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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

SHORTENED VERSION OF DOCTORAL THESIS

ZKRÁCENÁ VERZE DISERTAČNÍ PRÁCE

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

CONTENT

1 INTRODUCTION

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 construction investment 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.

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 also analyses 12 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.

2 THE AIM OF DISSERTATION WORK AND RESEARCH QUESTIONS

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.

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?*

3 STATE OF THE ART ANALYSIS

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).

According to PMBOK (2008) project management represents following fundamental 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, and time.

Process Triangle which is a balancing act of risk, quality and resources

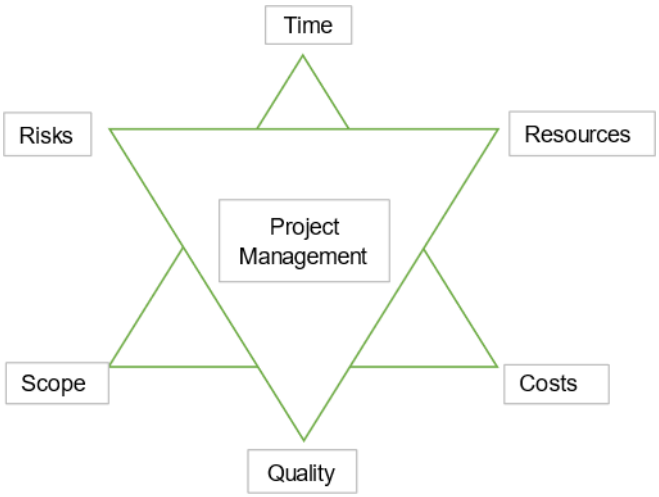

Figure 1 Project Management Star, edited by author (PMBOK, 2008)

3.1 Construction investment project

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.

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).

3.1.1 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

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.

3.1.2 Current approach to the 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 or 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.

Investing in a construction project involves various risks and changes in the cost of the project are one of them.

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

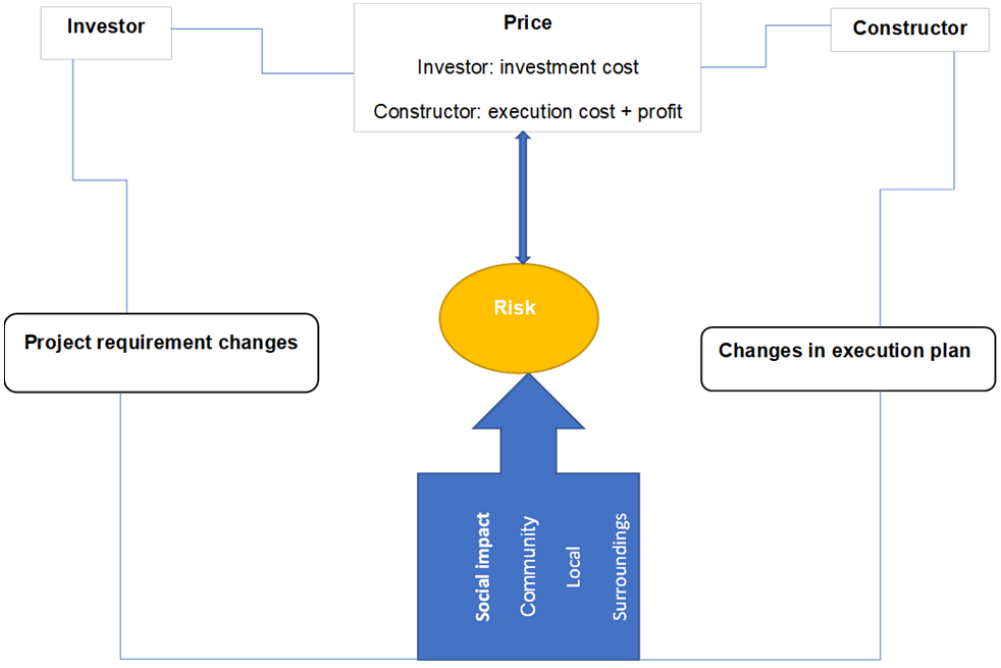

Figure 2 Relation implicating investor, constructor, local community, and price (Korytárová et al., 2013), (edited by author).

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.

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 and 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.
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.

