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Application of decision tree analysis and expected monetary value technique in quantitative risk management:

Evaluation of less risky investment strategy.

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ABSTRACT :

The objective of this thesis is to produce information for decision making for a case company that is in the industry of truck spare parts and accessories. The company intends to expand its operations in the coming years. For the past couple of years, the company has been piloting a business where used truck brake calipers are collected from the customer, reconditioned, and sold to the market as good as new with full warranties. In this thesis investment strategies have been named Option 1 and Option 2. The first option has higher capital investment costs due to larger production facilities, more workforce and equipment as well as larger brake caliper stock. The circular economy is strongly present in this thesis because the brake caliper business is truly the heart of the circular economy. The growing world population, the strong growth of the middle class, and the increased consumption of natural resources are making climate change reality. This is driving companies towards net-zero emissions and sustainable development. Two different investment strategies were examined through decision tree analysis (DTA) and the expected monetary value (EMV) technique. These investment strategies were carefully planned and quantified. The investment strategy with higher or lowest negative EMV value was selected and evaluated by using financial analysis calculations. The financial analysis calculations were used to calculate the profitability of the selected investment and thus needed information was generated for the case company´s decision making. Risk management is an important area when considering new investments and this needs to be adapted in day-to-day operations.

KEYWORDS: Decision Tree Analysis, Expected Monetary Value, Risk Management, Brake Caliper, Circular Economy

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Abbreviations

AC	Actual Cost
AD	Actual Duration
AT	Actual Time
BAC	Budget At Completion
CE	Circular Economy
CFO	Chief Financial Officer
CO2	Carbon Dioxide
CPI	Cost Performance Index
DTA	Decision Tree Analysis
EAC	Estimated Duration at Completion
EMV	Expected Monetary Value
ES	Earned Schedule
EV	Earned Value
EVM	Earned Value Management
IRM	Institute of Risk Management
IRR	Internal Rate of Return
ISO	International Organization for Standardization
MCS	Monte Carlo Simulation
MT	Megaton
NPV	Net Present Value
PP	Payback Period
PDWR	Planned Duration of Work Remaining
PMBOK	Project Management Body of Knowledge
PV	Planned Value
ROI	Return On Investment
SME	Small and Medium Size Enterprise
SPI	Schedule Performance Index
SV	Schedule Variance
VAC	Variance at Completion

1 Introduction

Investment risk is the probability of monetary losses in certain investment. Higher the risk is then higher the uncertainty. When talking about risk in investments it is the expected or unexpected losses (The Economic Times, 2022). Thakur (2021) is complementing this statement as she writes in her article that investment risks describes the level of uncertainty of losing the invested money or part of it.

Verhoef (2005) elaborated in his article how investment risks can be quantified by using different tools and techniques which are meant for commercial risks evaluation. In his article net present value (NPV) was introduced and the purpose of it is to calculate net value of invested money. If the NPV value is positive the investment is worth of consider and should raise attention within decision makers.

Payback period (PP) was other useful tool which indicates the time of the investment to pay itself back. Internal rate of return (IRR) tells that the investment is worth of executing if the IRR isn't close to discount rate Vehoef´s (2005). Return on investment (ROI) was the fourth commonly used tool in Vehoef´s (2005) article and high ROI value describes the attractiveness of an investment. Higher the ROI value, more attractive the investment is.

Verhoef´s (2005) statements after 13 years are still valid as Lei, Shiyun, Yanfei & Yuan (2018) are complementing that NPV, PB and IRR are very usable techniques to evaluate investment risks. Xiong & Wang (2021) wrote in their article that the main purpose of economic evaluation in investment projects is to mitigate risks. They also raised the importance to use NPV and IRR before executing any investment projects.

These techniques which were raised in this chapter by different authors will be applied later this thesis when evaluating risks in investment strategy.

Competition in the domestic market is fierce in the business where the case company is operating. There are also foreign players in the domestic market, which further intensifies competition. For small and medium-sized businesses to succeed in the markets, they need to be agile, flexible, and courageous. The objective of the case company is to gain a strong foothold in the domestic market and the company has decided to invest its new circular economy business. Strategic investment decisions have great impact on the long-term financial and operational performance of a company. By choosing the correct and most suitable investment decision company can gain a competitive advantage in the market (Atik 2012).

According to capital investment theory, all the investments whose returns are higher than the invested cost should be attractive for all the decision-makers. If there are different investment strategies on the table, the one with the highest return should be chosen (Cooremans, 2011.)

The aim of this thesis is to provide information for a case company which has already taken the decision to invest in new business and expand their operations. Strategic investment decisions always involve risks, and these risks can be quantified by using a different types of risk evaluation techniques.

1.1 Research objectives and questions

Q1: *What are the available risk evaluating techniques related to new investment strategy in a circular economy business?*

Q2: *How risk evaluation techniques helped to reduce risk with the chosen investment strategy?*

Q3: *How financial analysis can be used to justify a new investment decision?*

For companies to succeed in competed domestic markets where there are also foreign players, these companies need to think about how they would gain a competitive advantage over other players. The case company conducted a piloting program of two years and found that with a domestic skilled workforce and a good business model, they have found a way to stand out from the competitors. Case company decided that it is time to expand their business to gain more market share and satisfied customers. The only dilemma was, how much it makes sense to invest in this new business which had a positive piloting phase. Two investments strategies of different sizes were decided and thus the first research question was formed:

DTA and EMV technique will guide to choose less risky investment strategy. Once more suitable strategy is chosen, financial analysis calculations will be performed. Several financial analysis techniques can be utilised to calculate the profitability and risk of an investment. Companies base their investment decisions on these financial analyses and the case company decided that it is important to perform financial analyses on their investment strategies as well.

1.2 Structure of study

Thesis is divided into six different main chapters and the idea is to start from the introduction and literature. Then logically proceed towards calculations and the end conclusion. The exact structure is as following:

Chapter 1 contains the introduction of the subject of this thesis with the objectives and research questions. Case company is presented and the product which is in the centre of the new business is introduces. Structure of the study explains how the thesis is structured.

Chapter 2 has the theoretical part where circular economy, and the emission related issues are written. Then comes theoretical part of the risk management and ISO 31000

standard is important part of it. After these, it is time to write about business risk as this is the type of risk that the case company is willing to take with their new investment strategy. Lastly six different risk evaluation techniques are introduced.

Chapter 3 has the methodology of the thesis explained and the structure of the data which is used in the calculations. The final part of chapter 3 is financial analysis. It has four different calculations to analyse investment decision.

In chapter 4 all the calculations are made, and results are visible. In other words, chapter 4 has all the numbers to evaluate if the selected investment strategy is worth of execute.

Chapter 5 is for discussion and in this chapter the results are known already, and it is time to speculate.

Chapter 6 is the chapter for conclusions. In this chapter all the facts are expressed, and the outcome of this thesis is explained. In this chapter also all the answers presented for research questions.

2 Theoretical framework

2.1 Risk management

Risk management principles guides managers and organizations to manage risks and uncertainties in business environment on a daily basis. Risk management raises the understanding and awareness of possible future scenarios and makes decision making more rational. It aims to control the magnitude of risk and the possibility for certain risk to occur as well as the awareness of aftermath when risk occurs (Anderson 2014, 2-3).

Risk management evaluates and selects most suitable outcomes i.e. less risky options through cause and consequence events. Cause and consequence provide information related the costs of risks and demonstrates the pathway of why the risk is present (Anderson 2014, 2-3). ISO31000 standard describes risk as the effect of uncertainty on objectives and the intention of ISO3100 is to establish a globally recognised risk definition for all types of organizations (Hardy & Allen, 2014).

Anderson (2014, 2-4) is elaborating that risk management is a proactive mindset where planning has extremely important task. Organizations needs to be prepared in advance so when the risk occurs there is already a plan how to mitigate the consequences of the risk. It is not an easy task to be prepared for risks to occur as Fertis, Baes & Luthi (2012) are writing that, risks are dynamic and changes their form during time and different environment.

Risk management is the overall process which helps to understand the risk, mitigate the risk, and share the risk. Understanding the risk means the knowledge of what are the reasons why risk occurred and what are the consequences of the risk. Risk mitigation is the action how to reduce or eliminate the risk and the impact of it. (Anderson 2014, 2-4). Risk management is something that provides understanding how to measure risks as Eyvindson & Kangas (2018) are pointing out in their article that different type of risks are measurables and therefore company can be prepared for different type of outcomes.

Anderson (2014, 5) is raising an interesting point as he is writing that risk is not necessarily a bad thing. Normally risk management tends to investigate the negative impact of certain possibilities but it can also help to find positive outcomes by using the same approach. It will support organizations to understand what are the causal chains that leads to positive results. By understanding this, organizations can but more their resources to maximize these outcomes. Second interesting point was that even though the risk level or certain decision is high it still might be the correct decision. Managers in organizations tends to have good risk awareness and they are capable controlling high risks.

If organizations want to have effective risk management, they need to include risk management into decision making and it cannot be treated as separate function. Risk needs to be seen as an important factor and organizations needs to but their resources on managing and recognises risks. Risk is uncertainty which needs to be controller and understood (Hardy & Runnels, 2014).

The effective risk management creates value to organizations when it is implemented on decision making as it explicitly addresses uncertainty. Risk management should be systematic, structured, and timely integral part of organizational processes. Risk management isn´t a statistic and one size fit for all type of thing. It needs to be tailor for every organization as it is heavily linked on human and organization cultural factors. Risk management aims for continuous improvement, and it should be transparent. Risk management plans and actions are based on the best possible information, and it can be modified based on the nature of information (Olechowski, Oehmen, Seering & Ben-Daya, 2016).

Olechowski et al. (2016) have studied risk management capabilities in project managers daily work, and they noticed that project managers have very limited knowledge about risk management. A decent set of standard risk management methods would support

project managers in their work and not just make them more professionals but also to help organizations to be more efficient.

Olechowski et al. (2016) suggested in their article that project managers should have a set of principles rather than a set of perspective methods. They suggested risk management principles to be based on ISO:31000 risk management standard. According to their article this is the only published globally recognised standard which goal is to have high quality guidance on creation, evaluation, selection, and implementation of correct risk management practices. In case company there isn´t any project manager as such but based on the theory, risk management methods on a manager level needs to be explicit and risk awareness needs to be present.

2.2 ISO 31000:2018

International Organization of Standardization (ISO) is a global federation for national standards. ISO standards are approved in ISO technical committee and used worldwide as well known and applied standards. ISO 31000 is created for any type of company or organization and the purpose of it is to provide guidance and structure for risk management processes within organizations and therefore it provides help to mitigate and manage risks. ISO 31000 guides organizations to create risk management framework and how to improve risk mitigation actions. The implementation of ISO 31000 requires awareness and collaboration of internal stakeholders within the organization. Risk management is based on principles, framework and process built in ISO 31000 which are described in Figure 1. It is essential to understand that ISO 31000 itself doesn´t take all the risks away but it helps organizations to understand and control the existing and upcoming risks (PECB, 2018).

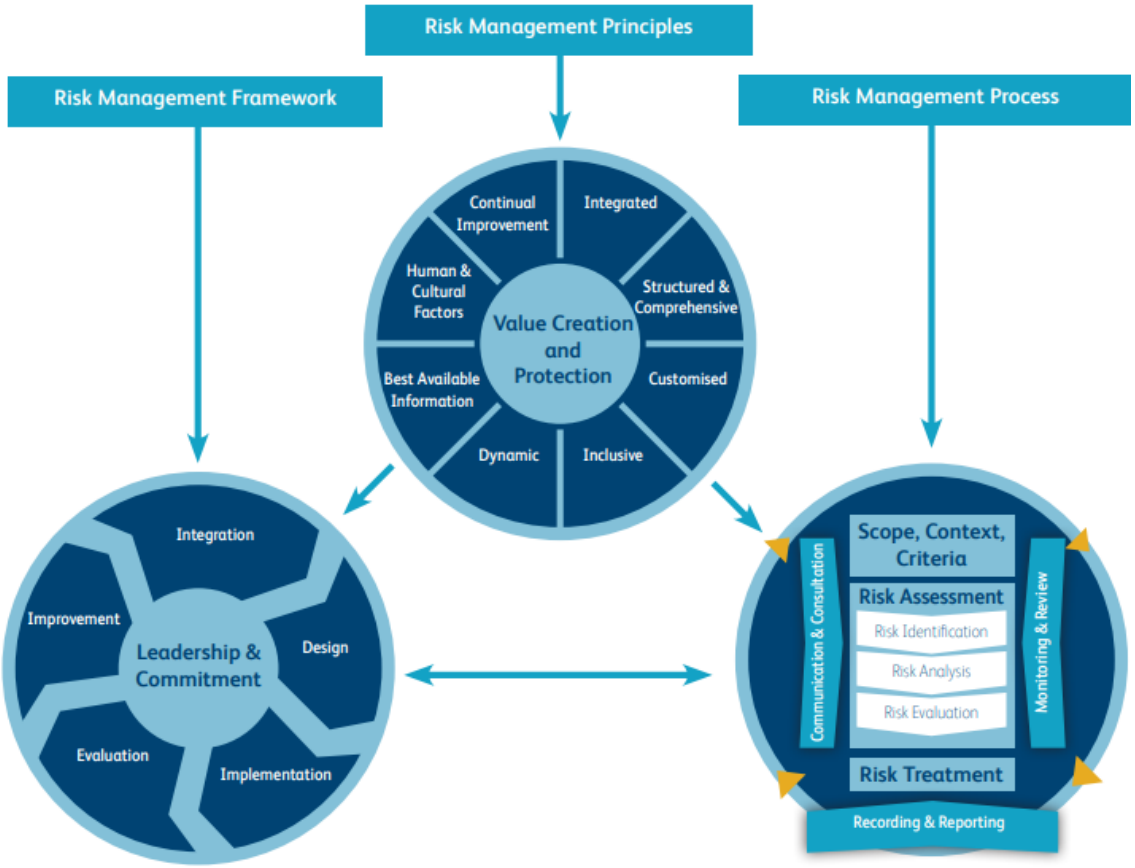

Figure 1 Principles, framework, and risk management process in ISO 31000:2018 (Institute of Risk Management, 2018).

