principles of long-term sustainability, as it has been demonstrated in the approaches of this thesis and additionally, the method used in this research show how to successfully invest in the construction project with a good social-economic impact.

6.1 Application of the achieved results

The objectives of applying the risk management in ex-ante phase of construction investment is to maximise the success of the project in terms of profit and benefit for the society. In order to minimize the risk of project, it is preferred to include risk management from the beginning of project and monitor the risk throughout all stages of the project.

The suggested risk management combines law of economic efficiency, assessment of project and risk management. The primary aim of investing in the construction of manufacturing and warehouse facilities is to achieve the desired socio-economic yield.

A suggested risk management method and risk register can lead to a positive return on investment and contribute to the socio-economic development of the community.

The suggested method consists of using economical evaluation, SWOT analysis of investment projects and environmental risk mitigations initiatives.

The economical evaluation methods use Net Present Value, discounted payback method, return on Equity and Internal Rate of Return which helps to evaluate the profitability of the projects.

SWOT analysis provides evaluation of internal and external factors that can impact the success of the investment project.

Analysis of initiatives to mitigate the risks shows how to apply the risk mitigation in socially economical and successful way so that the initiatives can improve both the environment and the cash flow.

6.2 The contribution of the dissertation research for the further development of science

The scientific contribution to the field of Construction Management lies in including the risk management into the whole life cycle management and all stages of the project in order to achieve a more efficient process of planning the investment projects.

The following areas were reviewed as part of risk management:

- Risk management methods by global notable authors,
- Construction project risk classification in the Czech Republic,
- Construction project risk classification in the world by notable authors,

- Construction of warehouse and manufacturing risk classification according to investors,
- Survey of CEO expected risks for the 2020-2023 period.

The following areas were mapped within the dissertation research in this context:

- Possible risk in construction investment project, precisely the manufacturing and warehouse facilities,
- Environmental risk during and after the construction,
- Current and new methods of risk management in manufacturing and warehouse construction investment projects,
- SWOT analysis for manufacturing and warehouse construction investment projects.

6.3 The contribution of the dissertation research for practice

The main benefit of the dissertation research for the practice is the risk register, which contains the possible risks in investing in manufacturing and warehouse construction projects and the recommendation of how to eliminate the risks before the project, during the construction investment and after the project as well as how to include the risk factors during the preparation phase.

The second benefit of the dissertation thesis is the social - economical evaluation method for decision making during the investment in the manufacturing and warehouse construction projects.

For the investors:

- Increase the social economic benefits in construction project investment,
- Increase the social economic benefits in risks management initiatives,
- Effective risk management in construction project,
- Effective investment in construction project,
- Initiatives to mitigate the environmental risk,
- Lay down the risk register for construction investment.

For the constructors:

- Increase in economic benefits in construction project execution,
- Reduction of cost overrun risk,
- Reduction of risk which delay the project,
- Effective risk management in the construction project,
- Initiatives to mitigate the environmental risk connected to the construction execution,
- Development of the risk register for construction project.

When applying the results and method of this thesis, the following ca be expected:

- Lower unplanned expenses and work,
- Higher accuracy of project plan deadlines,

- Increase of investment social economic benefits,
- Lower environment risks,
- Improved management of the risk in general.

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List of Abbreviations

CF	Cash Flow
CO_2	Carbon Emission
COSO	Committee of Sponsoring Organizations
DCF	Discounted Cash Flow
DPP	Discounted Payback Period
EBIT	Earnings Before Interest and Taxes
EBT	Earnings Before Taxes
ERM	Enterprise Risk management
EQ	Equity
EVA	Economic Value Added
GDP	Gross Domestic product
IRR	Internal Rate of Return
NCF	Net Cash Flow
NPV	Net Present Value
PBMOK	Project Management Body of Knowledge
PP	Payback Period
PMBOK	Project Management Body of Knowledge
ROE	Return on Equity
ROI	Return on Investment
SWOT	Strengths Weaknesses Opportunities Threats
TC	Total Costs
TR	Total Revenues
UNIDO	United Nations Industrial Development Organisation
UN	United Nations
WACC	Weighted Average Cost of Capital

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