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

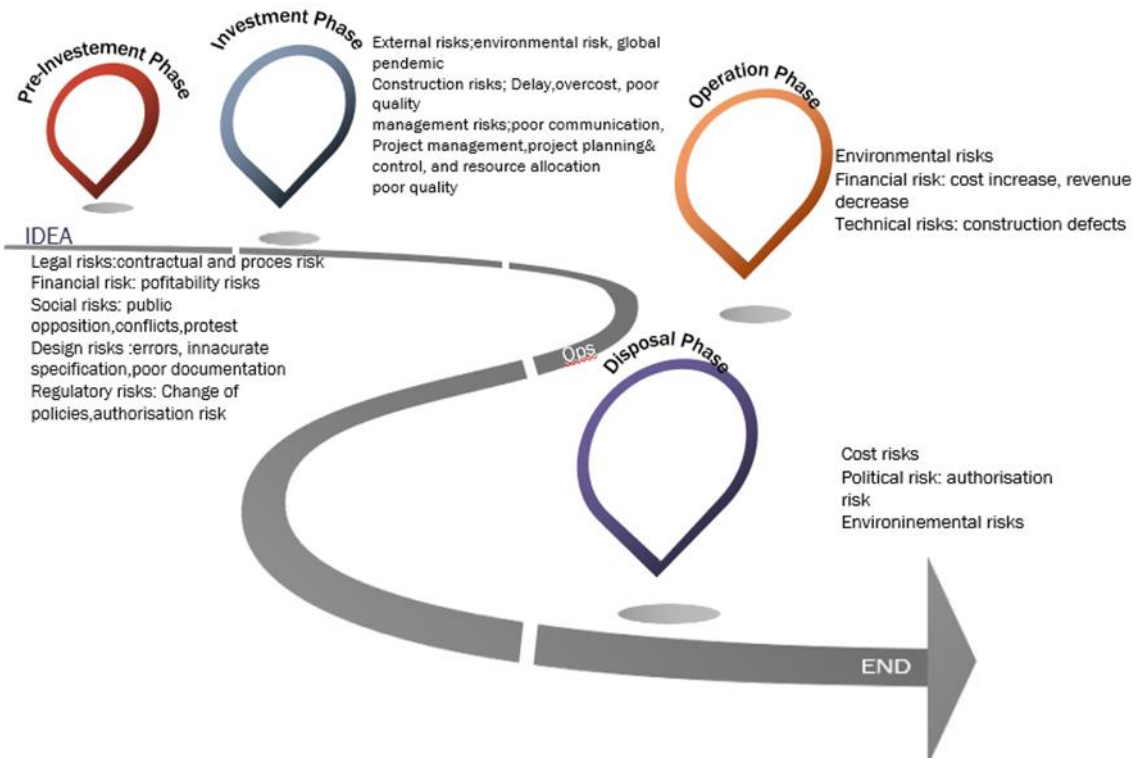

Figure 3 Investment risks in the construction project cycle (author's own work)

3.2 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.

3.2.1 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.

Inputs into the 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.

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 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.

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.

3.2.2 Qualitative risk analysis

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.

3.3 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.

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.

3.3.1 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.

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

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 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.

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 total cost of investment and total cashflow is the most used to calculate the 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.

3.3.2 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.

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.

Formula to calculate NPV is:

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

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.

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.

4 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 samples consist of:
  - The manufacturing and warehouse facility construction projects in Ždár nad Sázavou,
  - 12 manufacturing and warehouse projects in Central and Eastern Europe,
  - 12 initiative projects to eliminate the environmental risk in the manufacturing and warehouse projects from 3 continents (Europe, America, and Asia).
  - Global CEOs survey

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.

4.1 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 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.

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 m2, the new facility would have 3,239 m2 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 4 First draft of Žďár nad Sázavou layout

Evaluation of economic efficiency

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 3.11 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 saving is EUR 0.332

Total investment EUR 3.110 million.

$$PP = \frac{3.11}{0.332} = 9.4\ years\ of\ simple\ payback\ period.$$

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 total investment 3,100,000 * 30% of investor own capital = 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.

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

Net present value

The following figure below is used to measure the present value of expected cash inflows and outflows over time of the project. The internal rate of return is 4.8% for the desired payback period of 12 years.

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											

Figure 5 Net present value.

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

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.

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 2 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 3 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%.

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 4 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.

4.2 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.

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 5 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.

Industrial area	Advantages of the location
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 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 6 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 most 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.

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 7 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

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
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.

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

Environmental risk

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.

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.

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.

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.

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.

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.

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 lifetime 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 8 Economic efficiency calculation cost-saving initiatives

Location	**Projects**	**Reduced consumption**	**Unit of measure**	***tCO₂***	**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

Initiatives to reduce the environment risk should be selected according their social economic efficiency in order to focus on initiatives or project that have the biggest impact.

4.4 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 6 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.