2.2.1 ISO 31000 – framework

The basic idea of the ISO 31000 - framework is to support organizations and companies to implement risk management strategy. Organizations and companies can evaluate their risk management activities, strategies and create necessary improvements based on the framework components. The ISO31000 framework can be customized, and its components should be tailor made for each case organization (ISO, 2018).

The active participation on the implementation is heavily linked on top management commitment. Figure 1 demonstrates the components of the risk management framework, and it clearly states that leadership is in the centre of it. Top management should make sure that the risk management is integrated within the whole organization, and

everyone should be committed to it. Top management needs assign needed resources, responsibilities, objectives, strategies, and take care of the needed communication when creating risk management strategy. Management´s responsibility is containing, monitoring, and securing that risk management framework stays on the correct level once it is implemented (ISO, 2018).

ISO (2018) is stating that integration is an important component of the framework, and it expresses that risk management within a company requires understanding of the organization's structures and context. Everyone in the organizations has the right and the responsibility to rake part on the risk management. Integrating risk management is a dynamic road and it should be customized per case company and risk management should be part of the everyday work.

Design component refers to the aspect that when designing the framework for risk management organization needs to know its internal and external structures. External structures are social, cultural, political, legal, technological, and economical drivers. Internal structures refer mission, vision, values, strategy, objectives, and internal stakeholder relationships which needs to be well clarified (ISO, 2018).

Implementation guides how organizations should implement risk management framework and it describes the need to have clear implementation plan with relevant resources. Implementation shows how, when, and where decisions are made within the organizations and who is accountable of these decisions. If there is a need to modify decisions making process, implementation component guides with that process. Implementation of the framework provides clarity in decision making and takes stakeholders into account as stakeholders, especially internal ones need to be involved in the implementation of risk management framework (ISO, 2018).

Risk management framework needs to be evaluated and organization needs to monitor and measure the performance of risk management framework. The risk management

framework needs to be specifically evaluated against earlier set purpose and see if the risk management framework still meets the target (ISO, 2018).

Risk management framework should be present in daily basis as framework over time leads to improvements. Especially when there are gaps in risk management the improvement component of the framework helps to create plans and tasks to fill the gaps which automatically leads to improved risk management (ISO, 2018).

2.2.2 ISO 31000 – principles

Principles describes what is needed to achieve integration in organizations for healthy risk management. Framework guides how to achieve required integration. The aim of the principles in ISO 31000 are to support and guide risk management by communicating the purpose and creating value. There are eight different principles as Figure 2 shows. The principles work as foundation in risk management framework and processes by helping to manage uncertainties (Institute of Risk Management, 2018).

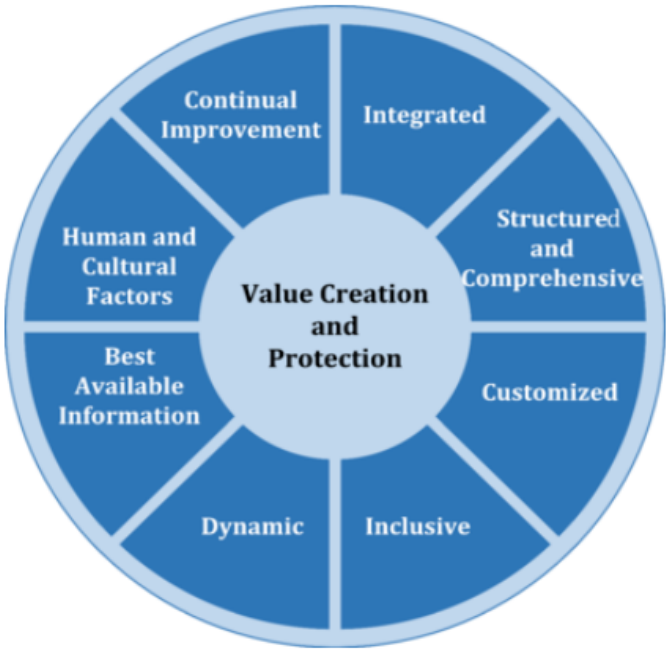

Figure 2. Principles (ISO, 2018).

In the centre of principles is value creation and protection. According to ISO 31000 these are the main purpose of risk management. The first piece of the circle is integration which means that to have efficient risk management it should be integral part of the overall organization. Structured and comprehensive way of work in risk management creates wanted results and results can be comparable. Risk management framework and processes are always customized to be suitable for the case organizations internal and external objectives. By inclusive it is meant that stakeholders' timely views, opinions and advice are needed so the risk management would gain wanted results and correct performance. Organizations are facing risks which are dynamic as risks changes form when the organizations external or internal context changes. Risk management activities and decision are based on the best available information which contains historical data, current analysis, and future predictions. The quality of information is vital as it should be timely, relevant, and realistic. Human and cultural factors are influencing on risk management as there can be significantly variable on many levels. Risk management is not a static state which keeps same form all the time, as a matter-of-fact risk management needs to continuously be improved through learning and experiences (ISO, 2018).

2.2.3 ISO 31000 - process

In risk management the process component should be integrated part of the overall decision making and management. Process can be utilized in operational, programme, strategic and project levels. Below in Figure 3 are presented the process component and all the elements belonging to it (ISO, 2018).

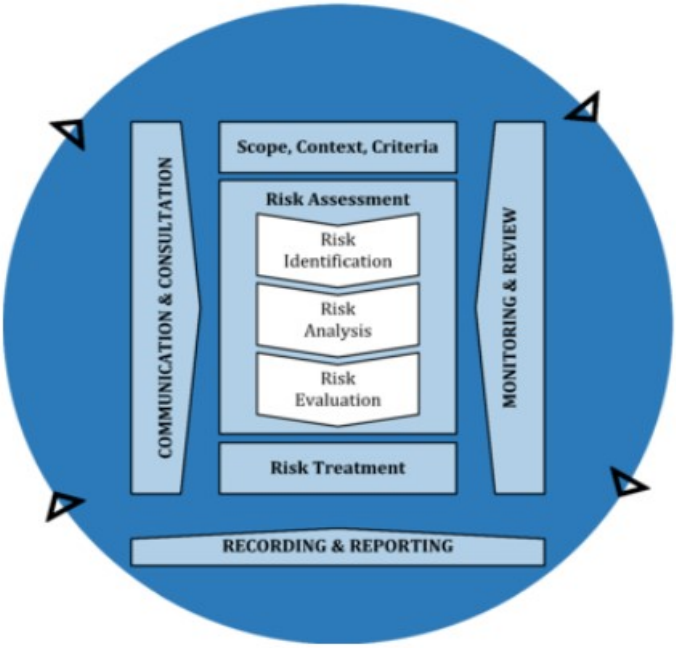

Figure 3. Process (ISO,2018).

The aim of communication and consultation is to help stakeholders to understand and control risks. This element supports to take necessary actions to mitigate the risks. Communication leans more on the understanding side and consultation refers more on the decision making where information and feedback are collected to support decision making. The goal of communication and consultation is to gather needed expertise in risk management process, help to understand risk criteria, evaluation of different risks, provide correct information for decision making, and create awareness within the areas where risks are constant (ISO,2018).

ISO (2018) is clarifying that scope, context, and criteria element's purpose is to provide guidance for customizing the process, and to enable efficient risk treatment. The aim is also to understand the scope with external as well as internal contexts of the risk management process. Defining scope in risk management process is important as scopes can be very broad and messy if not clearly defined. The process scope can be on a strategic, operational, programme, or project level so the predefined scope helps to understand and control risk management. Context of risk management process can be established once the external and internal environment is understood. Understanding the context is

essential because risk management belongs in the context of objectives and activities within organization. Organization should clarify beforehand the type of risks they want to take, and evaluation criteria related risks needs to be clearly stated. Risk criteria should go hand in hand with risk framework and it can be customized for its purpose. Risk criteria would need also to take into consideration the opinions of organizations stakeholder and keep in mind that risk evaluation criteria have a dynamic form, so it needs monitoring.

ISO (2018) is clarifying that risk assessment means the overall picture of identification of risks through analysis and evaluation. Systematic risk assessment with stakeholders' perceptions, views and comments based on best available information is required. Risk identification contains all the actions and work to be done to identify and recognize possible risks and their impact on tangible or intangible outcomes. Risk analysis is a process where the risks are examined and understood more specifically. It is a detailed process where the risk like hood, occurrence, risk level, and consequences are examined. The available information determines the depth of risk assessment. Methods in risk assessment can be categorized to quantitative, qualitative or a hybrid of these two depending on the environment and the application of use. Risk assessment provides the help to evaluate risks and understand them better. The outcome of risk assessment provides data for decision making. Risk evaluation involves risk analysis and the analytical mind set of evaluation risk analysis results. Once the results are known those should be recorder, communicated and validated within the organization. The core of risk evaluation is to determine what type of actions are needed to do in an environment where identified risk is present. Actions could be as following:

- Stop ongoing work.
- Evaluate the possibility of risk treatment.
- Investigate the identified risk more and to increase understanding.
- Continue with current way of work.
- Re-evaluate the goals and objectives.

Risk treatment purpose is to find and conduct suitable risk treatment option for identified risks. It is continuous process of choosing most suitable risk treatment option, planning and implementation of it, evaluate the efficient of it, determine if existing risk is acceptable and if not, take the necessary actions to get rid of it. The selection of most suitable risk treatment option includes the examination of costs, efforts, and disadvantages. The most suitable risk treatment options should be in line with organizations objectives, risk criteria and available resources. It is important to propose selected risk treatment option to organizations stake holders and listen their feedback if selected option is suitable of everyone. Monitoring and reviewing risk treatment are a big part of this process as risk treatment may also lead to unwanted results and the ongoing activities needs to be reorganised. There needs to be a plan for risk treatment which contains plan how to inform about the upcoming risk treatment, plan how to monitor ongoing activities (ISO,2018).

Monitoring and review raise the quality of risk management process. It is important to periodically to conduct monitor and review actions, so the risk management process performs on a wanted level. Monitoring and review are meant for all the stages in risk management process and information gathering, planning, and analysing is a vital part of it (ISO, 2018).

The results and outcomes of risks management process are advised to be recorder and reported and then communicated within organization. Reported and recorded data provides support for decision making and therefore improves risk management activities. Reporting should raise the quality of discussion between top management and organization´s stakeholders (ISO,2018)

2.3 Business risk

The meaning of business risk is hard to generalized as the business risk is dependent on the features of organization´s activities but is sure that business risk is constant in daily business (Wolke, 2017). Business risk management is essential part of company´s

strategical actions and it should be implemented in every company. Business risk management helps to gain advantage against competitors and makes company's business more profitable (Kaleininkaite & Trumpaite, 2007).

Dvorsky, Belas, Gavurova & Brabenec (2020) examined in their research the attitudes of entrepreneurs towards company's business risks. Strategic, financial, and operational risks were raised and according to entrepreneurs these are the main business risk types why companies' failure. Especially financial risk was seen important when talking about SME (small and medium-sized enterprises) normally financed by the owners of themselves. This type of financial arrangement might lead to higher operational costs which may cause possible debt payment problems.

Cera, Belas & Strnad (2019) also supplemented the financial risk aspect stating that access to good finance is important and companies, especially SME, tends to be dependent on external loan as external loan is seen more stable compared to the self-financed business. Cera et al. (2019) also explored the attitudes of entrepreneurs towards business risks and in their research, they found that political environment, competitive environment, business relationships and entrepreneur's own attitudes are linked directly to business risks. Political environment can cause more bureaucracy and lead to inefficient performance. Competitive environment may cause business risks as customers are demanding higher quality products with lower costs and companies should meet these demands to keep their market share. Business relationships means the connections with suppliers, competitors, customers and employees and it is essential to have good connections with these parties or otherwise business environment becomes very difficult. Entrepreneurs own attitude considers the poor management and leadership risk which may lead to business failure.

Wolke (2017) has demonstrated what type of business risks there are present in daily business activities. These risks are visually explained in Figure 4. Existing risks can be categorised with certain limitations to two different risk categories: financial risks and

performance risks. These two main risk categories have sub-categories. Financial risk contains market price risk, default risk and liquidity risk. Market price risks refers to the risk of high interest rates of loans. Currency risk is threat when company´s business is on the import/export business where currency fluctuations may cause losses. Share risk refers to stock risk where company has purchased stocks. Real estate pricing risk contains the risk of impairment of real estate. Default risks is the risk when agreed loan payment terms aren´t met and this might cause liquidity problems. Performance risk is in involved in the business where goods and services are created. Performance risks are divided to operational risk and sales- /procurement risks. Operational risk includes risk of failure on person, processes, or system operation. Sales risk occurs when planned sales objectives and goals are not achieved. Procurement risks arise when losses are made due to high cost of raw materials supplies or operating materials.

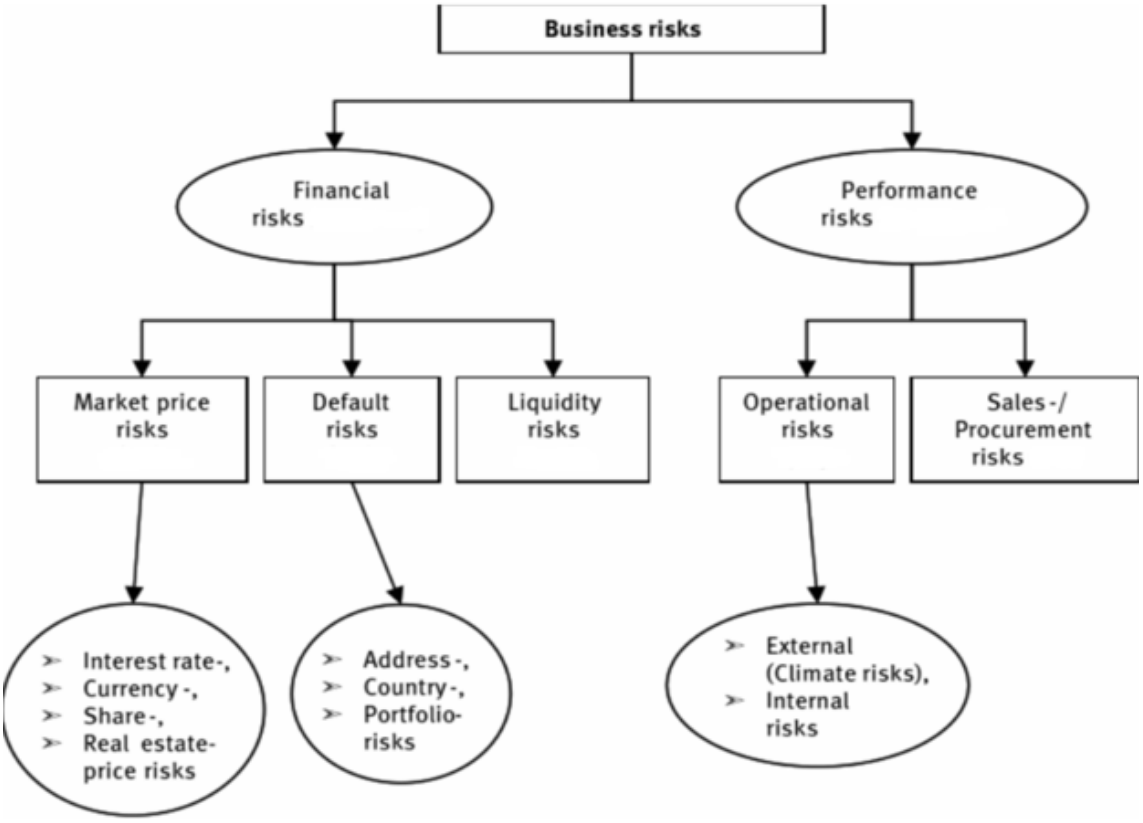

Figure 4. Different business risks (Wolke, 2017).

The most important point to have successful business risk management according to Dvorsky et al. (2020) is the availability and utilization of information. Good quality information supports in decision making and in risk evaluation as well as in risk management. Business risks which may lead to company's termination can be divided to internal and external contest. Internal is linked to poor leadership and false management. External has technological change, deregulation, and competition. Both internal and external business risk can be controlled better with good information utilization.

2.4 Risk evaluation techniques

Strategical capital investment always contains risks and uncertainties. Managers needs to have support for their capital investment decisions making, and different risk evaluating techniques can support with these decision. Strategical capital investment refers to substantial investments which contains high risk, produce hard to quantify outcomes, and have long impact on company´s overall performance. Investment could be a new production line, new manufacturing processes or a substantial shift in production lines (Alkaraan & Northcott, 2005). The aim of a capital investment is to increase organizations economical resources and financial values. Investment is unlikely to be successful without a proper investment strategy and evaluation plan. Investments always contains risks and therefore risk recognition and identification are mandatory (Cooremans, 2011).

In all real-life business environments, there is always a possibility that a risk of a certain investment will be realized. However, risks can be estimated and calculated. There are analyses and techniques that can be used to minimize the magnitude of risks. Risk analyses is built from the use of these techniques and the main purpose of risk analysis is to create data, analysed it and provide results and information for decision making (Tamošiūnienė, 2006).

Predicting future is always a hard thing to do but still managers and decision makers need to do these forecasts based on their best estimation. Several techniques have been created to help managers in their decision making and to mitigate possible risks

(Flostrand, 2017). Six different techniques are evaluated and examined in this thesis. Below Table 1 to demonstrate these techniques more detailed description in subchapters.

	Technique	**References**
1	Monte Carlo Simulation (MCS)	Tamošiūnienė & Petravicius (2006), IBM (2020), Lourens & Van Geer (2016), Lin, Shen, Zhou & Xu (2020)
2	Earned Value Management (EVM)	Willems & Vanhoucke (2015), Vandevoorde & Vanhoucke (2006), Anbari (2003)
3	Ishikawa diagram	Dinamika (2016), Ecobici (2017)
4	Delphi technique	Flostrand (2017), Hasson, Keeney & McKenna (2000),
5	Decision Tree Analysis (DTA)	Prasanta (2012), Dash (2017),Yang & Zhou (2020),
6	Expected Monetary Value (EMV)	PMBOK (2017), Dash (2017), Usmani (2021),

Table 1. Risk evaluation techniques.

2.4.1 Monte Carlo Simulation (MCS)

Tamošiūnienė & Petravicius (2006) used Monte Carlo Simulation when they analysed investment risks. According to them they see MCS as a probabilistic risk analysis technique in which the effects of key variables are presented from a risk perspective. It is a a methematical simulation where several calculations exercises are conducted. In the simulation, successive scenarios are constructed based on input values of project uncertainties. Simulation is handled in a way that the random selection of values in certain probability distributions doesn´t break the correlations of existing project variables. The results from the simulations are collected and analysed statistically.

IBM (2020) is complementing Tamošiūnienė´s & Petravicius´ (2006) findings. IBM is writing that MCS is a probability technique which calculates certain outcomes based on algorithms and these calculated results provides valuable information for decision making on future investments. MCS uses probability distribution on uncertainty and simulates results by utilising random variables in a range of maximum and minimum values. MCS repeats these simulations thousands, or tens of thousands of times and the results will show possible outcomes.

Lourens & Van Geer (2016) are pointing out that it could be a disadvantage when tremendous amounts of calculations are needed to have reliable outcomes. On a positive side Lin, Shen, Zhou & Xu (2020) are raising that MCS is a good and popular tool used in probability analyses with engineering systems. The ability of simulating complex systems by using mathematical equations and avoiding human errors due to repeated simulations are making the MCS trustable risk evaluation technique.

2.4.2 EVM (Earned Value Management) metrics.

Earned Value Management is a technique which monitors and measures project budget and time during the execution (Willems & Vanhoucke, 2015). EVM calculations shows if some troubles are ahead in terms of exceeding budget or late completion of a project. Vandevoorde & Vanhoucke (2006) have the same findings in their article as they are writing that EVM is a technique that gives an early warning if some corrective actions need to be done during project execution as EVM provides the information related scope, time, and cost management. Important character of EMV is to predict total project duration and comparing it to the estimated duration. Some clear and simple calculation formulas are included in EVM which provides valuable cost and schedule related information. Project progress schedule variance (SV) measures volume of done work versus planned work and. SV describes the difference of earned value (EV) and the planned value (PV).

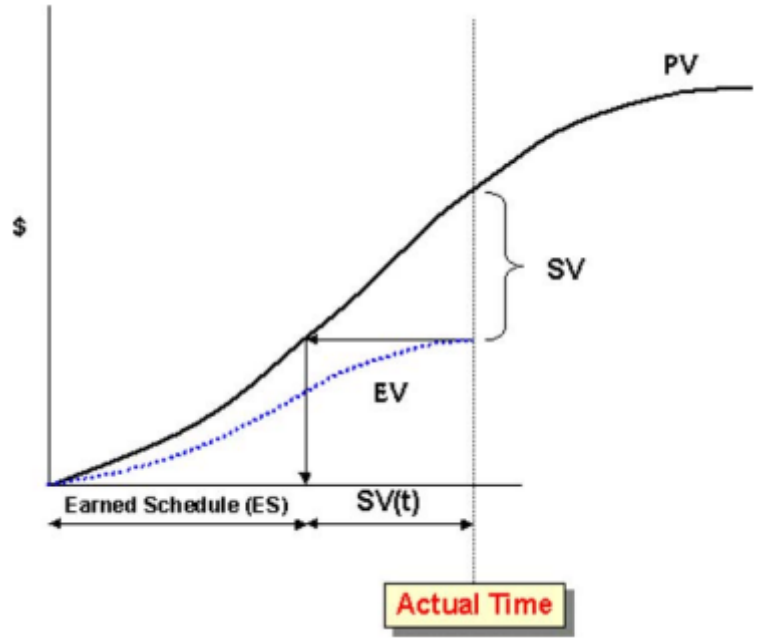

Figure 5. Schedule variance (Vandevoorde & Vanhoucke, 2006).

$$SV = EV - PV \quad (1)$$

If SV is greater than 0 it means that work has been conducted more than planned e.g. work is ahead of planned schedule and if SV is smaller than 0 project is behind of schedule (Vandevoorde & Vanhoucke, 2006).

Schedule performance index (SPI) describes the ratio of earned value (EA) versus planned value (PV) and it indicates the efficiency of work. If the SPI is <1 the efficiency of work isn´t at the same level as what has been planned. At the end of the finished project the SPI is always 1 (Vandevoorde & Vanhoucke, 2006)

$$SPI = \frac{EV}{PV} \quad (2)$$

Lipke (2006) corrected the time and effective aspects and introduced Earned Schedule (ES) which takes into consideration the exact time and correct effectiveness of a work.

ES describes at what time frame PV and EV occurs. Vandevoorde & Vanhoucke (2006) are introducing in Figure 5 schedule variance (SV) which measures project progress.

It has been criticised that SV and SPI aren´t accurate indicators as SV is measured against monetary value and not time value. Secondly SV=0 might mean that project has been executed properly or that project is under work according to plan. SPI doesn´t consider the correct effectiveness of work as always at the end of project it indicates 100% even if the project was completed late. Due to these reasons SV(t) and SPI(t) were formed. The abbreviations are same as before but (t) describes the time element. The purpose of formulas 3 & 4 is to describe the actual time (AT) to the earned schedule (ES) i.e. comparison between real project performance against real time expected time performance (Vandevoorde & Vanhoucke 2006).

$$SV(t) = ES - AT \quad (3)$$

$$SPI(t) = \frac{ES}{AT} \quad \text{(AT refers for actual time)} \quad (4)$$

Vandevoorde & Vanhoucke (2006) are stating that the projects total duration forecasting is in the heart of EVM and it can be calculated in estimated duration at completion (EAC) by summing up project actual duration (AD) and planned duration of work remaining (PDWR):

$$EAC(t) = AD + PDWR \quad (5)$$

Other key components in EVM are budget at completion (BAC) and actual cost (AC). Anbari (2003) has created visually understandable chart of the BAC and AC where performance index calculations are showing the budgeted values compared to the actual values in project. Cost performance index (CPI) describes the actual cost of work performed and the formula is simply the estimated value (EV) divided with the value of actual cost (AC).