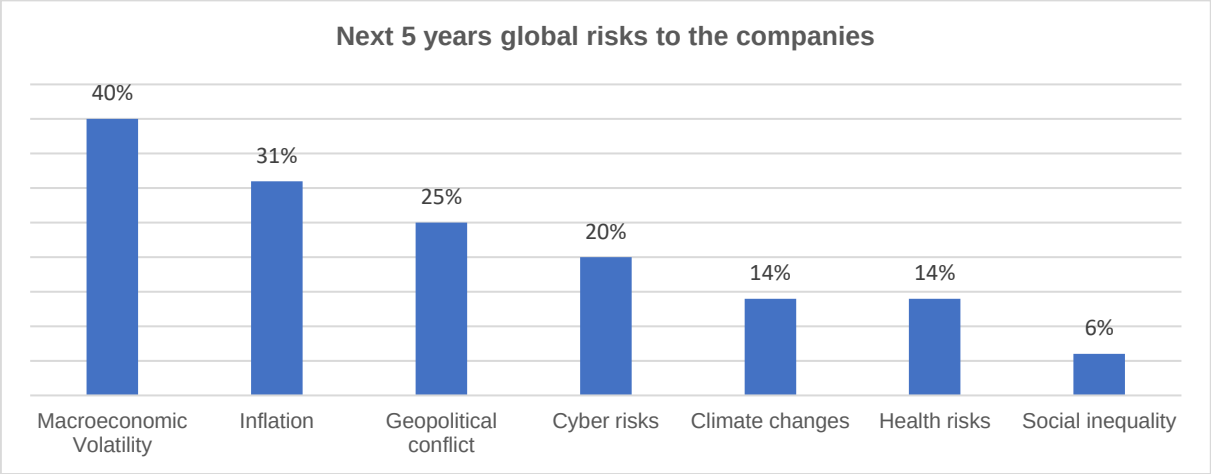

Figure 7 Next 5 years global risks to the companies

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.

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 9 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.

4.5 Results

4.5.1 Risk register

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 10 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.

5 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.

5.1 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.

5.2 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.

5.3 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.

REFERENCES

DELOITTE CZECH REPUBLIC, Outlook of the Czech economy for the year 2020 pp.2, 2020.

EUROSTAT / STATISTICS EXPLAINED / GLOSSARY: Carbon dioxide equivalent, accessed on 09th October 2022

FORBES CZECH, CEO survey, 2021.

FOTR, Jiri and SOUČEK, Ivan, Investiční rozhodování a řízení projektů.Grada Publishing, a.s., 2011.

HÁLEK, Václav. Krizový management, aplikace při řízení podniku. Hradec Králové: Gaudeamus, 2006. 317pp.

HNILICA, Jiří and FOTR, Jiří. Aplikovaná analýza rizika ve finančním managementu a investičním rozhodování. Grada publishing, 2009. 264 pp.

KALISA, Eric, Jana KORYTÁROVÁ. Environment Risk Management of Warehouse and Production Hall Investment Projects. In: Journal of Physics: Conference Series [online]. IOP Publishing, 2023, s. 1-8 [cit. 2023-08-07]. ISSN 1742-6588. Available at: doi:10.1088/1742-6596/2423/1/012012.

KALISA, Eric, Jana KORYTÁROVÁ. Industrial Zone Development by Warehouse and Production Hall Constructions. In: IOP Conference Series: Materials Science and Engineering [online]. IOP Publishing, 2021, s. 1-9 [cit. 2023-08-07]. ISSN 1757-899X. available at: doi:10.1088/1757-899X/1203/2/022023.

KORECKÝ, Michal, TRKOVSKÝ, Václav. Management rizik projektů se zaměřením na projekty v průmyslových podnicích. Grada Publishing, a.s., 2011. 584 S. ISBN 978-80-247-3221-3.

KORYTÁROVÁ, Jana. et al. Management rizik souvisejících s dodávkou stavebního díla, Akademické nakladatelství CERM, 2011, 147pp, ISBN 8072047256, 9788072047253.

MATĚJKA, Vladimir et al., Management projektů spojených s výstavbou. Praha: Informační centrum České komory autorizovaných inženýrů a techniků činných ve výstavbě. 2001. 212 S. ISBN 80-86364-56-9.

OUR WORLD IN DATA, CO2 emissions. Retrieved from https://ourworldindata.org/co2-emissions accessed on 09th October 2022

PMBOK, project management body of knowledge, Sixth Edition, 2017.

PWC, PwC's 26th Annual Global CEO Survey, 2022.

SMEJKAL, Václav., RAIS, Karel. Řízení rizik ve firmách a jiných organizacích. 2nd edition. Grada Publishing, 2006, 300 pp., ISBN 978-80-247-1667-4.

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KALISA, E.; KORYTÁROVÁ, J. Industrial Zone Development by Warehouse and Production Hall Constructions. IOP Conference Series: *Materials Science and Engineering*. Bristol, UK: IOP Publishing, 2021. s. 1-9. ISSN: 1757-899X.

KALISA, E. DOPAD STAVEBNÍ INVESTICE NA HOSPODAŘENÍ SPOLEČNOSTI. *Juniorstav 2019*. Brno: VUT v Brně, FAST, 2019. s. 569-574. ISBN: 978-80-86433-71-4.

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. 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.