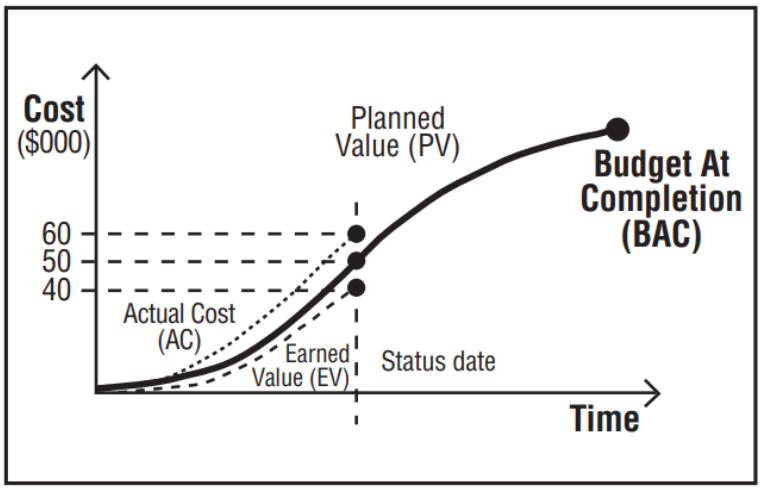

Figure 6. Planned Value, actual Cost and earned Value.

$$CPI = \frac{EV}{AC} \quad (6)$$

The cost overruns or underruns at the completion of project is critical information and it can be calculated when budget at completion (BAC) and estimated duration at completion are known (EAC). Variance of completion (VAC) indicates the cost over- or underruns. If the result is negative, it means that there will be cost overrun. Zero refers that the project will be executed within the budget and positive value will mean that there will be cost underrun (Anbari, 2003).

$$VAC = BAC - EAC \quad (7)$$

EVM calculations requires fixed ending date of a project and accurate budget. The beaty of EMV technique relies on the detailed information about the project status and it indicates if there will be some time or cost risks ahead. EVM results supports be calculated in real time and corrective actions can be conducted before the risks materialize.

2.4.3 Ishikawa diagram

Ishikawa diagram, cause and effect diagram or fishbone diagram presented in Figure 7. These are the names for this tool which has a shape of a fishbone. It is a good tool to find root causes and the underlying problems in quality. The fishbone, where the head is the cause and body shape of a fish bone indicates the cause of known problems. Root cause is the deepest and first cause of a problem which effects on the outcome. The idea is to go several layers down to the point where the first cause i.e., root cause is clarified. Ishikawa diagram concentrates on raising a problem or groups of problems and the cause of these problems. The idea is to clarify the major causes and investigate those though sub causes where details are clearly pointed out. Fishbone is both a tool and a technique that chops the problems to smaller more understandable pieces (Dinamika, 2016)

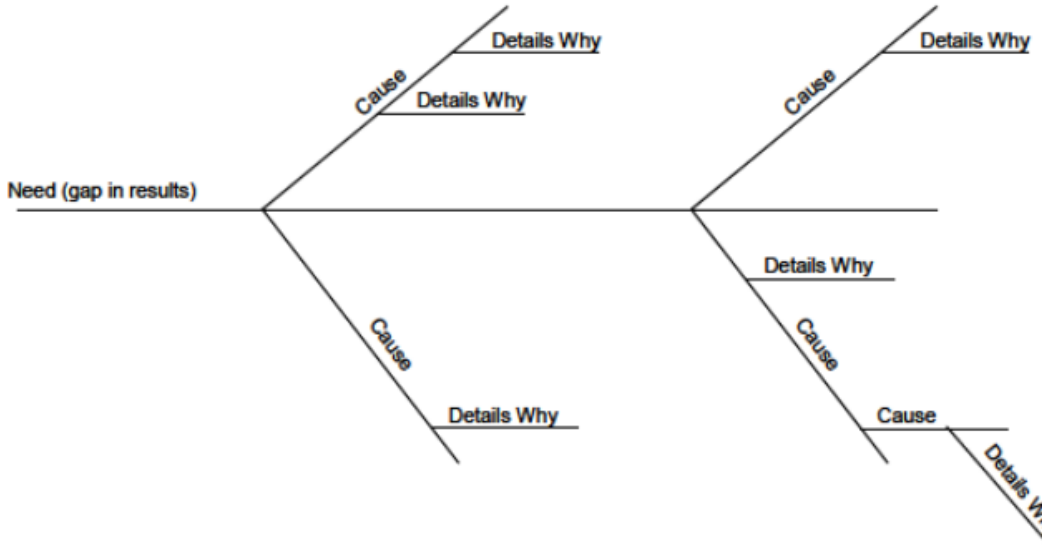

Figure 7. Ishikawa diagram (Dinamika, 2016).

Fishbone diagram can be implemented in any type of activity which helps to understand ideas, point of views and conclusions when dealing with problems. It helps decision makers to understand the causes of certain activities and events of any type. Causes are normally grouped in different categories which typically includes people, methods,

machines, materials, measurements, and environment. Fishbone diagram is normally used in product design and quality defect prevention by identifying causes in product manufacturing (Ecobici, 2017).

2.4.4 Delphi technique

Forecasting and predicting future is a common task within managers and executives. This is not the easiest task, but it is something which is part of the daily work life. A typical way is to gather historical data and by analysing these decisions can be made based on certain assumptions. Not always historical data is available or when the business environment is extremely dynamic managers need to rely on different type of approach. One of the approaches is called Delphi technique where the opinions of experts are gathered and transferred into group consensus (Flostrand, 2017).

Delphi technique gathers a certain group of experts around a common subject. This group of experts are asked to give their best opinion about uncertain possible future happenings in form of structured questionnaires and these experts doesn´t need to be physically present. These questionnaires are filled as anonymous by these experts. Experts should evaluate the possibility of occurrence and the potential impact. All the opinions and response are pooled and analysed. Then these responses are summarized and sent back to experts. In second round, experts are asked to reassess their judgements groupwise. After second round there will be a third round based on the same principles if necessary (Flostrand, 2017). The questionnaire can be qualitative or quantitative but if the questionnaire is qualitative, the second-round questionnaire will be quantitative as this helps to transfer the answers on group consensus. The process can contain multiply rounds and not limited to two. The summarized responses are communicated back to experts and this process is repeated until consensus is reached (Hasson, Keeney & McKenna, 2000).

The process of Delphi starts from clearly presented research problem and continue to topic and method justification. It is important that the experts are certainly experts in

the field where Delphi is utilized. The data used in Delphi needs to be good quality data and relevant for the subject. Response rounds are conducted and there isn´t any agreed number of rounds as those needs to conduct to the point when consensus is reached. Then it is time for the conclusions and decisions how to proceed. Hasson et al. (2000) have stated the Delphi process in Table 2.

Research problem:	Clearly defined
Research rationale:	Topic and method justification
Literature review:	Topic understudy
Methodology:	Data collection: clear explanation of the Delphi method employed
	Rounds: number employed, outline of each
	Sample: experts selection process and characteristics described in detail
	Reliability and validity issues identified
	Statistical interpretation: guidelines for the reader
	Ethical responsibilities: towards 'expert' sample and research community
Data Analysis:	Response rate for each round
	Round 1: presentation of total number of issues generated
	Round 2: presentation of results indicating the strength of support
	Further rounds (if applicable): presentation of results
Discussion :	Issue of consensus
and conclusions	Interpretations of consensus gained/not gained
	Direction of further research leading from conclusions
Appendices:	Copy of each round questionnaire illustrated.

Table 2. Delphi process (Hasson, Keeney & McKenna, 2000).

Ideally the number of experts should be 10-18 persons and these experts can´t be competitors. It is recommended that experts could at reserve least 3-5 days for the Delphi technique (Flostrand, 2017).

2.4.5 Decision tree analysis (DTA)

DTA is a visual model of a shape of a tree, hence the name, with branches to demonstrate possible action outcomes. Figure 8 demonstrates how DTA logically forms the risk structure and demonstrate the less risky alternatives. It provides a clear understanding of

quantitative risk management perception. DTA utilise the calculation formulas of Expected Monetary Value (EMV) to find out the best possible alternatives (Prasanta 2012).

DTA starts from black square which represent uncertain future event from where different option lines are starting. Black circles are different chance nodes where branches are going and the end of a branch is triangle which demonstrate the end-state of a decision, Table 3 shows the symbols. When analysing decision tree, the analyse starts from left and moves to right, starting from decision node. Probability values are stated between the nodes. (Dash, 2017).

Notation	Shape	Meaning
■	Filled-up square	Decision node
●	Filled-up circle	Chance (condition) nod
◀	Reverse triangle	End of branch

Table 3. Decision Tree Analysis symbols (Dash, 2017).

Decision node contains a cost of the decision alternative. In chance node input is the probability of certain event and output is the net path value which will be used in EMV calculation, and it is basically the payoff of the invested cost (Dash, 2017). Once all the values of the branches are calculated it is time to move on to EMV calculations for each decision node. The formula on EMV calculations as such isn´t complex but all the hard work relates to finding the correct data:

$$EMV = P \times I \quad (8)$$

The probability of certain risk is P and I describe the impact of it. Probability is a certain percentage and impact has a negative or positive value. In chapter *4 Results and analysis* EMV calculations are conducted based on DTA.

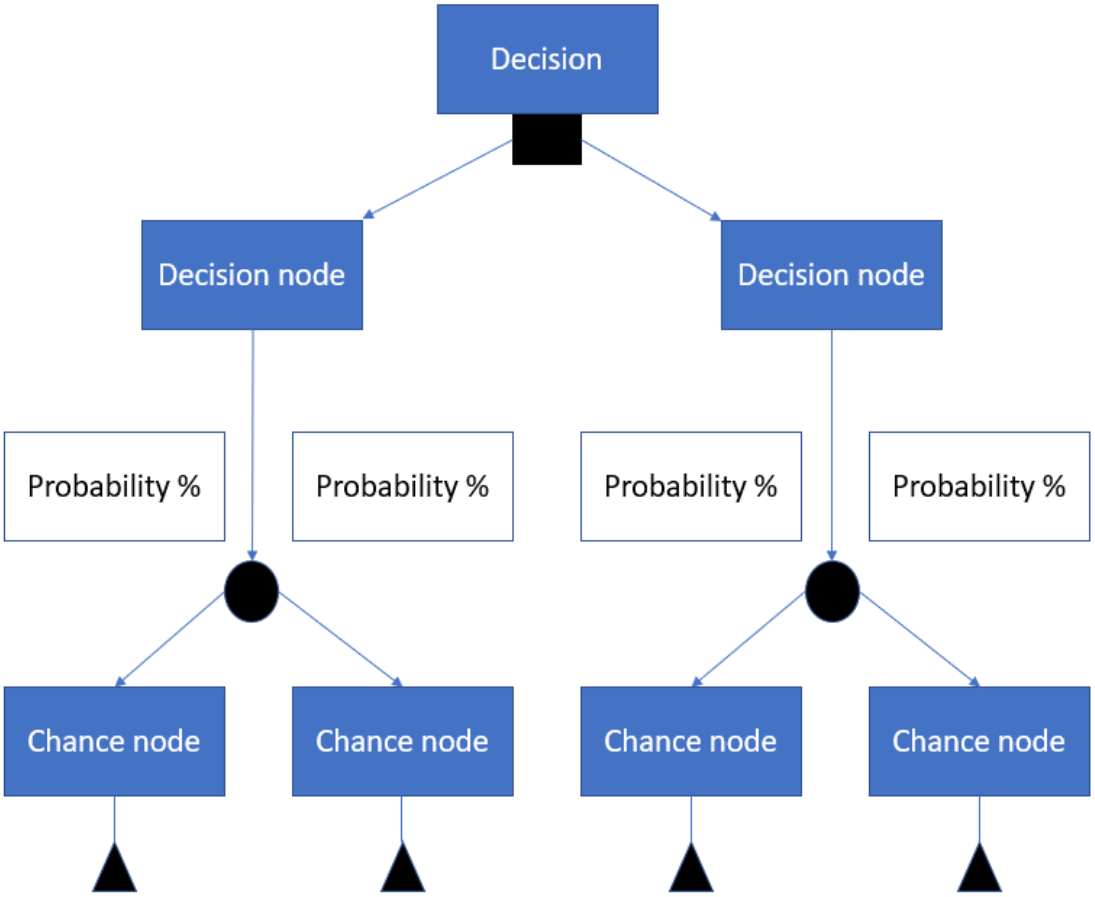

Figure 8. Decision Tree Analysis path.

Yang & Zhou (2020) utilized DTA in their research where the objective was to understand the level of carbon dioxide (CO2) emissions due to inland travelling in China. The object of the study was to raise the influence factors of individuals and their relationship to CO2 emission. DTA provided quantitative measures of every influence factor for different type of trips that generated CO2 emissions. There were three reasons why DTA was selected as a method in their study. First reason was that the data that DTA uses has no constrains and the data can be utilised to investigate continuous independent variables and categorical variables as well. Secondly DTA is nonparametric statistical tool that has the possibility to use any kind of functional forms and doesn´t have any detailed

specification of the distributed data. Thirdly DTA investigates the collaboration outcome between independent variables.

2.4.6 Expected monetary value (EMV)

The PMBOK (Project Management Body of Knowledge (2017) defines the Expected Monetary Value as a statistical concept that calculates the average outcomes when future includes scenarios which may happen or may not happen. Dash (2017) adds that EMV is a useful technique that performs quantitative risk analysis where identified risks are quantified. The EMV provides clearance on uncertain futures scenarios where the outcome can be positive opportunity or negative threat. As Dash and PMBOK (2017) described EMV to be a statistical and quantitative calculation analysis, Usmani (2021) elaborates EMV by writing that it is a mathematical calculation technique where probability and impact are to be calculated. Probability is the possibility that a risk will happen, and impact is the cost if it. The EMV calculation formula (9) was introduced in chapter 2.5.5. and the formula is simply multiplying the probability with the cost of identified risk.

Usmani (2021) raised following positive notes related to the utilisation of EMV analysis:

- EMV technique calculates the average outcome of predefined unknown occurrences.
- It supports to make a correct decision with decision tree analysis
- In general, it can be utilised with low costs and there in not a need to invest money to use EMV

Important aspect in Usmani`s (2021) writing was that when doing calculations by using EMV and DTA the risk attitude needs to be zero or otherwise calculations won´t give correct results. The data used in these calculations needs to be good quality data.

This thesis is meant for real life company who is facing uncertainties in their future business operations and especially with their investments. One of the goals of this thesis is

to provide support how to mitigate possible risks in decision making and create understanding about future scenarios. Different techniques were introduced, and these techniques can be utilized when ever there is a need to quantify possible business risks.

2.5 Circular economy

Circular economy (CE) is a hot potato at the moment and the importance of CE has been recognized all the way at the EU management level. Other national governments such as China, Japan, UK, France, and Canada promoted CE as very important topic in their societies. It has been calculated by European Commission that only in EU, circular economy would gain 600 billion euros benefits in manufacturing industry alone. From this 600 billion 2.5billion is the share of Finland´s economy. When considering the global economy, the total benefits could be as much as 1000 billion US dollar per year (Korhonen, Honkasalo & Seppälä, 2017). Reike, Vermeulen and Witjes (2018) are complementing that for the past 5-10 years CE has gain a lot of attention within policymakers, consultants, and science. In 2018 the CE academic literature grew by 50% over the past five years. In manufacturing industries CE has been seen as a vital element towards lower emission policy.

World´s natural resources are constantly declining, and the exponential economic and population growth are on a level that cannot be met with current natural resources. Due to this unwanted global situation, manufacturing companies needs to fulfil obligations and comply with strict legislations and to do so, they need to think about ways to keep the carbon footprint low in their manufacturing processes (Lieder & Rashid, 2016).

Even if CE is a hot topic, it still requires a lot of effort especially within individuals and company cultural behaviour. Business and policymakers have a crucial role as they should be in the front line leading the world towards more sustainable behaviour. Kirchherr, Piscicelli, Bour, Kostense-Smit, Muller Hubrechtse-Truijens & Hekkert (2018) conducted a survey where approximately 50 CE experts were interviewed. The outcome of this survey and interviews were that world is moving towards CE too slowly. The main

reasons were the lack of consumer interest and awareness, as well as too hesitant company culture. The technology is already there available on the markets, but the actions are missing. The role of governments are important as they can support the transformation towards CE by for example adopting policies that favour CE. One type of incentive could be tax reliefs. Even with the help of governments there is still a strong need to change the behaviour of individuals and companies.

CE is often referred as sustainable development as the goal of CE is, that today´s needs and consumption can´t risk the environment and the available resources of future consumption. Korhonen et al. (2017) are defining CE in their article as an economy which is societal production-consumption based economy that utilizes cycles for sustaining materials, energy, and nutritive substances for economical uses. The material flows coming from society's back to nature is essential and the aim is that nature can reuse these materials. These types of materials could be pulp, paper, timber food and biomaterials. Often this type of reuse of societal materials is called economy-nature-economy cycle. For example, biomass is collected from nature and used to produce energy, once biomass is used in energy production it is returned to the nature to support nature´s living

Depending on the source there are several definitions for CE and since the literature is fairly new there isn´t one common and agreed definition for CE. Eco-industrial definition is to utilize closed loop materials in society. It is based on 3R principles which is reduce, reuse, and recycle. The intention is to have closed loop of materials i.e. circular material flow and to reuse these materials as much as possible by minimum amount of energy. Economical definition is leaning on spiral-loop, which means that society needs to minimize the amount of material, energy production and waste without jeopardize economic growth, or social and technological development. Lieder & Rashid (2016) gives the definition for CE as from Industrial perspective and they describe it as economy which is regenerative by purpose and clearly defined design. Wysokinsa (2016) considers CE as closed loop economy where waste generation is as minimum as possible, and any waste can become as resource.

Korhonen at el. (2017) are also pointing out in Figure 9 how environmental target of CE is to minimize the production-consumption materials and energy consumption. As same time the waste and emission outputs are lower through efficient material use and renewable based energy production.

Economical target is to minimize production-consumption processes materials and energy costs, waste management and emission management costs, reduce environmental and legislation costs, as well as to aim to innovate new product designs, and open new market opportunities for these new product designs (Korhonen at el. 2017).

Social objective is to increase employment and to aim for more efficient use of existing physical materials through cooperation within society. Cooperation between different societal parties will increase also through sharing economy (Korhonen at el. 2017).

Circular economy would decrease emission costs which are coming from landfill management and operation, emission taxes and from different type of emission legislations costs. This type of environment-economic-social circular economy business creates new type of markets that requires new employees. The business is long lasting type of business as materials are recycled many times and the value of these materials doesn´t disappear after first use. Circular economy also boosts the image of companies towards greener side and in current economic environment the green values support companies' reputation (Korhonen at el. 2017).

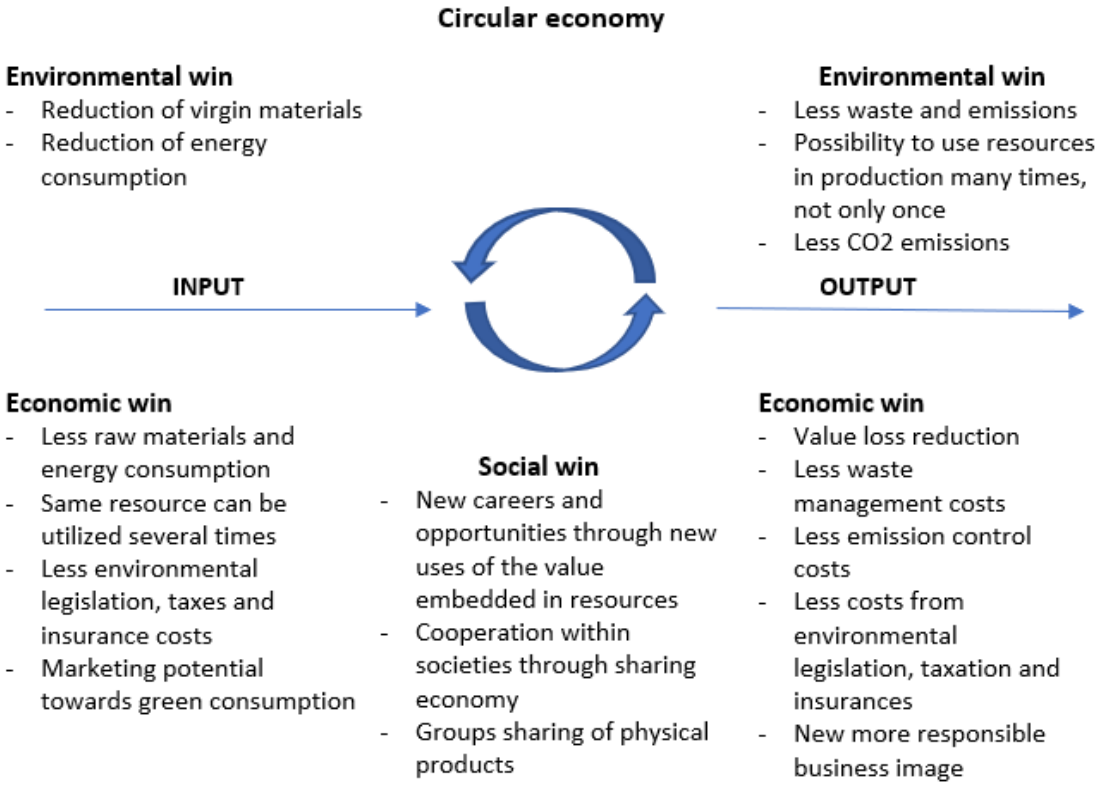

Figure 9. Sustainable circular economy (adapted from Korhonen et al., 2017).

Well-known global Finnish company Ponsse is one of the leading forest machine manufactures in the world. The factory where Ponsse manufactures machines is located in Vieremä. The Ponsse product family is large containing all sizes of forest machines (Ponsse, 2022)

According to Teknologiateollisuus (2021) more than 90 percent of the weight of Ponsse's forest machine is recyclable materials. Old machines are collected back to manufacturing premises where new spare parts and other repairing activities are conducted. The machine can be upgraded to today's level, extending its life cycle with up to 4 new owners

The ideology to repair used forest machines to match latest market requirements is identical as what the case company in this thesis is doing with brake calipers. Case company is utilizing existing and used brake caliper blocks which are acquired from markets. Worn parts are replaced with new ones and the bock is sandblasted and painted.

Ponsse´s factory refurbishment can save up to 85% in energy, and up to 90% in materials but most importantly the activity saves up to 93% in greenhouse gas emissions compared to the production of new ones. Old parts and machines are reconditioned, and these are given the same warranty as what would have been given to the totally new parts and machines (Teknologiateollisuus, 2021).

Ponsse has its own recycling centre where components and spare parts are collected. For example, Ponsse's subsidiaries are allowed to return slow-moving spare parts to Ponsse´s recycling centre so that these spare parts wouldn´t fill their stocks (Teknologiateollisuus, 2021).

Utilizing this possibility, they can buy newer and faster-recycling parts. The parts are inspected and evaluated at a recycling centre. Some of them end up directly in metal recycling, some become spare parts in stock, and some can be sold as a factory refurbished part after inspection and cleaning (Teknologiateollisuus, 2021).

All material flows are recorded including also scrabbed materials. Ponsse has a workshop that has focused on refurbishing parts. To increase the quality of the parts and the efficiency of the refurbishment work, Ponsse established a workshop focused on the refurbishment of parts. The workshop refurbishes large mechanical transmission components that will wear out. Most - almost 90 percent - of Ponsse's parts repaired and used in Finland are resold in Finland. The rest of the circular economy products go mainly to Europe (Teknologiateollisuus, 2021).

Korhonen et al. (2017) are writing about interesting business related to CE. They are referring to sharing economy where people consuming of already existing goods and services. This business will bring new type of social, economic, and environmental cost savings. This requires also new type of business concept which consists for example leasing

a house, leasing a car during holiday trip, renting a laundry machine from neighbour, or for example leasing an office during work week.

The behaviour of individuals needs to be reorganised and this means that the typical individual only own and consume type of behaviour needs to be transformed to every-one own and share society. Sharing economy will reduce nature-society-nature material flows and energy consumption. This is still quite small business especially in Finland where the utilisation of rent car is less than 10% (Korhonen et al. 2017).

2.5.1 Circular economy towards net zero emissions

European Union aims to be net-zero greenhouse gas emission free society by 2050. This means that there are several important and massive action to be made. The need is urgent and everyone in society and economic sectors have important role. Electricity, industry, transport, and heating + cooling facilities needs to pay attention to their emission footprint (European Union, 2021).

The Ministry of Economic Affairs and Employment of Finland have conducted report in 2020 of Finland's long-term strategy to reduce greenhouse gases. The report has information of all the actions how Finland is aiming for the net-zero greenhouse gas emission free society by 2050. In this report Finland guarantees that it will stop using coal by the latest 2029 and at least halve the use of peat by 2030 (European Union, 2021).

To meet the target Finland will increase the share of biofuels in transportation as well as electric and gas-powered cars. Renewable electric sources will grow and the utilizing of oil in domestic heating will decrease. Circular economy also has a vital role to meet the target as in the report it is stated that the circular economy, the sharing economy, and significant energy efficiency are key elements in achieving the low emissions target (European Union, 2021).

As in the European Union report (2021) was stated CE has an important role in emission reduction. The same philosophy applies in China´s strategy to decrease emissions. Zhe, Coteb, Qinghu, Wue, Wenf, Liub & Dongg (2015) wrote in their article that China is heavily utilizing CE to meet the Paris agreement GHG emission levels. China has implemented CE strategies especially in plastic recycling in various scales such as, individual level, company level, industrial level and within cities as well as in nations

The overall plastic production in China is massive as it represents 25% of global plastic production. Chinese plastic recycling industries (CPRI) conducted an analysis which calculated how well circular economy mitigates greenhouse gas emissions. The result was clear, plastic recycling reduced greenhouse gases in years 2007-2016 by up to 6.9 Mt. (Zhe et al. 2015)

To have effective CE there are three aspects to consider. CE needs to be measurable as it is important to measure how CE is supporting towards net zero emissions strategy. From the measured values it needs to be visual if the impact of CE is at the desired level or if there is some improvements to be made. Secondly government needs to improve legislative and regulatory environment. Thirdly technology needs to be advanced and available (Zhe, Coteb, Qinghu, Wue, Wenf, Liub & Dongg, 2015. Figure 10 demonstrates the plastic waste circular economy how the waste can be recyclec in a way that it can be reused in different applications.

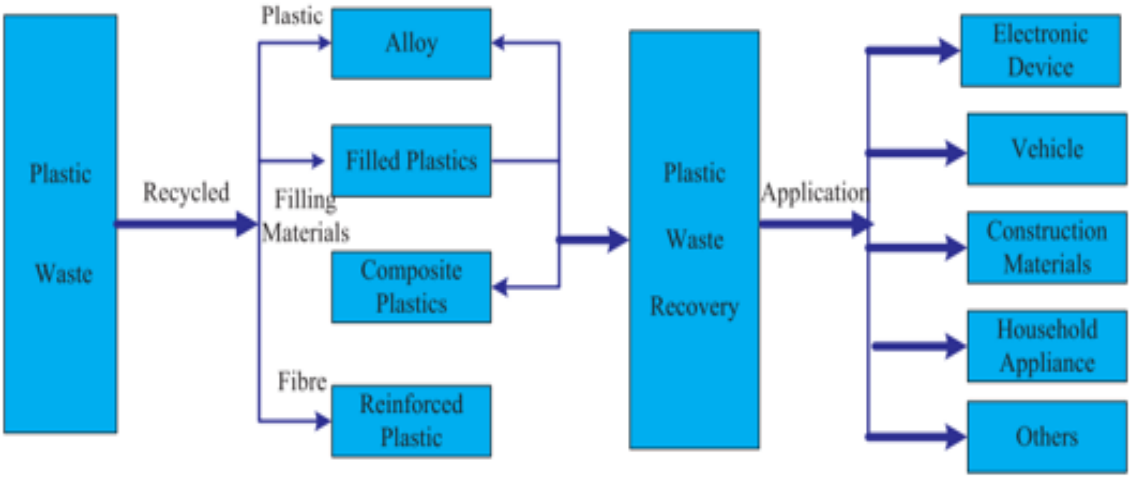

Figure 10. Plastic waste circular economy in China (ZHE et al., 2015).

Zhe et al. (2015) are writing that the recyclable plastic waste products are mainly packaging products, home appliance, electronic devices, and vehicle plastic. CPRI demand for recycling plastic waste targets wasn´t met with domestical plastic waste flows and therefore China started to import plastic waste abroad. This created new jobs and reduced GHG emission globally.

3 Methodology

3.1 Study methodology

To proceed logically and structural way in the research, the research onion model by Saunders, Lewis & Thornhill (2009) is introduced in Figure 11. There are six layers in the onion and the path starts from the outermost layer and goes layer by layer to the innermost layer of the onion. Each layer describes the different stages of the research. The philosophical perspective is positivism as the subject is observable social reality. Research approach has two options: deductive or inductive. The research approach in this thesis is deductive as there are existing studies related to investment strategies and this research aims to answers on the predefined research questions (Sileverman, 2013).

Research strategy is a case study as the findings from the study can answer to the research questions, and as Morris & Wood (1991) stated, case study is a correct strategy if the researched wishes to gain a deep understanding of the context of the research. As the research is quantitative research and the data is gathered from existing databased the research choice is mono method. Research time constrain is focusing on a particular phenomenon at a particular time and this makes the research as cross-sectional study.

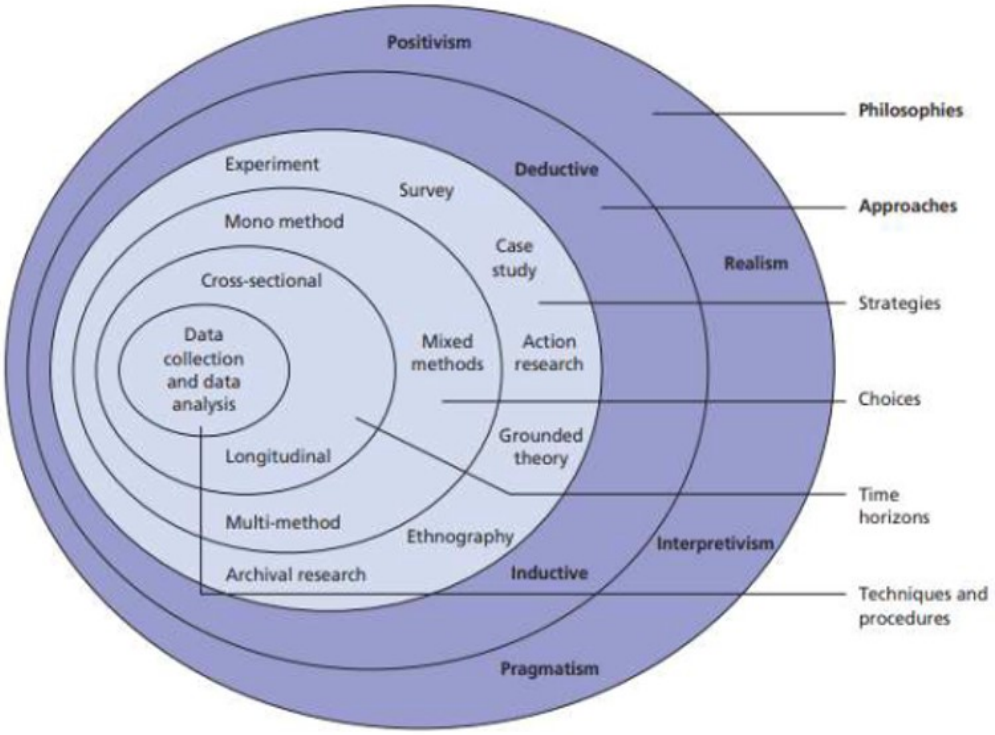

Figure 11. Research onion layers (Saunders, Leis &Thornhill, 2009).

3.2 Data

To know which type of data is required it is important to understand the overall scale of both investment options. To have an efficient brake caliper manufacturing plant it needs to include skilled workforce, high-quality equipment, sufficient production premises, brake caliper stock and spare parts. All of these requires invested money from the company and to have accurate invested options calculated the data needs to be correct. In table 4 the data i.e. the costs are identified line by line and these cost item lines together creates the total investment amount for both options.

An examination of the Table 4 shows that production facilities contain the largest item of expenditure. In Option 1 production facilities require minimum of 600 m2. The reason for the large production facilities is explained by the fact that investment strategy Option 1 requires more workforce, larger brake caliper stock, painting and sand blasting rooms.

Option 2 has less workforce, painting and sandblasting are outsourced as well as brake caliper stock is smaller. Due to these reasons the production facility in Option 2 does not need to have as large footprint as in Option 1. It has been decided that facilities of Option 2 are limited to a maximum of 120m2. The prices and more detailed descriptions of the production facilities are presented in the appendices at the end of the thesis. Three different production facilities for both Option 1 and Option 2, were carefully selected and the average sales price of these premises was calculated and used in Table 4.

Equipment for painting and sandblasting	**Option 1**	**Option 2**
Sandblasting cabinet	3,000 €	0 €
High pressure sprayer	500 €	0 €
Compressor	1,200 €	0 €
Fixed costs		
Labour cost	143,137 €	35,784 €
Industrial hall	425,000 €	106,667 €
Painting and sandblasting premises		
Powered roof ventilation	5,000 €	0 €
Painting/Spray tables	500 €	0 €
Shelves	4,000 €	2,000 €
Stock		
Brake caliper stock (pcs.)	2,500	500
Brake calibers in stock	125,000 €	37,500 €
Brake caliber tools	6,000 €	2,000 €
New spare parts for brake caliber	169,350 €	32,370 €
Total	**885,187 €**	**216,821 €**

Table 4. Investment structure.

it is decided in Option 1 that sufficient sandblasting cabinet would have 5,5 bar pressure and air consumption 707 l/min. This type of sandblasting cabinet would be powerful enough to blast the rust and old paint from brake caliper blocks. After the block has been cleaned it will be painted by high pressure sprayer power of 1500W and paint consumption of 1.4l/min. Compressor which is powerful enough would be minimum of 4kW. To have safe and functional painting room it needs to contain powered roof ventilation which circulates the air, hardwearing tables, and shelves to store treated brake caliper blocks.

Investment cost structure doesn´t include the rent of a land, any insurances related to facility or equipment. Also, electricity and water consumption has been left out from the calculations. Land rent may vary depending on the size, age and the form of heating of the facility. Insurance costs were left out as the amount of insurance fee is dependent on the facility characteristics (m2, year of completion, facility material) and this info is available at the time when the facility has been acquired. Electricity and water are depending on the consumption, and it is not a fixed cost so therefore these has been left out.

When considering salary-related expenses, in addition to salaries, there are so-called wage incidental expenses. These include wages and salaries paid for non-working hours (for example, annual leave pays, sick pay and holiday pay), social security contributions (earnings-related pension, unemployment, sickness, accident and group life insurance contributions) and company-specific personnel costs for example, training and labour costs (Confederation of Finnish Industries, 2021). Isosävi (2019) is writing in his article in Palkkaus.fi webpage that when considering hiring a new employee, the employer's side costs should always be considered when assessing the price of the work to be performed. In Table 5 it has been calculated what is the cost of an employee for the company if the hour salary of 15€ per hour has been agreed with the employee.

Employers´contribution 2021	% from employees gross salary	15€/h per employee
Health insurance premium	**1,53**	**0.02295**
will be paid if the employee is aged 17-67		
TyEL- pension insurance	**24.8**	**3.72**
When the amount of the employer's salary was less than EUR 2,125,500 in		
Unemployment insurance premiums	**0.5**	**0.075**
of the salary until 2 169 000		
Accident insurance	**0.7**	**0.105**
Group life insurance	**0.07**	**0.0105**
		3.93345
total salary cost for company per employee/hour		**18.93**
* yearly bonuses and bonus holiday days excluded		

Table 5. Employer contribution (Suomen yrittäjät, 2021).

In this thesis the labour cost is calculated as a lump sum based on Table 6 values. The total lump sum duration is 1 years and calendar working days 252 days per year. The hourly cost is calculated in Table 5. As mentioned in previous chapter the number of employees is more in Option 1. As a side note, the real-life working days amount may differ as first of May, Independence Day, and Christmas doesn´t have yearly fixed week-days and there will be sick leaves, personal holidays, possible weekend works etc.

Employee cost for 5 years	Option 1	Option 2
Amount of employees	4	1
Cost per hour	18.93 €	18.93 €
Hours per day	7.5	7.5
Working days per year	252	252
Years	1	1
Total cost in euros	**143,137 €**	**35,784 €**

Table 6. Labour cost.

It is important to calculate what is the maximum volume of brake caliper annual production in Option 1 and Option 2 as these values are to be used in EMV calculations when calculating the expected maximum return on high demand. Table 7 shows the maximum brake caliper annual production in units and in sales price.

Table 7. Maximum annual brake caliper production. (table has been intentionally left out due to sensitive information)

3.3 Financial analysis

The main idea of a capital investment is to raise the overall economic and technical capacity as well as financial value of the company. Capital investments might be costly, and they have a long-time impact on the company´s profitability (Cooreman, 2011). This chapter introduces the most used financial analysis techniques and some of these techniques will be utilized later in this thesis.

The financial analysis contains calculations and formulas which aims to determine the rationality and profitability of certain investment. In particular, the need for financial analysis arises when there are several investment options and those need to be prioritized. These calculations also make sense from a business perspective: when making calculations, it is important to pay attention to implementation costs, available returns, and

financing options. This review may lead to a better outcome than the original way of thinking. The bigger the investment, the more data collection is needed (Yrityssalo).

Alkaraan & Northcott (2005) are writing in their article that financial analysis techniques are the main type of information when considering capital investment strategies and that NPV (net present value), IRR (internal rate of return), ROI (return on investment) & PB (payback period) are all well-known and most used techniques. Cooremans (2011) is complying that financial analysis techniques are dominant methods when evaluation the profitability and success of certain investment. Also Bojanc & Jerman-Blažič (2007) raising the importance of NPV and IRR. According to them these are more accurate techniques for investment evaluation than ROI and PB. But to get clear and comprehensive understanding of the overall investment, they recommended to utilize all these techniques collectively.

Alkaraan & Northcott (2005) conducted a study between years 2002-2003 interviewing over 80 large companies in England from different industries. The interview results concluded that companies are using NPV, IRR and PB when evaluating different investments. The most used financial analysis technique was PB when considering new strategical investment. Similar kind of a study was conducted in Finland where Äikäs (2017) interviewed 44 persons from 23 different small and medium sizes companies. These companies were utilizing exact the same techniques than the companies in Alkaan´s and Northcott´s study.

According to Sandberg & Söderström (2003) there exists several financial analysis techniques for estimating investment profitability. When considering different type of investments, no matter the field of business of the company, company needs data for the decision making and financial analysis provides this in a quantitative manner.

In 2001 Graham & Harvey conducted a broad survey where 392 CFO (Chief Financial Officers) participated to the survey. The aim of the survey was to collect information

about the most used techniques regarding to capital investments. Figure 12 below shows the techniques which were the most used ones. In this thesis NPV, IRR and Payback are applied to calculate the attractiveness of more suitable investment strategy for the case company.

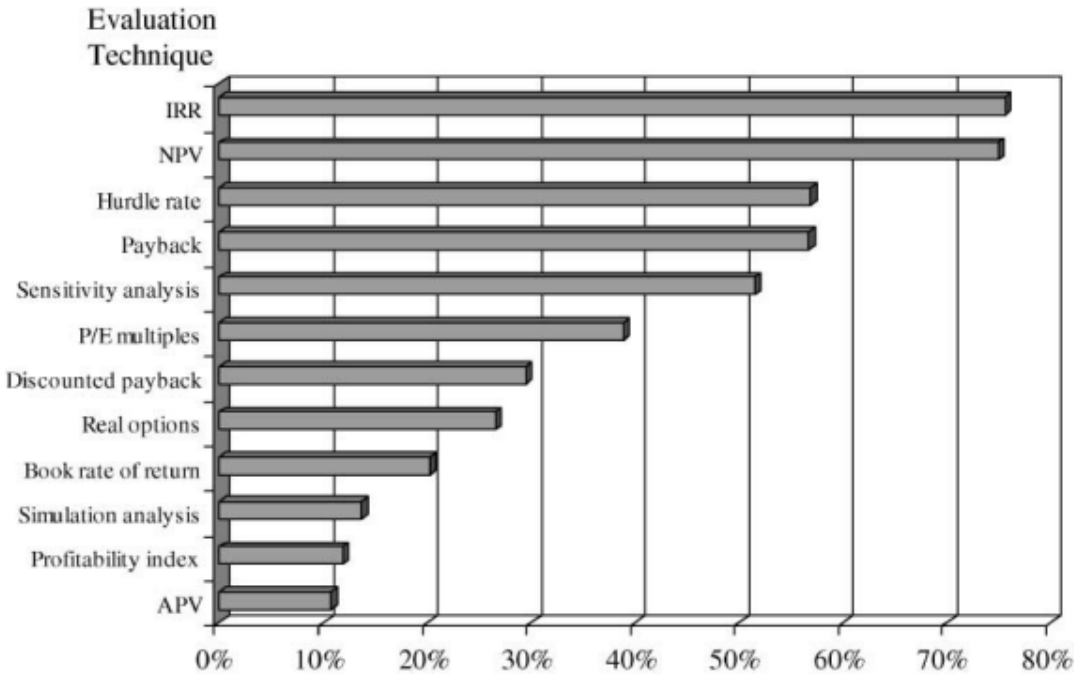

Figure 12. The most used financial analysis techniques within CFOs (Graham &Harvey 2001).

As the theoretical part in this chapter states, financial analysis techniques are effective and commonly used methods to examine investment decisions, and for this reason, these techniques have also been selected to this thesis so that the case company would have enough information for their decision making. In total four different techniques were chose.

3.3.1 NPV (Net Present Value)

NPV helps managers to evaluate project´s profitability and provide information if project is worth of execution. NPV is described as the measurement of attractiveness (Ben-Horin & Kroll ,2017). NPV indicates the return monetary value. Below is the NPV formula where

Bt is present value of the net income of time *t, Ct* is the overall investment cost and *i* represent the internal discount rate (Bojanc & Jerman-Blažič, 2007).

$$NPV = \sum_{t=0}^{n} \frac{Bt-Ct}{(1+i)\hat{}t} \quad (9)$$

The discount rate in this thesis has been chosen based on the literature and this is agreed with the case companies` management. According to Barrett (2019) the intention of discount rate is to calculate a net present value of discounted cash flow. There isn´t any agreed and commonly accepted discount rate percentage which would fit for all the NPV calculations, but Barrett (2019) suggested to use 7% discount rate as a rule of thumb.

Stewart, Race Rohadi & Schmidt (2021) used discount rate of 8% in their financial analysis. Aldridge Minerals (2010) did NPV calculations based on 7% discount rate when they calculated economic assessment in mining project. Bluestone announced 2017 that they used discount rate of 5% in their economic assessment for gold mine NPV calculations.

Alderon Iron corporation did a feasibility study in 2018 where they used discount rate of 8%. Based on the theory it can be safely concluded that discount rate should be somewhere between 7% and 8%. In this thesis for case company discount rate of 8% will be used.

Investment is reasonable when NPV is positive. This means that the investment generates profit. And as contrary negative NPV value means that the investment generates losses. The importance of NPV relies on the information where it tells the cash value of expected return (Bojanc & Jerman-Blažič, 2007).

3.3.2 IRR (Internal Rate of Return)

IRR represent the rate on which the NPV of a capital investment is zero. IRR is the rate that balances the present value of estimated future cash flows (Cooremans, 2011). IRR

is highly linked to NPV as discount rate in NPV calculations describe how risky the investment is. So higher the risk of the investment, higher the discount rate is. In other words, discount rate is the rate of return which investors expects to gain for lending the money (Kodkula 2014).

IRR calculates the break-even percentage and describes the potential of certain investment. It is a good technique when analysing long-term investments especially when costs variates significantly yearly basis. IRR calculates the percentage rate earned for every euro invested for certain time-period (Bojanc & Jerman-Blažič, 2007).

$$0 = NPV = \sum_{n=0}^{n} \frac{CFn}{(1+IRR)\hat{}n} \quad (10)$$

CF0 = Initial investment

CF1, CF2, CF3…CFn= cash flows

N= each period

N=holding period

NPV= Net Present Value

IRR = Internal Rate of Return

3.3.3 ROI (Return on Investment)

ROI calculates the value how profitable the investment has been on the investors side. ROI is a good technique to compare different investments as it is rather simple to use and it is very easily comparable (Menezes, Kim & Huang, 2015). Bojanc & Jerman-Blažič (2007) pointed out that ROI provides good decision support information as it calculates which of the investment options gives the best return for the invested money. Below ROI formula calculates the present value of accumulated net value minus the total investment and finally divides the value by the amount of investment.

$$ROI = \frac{Benefits - Cost\ of\ investment}{Cost\ of\ investment} \quad (11)$$

ROI formula is easy to use as basically it is only a formula where profit needs to be dived by the cost of investment. In this thesis. ROI will be used to calculate what is the return rate for the investment. Before ROI is calculated EMV and DTA calculations needs to be conducted.

3.3.4 PP (Payback Period)

Payback period is a method which tells the needed time for recovering the invested capital. Normally PP indicates the time in months or in years. The idea is to divide the invested capital by the annual income. As such PP doesn´t take a stand on the profitability side but it leans more on the risk side which is indicated by years or months (Cooremans, 2011). Atik (2012) describes PP as a good method to see how fast the investment can be collected but as a negative side PP only considers liquidity but not the time value of money. According to Anthes (2003) payback period is commonly used tool to measure and evaluate potential investments. It provides help to managers to determine if some projects are worth of investment over another. The PP formula described below.

$$Invested\ capital/annual\ icome \quad (12)$$

4 Case company

Case company is established 2007 and its business is in retail trade and manufacturing of vehicle parts and accessories for trucks. Company´s wants to aim its core business in the centre of circular economy and company is committed to reduce its carbon footprint as they see that manufacturing industry needs to take a bigger role to achieve sustainable future. The company has had a piloting program where they have investigated the possible new business on reconditioning of used brake calipers. Company has gained information about market demand, pricing, production lead times and among other things. In the pilot period the aim was to examine the new business of used brake caliper reconditing and see if there is economical potential in this type of business when welling the reconditioned brake calipers back to the market. Used brake calipers were picked up from the customer, dismantled, old blocks were sandblasted and painted. After this, the worn parts were replaced with brand new spare parts and the product was ready for markets after it is carefully tested.

Thanks to this new business, old brake calipers do not have to be sent far to southern Europe or the rest of the world for refurbishment but instead can be refurbished domestically by domestic labour and thus save CO2 emissions. As all work is done in Finland, the company has the Finnish key flag symbol. In the usual case, when it comes to consumer goods in the world of truck components and spare parts, worn parts are normally scrapped and completely new parts are bought to replace them. This is an unnecessary waste of materials and resources because recycling and reconditioning can make used components look like new ones, just as in the case of Ponsse, which is explained in more detail in chapter *2.1. Circular economy.* The Case company also promises the same warranty on refurbished brake calipers as on brand new brake calipers. The aim is to make truly durable and reliable components with long life cycle.

After the piloting phase case company has decided to invest on manufacturing premises, buffer stocks, spare parts, workforce, equipment and tools. Used brake calipers are

acquired from market and stored in the manufacturing premises. Option 1 will have 2500pcs in stock and option 2 has 500pcs. These brake calipers are reconditioned by sandblasting, painting and new spare parts are assembled to reconditioned brake caliper frame. The monetary investment in Option 1 contains more workforce and more processes as well as equipment. Option 2 is a more stripped-down approach where product volumes are more moderate. In both options transportation is handled by the company´s own truck and it was decided with case company´s management that the operational costs of the truck will be left out from the calculations presented in this thesis.

The purpose of the brake caliper is to stop the vehicle. In most of the trucks wheels are attached to metal disc which is spinning identically with tyres and the brake calipers function is to slow the disks from turning with friction. The brake caliper is like a press that presses the disc from both sides so when hitting the brake pedal brake fluid generates pressure on pistons, forcing the plates against the disk and creates friction which stops the disc from spinning (Goodyear, 2022). Picture 1 shows disassembled case company´s brake caliper.

Picture 1. Dismantled brake caliper.

5 Results and analysis

In this chapter DTA analysis and EMV techniques are used to calculate two predefined investment strategies. Once the highest or lowest negative EMV value has been calculated and investment strategy selected it is time to calculate financial analyses numbers. All the calculations are made with excel but some of the calculations have also been calculated old fashioned pen and paper style as well.

The case company wanted to conduct the calculations based on the possibility of strong, intermediate, and weak demand. The probability percentages for strong demand was decided to be 50%, for intermediate demand 35% and for the weak demand 15%. These probability percentages have been decided based on the previous piloting program which the company conducted, and the knowledge gained through this piloting it is safe to say that probability percentages are based on solid foundation. Probability percentages are the same for Option 1 and Option 2. as the market demand is the same, no matter the capacity of brake caliper production.

Strong demand has been calculated according to maximum production capacity and in chapter 3.2. *Table 7 Annual brake caliper production* describes what is the possible maximum production for both options. Intermediate sales have been calculated as it would cover 80% of maximum annual production. When calculating 80% of the maximum, it would mean… (text have been intentionally left out due to sensitive information)

The end node values are the strong/intermediate/weak demand minus the overall investment cost. In other words, end node value describes the net profit is. All the end nodes of all the branches needs to be calculated and these results can be positive or negative. Once the end node values are calculated there is a need to move backwards of the branch and multiply each of the values their probability percentages. After this the

results of each branch for both options will be summed up. Summed up values forms the EMV result and the investment strategy which has highest positive or lowest negative EMV value will be chosen for financial analysis calculations and will be suggested for the case company.

(Text have been intentionally left out due to sensitive information)

Figure 13. Decision tree analysis and expected monetary values. (figure has been left out due to sensitive information).

(Text have been intentionally left out due to sensitive information)

(Text have been intentionally left out due to sensitive information)

Table 8. EMV calculations with higher cost structure in Option 1. (table has been left out due to sensitive information).

Now it is time to move to financial analysis calculations and analyze investment Option 1 through NPV, IRR, ROI and PB. The calculations are made based on intermediate market demand. Financial analysis can be conducted for strong and weak market demands also but intermediate was selected due to the reason that it is the neutral version of these demands.

NPV calculations are based on the formula introduced in chapter 3.3.1

$$\sum_{t=0}^{n} \frac{Bt-Ct}{(1+i)\text{^}t}$$

Calculations left out due to sensitive information (13)

Calculations have been left out due to sensitive information (14)

NPV value is positive, so the project is forth to execute as the positive NPV value indicates that project generates profit.

Net present value calculations were made for also for strong and weak market demands scenarios. In all the different market demand scenarios the project would be wise to invest according to NPV. The calculations were made in excel and all the results are available in appendices at the end of this thesis. Cashflow was calculated for five years assuming that it would be steady during this whole period. Discount rate was decided to be 8% as explained in chapter 3.3.1.

Table 9 has a column for present value which indicates what is the actual value of the future income at this present moment meaning that. IRR calculations shows that the IRR value is 111.2%. When IRR rate is higher than discount rate investment is profitable. IRR shows that if discount rate would be 111,2% then the investment would generate 0€ profit.

Table 9. NPV & IRR at intermediate market demand. (table left out due to sensitive information)

(text has been left out due to sensitive information)

Calculations have been left out due to sensitive information (15)

The same calculations are made in Table10 below and in the table the ROI value in euros was calculated also.

Table 10. Return on investment (ROI). (Table has been left out due to sensitive information)

(Text have been intentionally left out due to sensitive information)

Calculations have intentionally been left out due to sensitive information (16)

Above result indicates that the investment would be itself back under 9 months at intermediate market demand.

6 Discussions

The circular economy is currently a very hot topic due to the global climate change. World is overusing natural resources so rapidly that the behaviour needs to change towards sustainable development. With the help of the circular economy, greenhouse gas emissions can be reduced, and the use of natural resources become more reasonable. The company's business relies heavily on the circular economy as brake calipers are recyclable. Wearing parts are replaced with new ones so that the brake caliper works on a desired way, but the brake caliper block can be reused, thus saving a lot of resources. This type of circular economy business will cut CO2 emissions especially in manufacturing and transportation sectors.

The theory chapter reviewed risk management and provided general understanding of risk management and how it should be a holistic part of decision-making. For risk management, the ISO 31000 standard was introduced, which aims to guide companies to minimize and manage risk. It is advised that case company should also reflect its own risk management to the ISO 31000 standard and thereby make risk management more systematic. Risks are important to be identified and recognized at an early stage and case company needs to be well prepared in advance in case of these risks will materialize. Risks should not be feared as they are involved in the day-to-day business. Companies should focus their resources to risk management as it needs to be integral part of a company's day-to-day business and cannot be ignored.

The data used in EMV and DTA calculations was gathered from several sources and it was estimated to be latest and greatest data available at that date. As Usmani (2021) wrote, if the data is bad quality data the calculations would not be correct, and the results would not be reliable. With bad quality data it is meant that data is outdated, incorrect or not suitable for the task. When case company is making the decision to invest to new manufacturing premises and hires new staff it will be essential to update the data and re-do the calculations. The calculations presented in this thesis are suitable for different type

of evaluation of what ever kind of investment plans and can be used for different purposes regardless of the company's` business.

In this work several different risk evaluation techniques were introduced and some of them might work also in this type of investment evaluation calculations, but DTA analysis and EMV technique were chosen for reason. Theoretical framework chapter dived deeper to these techniques and all of them have their advantages and disadvantages. Below is listed more detailed why these techniques weren´t selected for the case company´s purposes.

Reason why Monte Carlo simulation was not chosen is that it is based on programming, and it requires large data input as well as heavy simulation. In theoretical framework, it was pointed out that the MSC needs thousands if not tens of thousands of simulations for possible outcomes to be reliable. With EMV and DTA, there is no need for such heavy simulations. Because of the ease of use of EMV and DTA, these techniques were chosen over the Monte Carlo simulation. One might say that the simulations aren´t heavy at all as the automation does these all but still Monte Carlo requires an expert who understand how to operate MCS and to verify that the input data for the simulation correct.

EVM metrics indicates if a particular project is progressing according to the cost budget and project schedule. EVM provides a means to detect if any deviations are coming from either of these. In the case of case company, the investment project does not have a precise start and end date for the project, as the invested equity is intended for long-term tangible and partly human capital. In EVM metrics, the project schedule and especially the completion date play an important role in the calculations as it compares how the project is progressing. For this scheduling reason, the EVM metric is not the most appropriate evaluation technique for the case company´s purposes.

Ishikawa diagram would be good tool to analyse brake caliper quality problems, for example, which is rooted in people, processes, production machines, materials,

measurements, or the environment. However, the purpose of this thesis is to consider a suitable investment strategy and the Ishikawa diagram may not be the most appropriate tool for making this decision. Ishikawa maybe could be used for investment strategy evaluation but in this thesis, it is seen more as a tool to detect quality problems and as well as cause and effects. If there will occur quality problems in the company's production or products, then the Ishikawa diagram will be a very useful tool.

Based on the literature Delphi technique is a time consuming and heavy technique as it requires more than 10 experts for several days to evaluate the subject under investigation. More than 10 experts alone for several hours is most probably a very costly as is, not to mention the fact that these experts would spend days around this issue and not only few hours. The case company does not see the Delphi technique reasonable due to the higher cost and all time needed to arrange over ten experts around common subject. Delphi technique for sure would work and the questions isn´t that case company wouldn't trust on this technique. Reason for not to utilize this technique is simply related to resources which needs to be spend on this technique

In both investment strategies, the case company should hire more staff as company sees that with current resources case company wouldn´t been able to manufacture needed amount of brake calipers to meet the market demands. Disassembly, refurbishment, and assembly of brake calipers may be burdensome both mentally and physically for workers. It was seen important to raise awareness towards this matter as case company should invest on the well-being of workers and keep in mind that the employees are very important asset to take care of.

Financial analysis was considered mandatory as the calculations would provide information about the investment's profitability and risk level. All the calculations and evaluations in this thesis will provide guidance and support for the case company's decision makers and hopefully case company is able to make fruitful and profitable decision based on the calculated numbers, but as Cooremans (2011) stated in her article; even if there

is hard evidence and properly calculated financial numbers; you can´t just make long lasting and significant decisions based on the numbers. Decision makers should have experience and intuition besides all the numbers.

7 Conclusions and future works

The purpose of this thesis was to provide information about predefined investment strategies and evaluate the risks of these in company´s new circular economy business. Two different investment options were defined, and these were evaluated by using DTA, EMV and financial analysis. The exact cost structure of these investment strategies was left open intentionally by the case company as the cost structure clarifying was one of the objectives of this work.

It turned out that Option 1 had higher EMV value (211 014€) compared to Option 2 (57 230€) and therefore Option 1 was better alternative to proceed with. In chapter 4 it was expressed that only a 165k€ cost increase on manufacturing premises would change the EMV calculations on Option 2 favour. As this example shows the investment cost structure plays very important role and if the overall cost structure varies on the day when the investment decision is made, it is mandatory to revise all the calculations. The estimated market demand is the important aspect which plays vital role in the calculations. If the expected market demand will be something else on the day of investment decision is taken it is essential to update market demand values in calculation formulas as well. The third aspect effecting to the EMV calculations is probability percentages. These percentages are important to update in later phase if it is considered that the probability of strong, intermediate, or weak demand would be something else than presented in this thesis. To sum it up, there are three things that needs to be checked and validate on the day when investment strategies are reassessed: cost structure, market demand (expected sales) and probability percentages.

Several risk evaluation techniques were presented in this thesis, but DTA and EMV were the selected ones among with the financial analysis calculations. Some of the other techniques might work as well but DTA was chosen to calculate the best possible outcome of different investment strategies due to DTA´s versatility and data utilisation flexibility. The DTA proceed logically forward branch by branch and node by node to the point where EMV calculations steps in. Due to DTA´s logical and structural behaviour it provides clear

understanding on the subject. One of the biggest reasons of selecting DTA analysis and EMV techniques is related to the cost of using these methods. Company doesn´t need to invest large amount of money to the utilization of these methods and still even big monetary investment the results that DTA and EMV provides are accurate as well as provide important information for decision making.

NPV, IRR, ROI and PB were calculated based on intermediate market demand. Financial analysis calculations can also be calculated for strong and weak demand without a problem, but it was decided to use intermediate as it isn´t extremity value, as instead it settles on the neutral ground compared to these other demands. Financial analysis calculations gave positive signal that case company could proceed with Option 1 as it is profitable and in the light of financial analysis.

ROI calculation outcome was positive, and it indicated that the investment is generating profit and therefore investment strategy Option 1 looks reasonable. On the contrary ROI isn´t maybe the best possible technique to evaluate single investment decision. The best benefit of ROI is when comparing several investment options and the one that has highest ROI % is worth of execution. NPV calculations gave also positive result and indicated that investment generates profit. IRR rate was higher than discount rate and that tells that the investment would be worth of execution. Higher the IRR rate, higher the profit. Important to point out regarding to IRR that it is the most usable in circumstances where the cost structure is very dynamic on a yearly basis. In case company´s calculation it was expected that the costs and income are static yearly but it doesn´t mean that IRR wouldn´t suitable in case company´s investment strategy evaluation. Payback calculations concluded that the investment strategy Option 1 would be itself back in less than one year. This is truly something which should raise the interest in the case company´s management. As mentioned in the theoretical part it is important to utilize all the financial analysis calculations parallel and collectively to get the most reliable financial understanding.

When it comes to intermediate market demand, it can be concluded that the company's production does not need to run at full capacity and still company would be able to meet the needs of the market. When calculating financial analysis figures, sales were estimated to be stable for five years. Estimating sales for the future is always tricky, and no one can accurately predict what sales volumes will be in several years from now. As mentioned earlier, the calculations and formulas presented in this thesis can be easily updated to reflect the best understanding of the moment i.e. more recent data . This is one of the reasons what makes the findings of this thesis valuable for the case company. The analyses and methods used in the work can be modified and methods can be utilized whenever the market views change or, for example, if there is a need to change the scope of investments strategies.

Three different research questions were listed at the beginning of this thesis and now it is time to answer on those questions:

Q1 *" What are the available risk evaluating techniques related to new investment strategy in a circular economy business?"*. This thesis reviewed six different risk evaluation techniques. There was a lot of variation in these techniques, from thousands of mathematical simulations to expert teams of more than ten people. Circular economy is the centre of the company´s business but actually the business or market where the company is operating doesn´t play significant role when determine different techniques, as these risk evaluating techniques are not restricted for certain businesses. In Chapter *5. Discussion* all these techniques are explained why most of them weren´t suitable for the evaluation of less risky investment strategy for the case company.

Once the first research question had been formed, it was time to ask how the chosen techniques could reduce the risk and thus the second research question had emerged: Q2: "*How risk evaluation techniques helped to reduce risk with the chosen investment strategy*?" The techniques chosen to determine the profitability and riskiness of the investment were DTA analysis and EMV technique. DTA forms a risk structure and a logical path towards a less risky alternative using the EMV calculation formula at the final stage.

DTA contains all the costs and probability percentages as well as expected market demand values. EMV has a formula to calculate the probability of certain risk and the impact of it. EMV calculation is conducted for both investment strategies and the option with higher positive or lower negative EMV value is chosen. This way DTA and EMV helps to reduce the risk of investment as these two combined will provide quantitative information of less risky investment option.

Q3 : *"How financial analysis can be used to justify a new investment decision?"* Based on the literature and the studies conducted in Finland and England the financial analysis and the different calculation techniques provide valuable numerical information for decision support. Especially NPV, ROI, IRR and PP were identified as very important and most used techniques when evaluating new investment decisions. Financial analysis justify the decision by providing calculated information on important questions on net present value of invested money, the scale of investment risk , the return on investment and the time needed when the investment has paid itself back. All these are valuable information when decision makers are evaluation possible investment options.

There is a need to point out the limitations of this thesis. The data used in this work is rapidly becoming obsolete because the micro- and macroeconomics are in a constant state of change, and as a result, the cost structures will change at the same time. It is mentioned several times in this thesis that the calculation formulas are available to the case company regardless of time and do not expire in time. However, the data used in the formulas will become obsolete and will need to be updated when the calculations are made again.

Second point of limitation is related to benchmarking. It would have been interested to benchmark the case company's criteria for assessing market demand and compare it to other larger companies that have been in the industry for a long time. Market demand is always dynamic, and companies have a big task to understand the upcoming trends of the demand. In this work, benchmarking was omitted, but other researchers could

consider this if conducting similar studies for another real-life company that is looking to expand its operations using DTA analysis and EMV technique to minimize risks and create support for decision making.

With the support of this thesis case company gets more information for decision making and the work succeeded on finding less risky investment strategy based on the utilization of DTA, EMV and financial analysis. New investments always involve risks, and therefore risk management was highlighted in this work as an important focus area for the case company. This thesis hopefully provides sufficient amount of information for the case company to take the next step towards new profitable business in the field of circular economy.

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Appendices

Appendix 1. Investment costs. (appendix has been intentionally left out due to sensitive information)

Appendix 2. Employer contribution

Employers´contribution 2021	% from employees gross salary	formula	15€/h per employee
Health insurance premium	**1,53**	**0.00153x15**	**0.02295**
will be paid if the employee is aged 17-67			
TyEL- pension insurance	**24.8**	**0.248x15**	**3.72**
When the amount of the employer's salary was less than EUR 2,125,500 in			
Unemployment insurance premiums	**0.5**	**0.005x15**	**0.075**
of the salary until 2 169 000			
Accident insurance	**0.7**	**15x0.007**	**0.105**
Group life insurance	**0.07**	**15x0.0007**	**0.0105**
		sum of the values	**3.93345**
total salary cost for company per employee/hour			**18.93**
* yearly bonuses and bonus holiday days excluded			

Appendix 3. Labour cost. (appendix has been intentionally left out due to sensitive information)

Appendix 4. Productivity calculations for all market demands. (appendix has been intentionally left out due to sensitive information)

Appendix 5. EMV calculations with higher cost structure in Option 1. (appendix has been intentionally left out due to sensitive information)

Appendix 6. Net Present Value & Internal Rate of Return excel calculations. (appendix has been intentionally left out due to sensitive information)

Appendix 7. Return on Investment excel calculations. (appendix has been intentionally left out due to sensitive information).

Appendix 8. Manufacturing premise alternative for Option 1 and Option 2. (appendix has been intentionally left out due to sensitive information)

Appendix 9. Expected monetary value calculations in excel. (appendix has been intentionally left out due to sensitive information)