LAPPEENRANTA UNIVERSITY OF TECHNOLOGY
LUT School of Business and Management
Industrial Engineering and Management

MASTER'S THESIS

FINANCIAL PLANNING IN THE MINING INDUSTRY UNDER CONSTRAINED LIFE OF MINE

Examiner: Prof. Hannu Rantanen

Harri Nikkonen
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ABSTRACT

Author: Harri Sakari Nikkonen

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The lifetime of a mine is always of a certain length, and it is usually known right from the start of mining operations. The life of mine plan may change length several times during mining operations, mostly due to additional reserves found or lost due to economic viability. This study covers the issues relating to the short life of mine financial planning in the mining industry.

Uncertainty in the timeline of mining operations cause unwanted effects in financial planning. Planning for future investments, the scale of operations, or even the maintenance of equipment can be problematic if the timeline of the mining operations keeps changing.

The aim of this study is to build a model for financial planning for the later stages of mining operations. The model helps mining organizations to plan for closure specific aspects of mining operations pre- and post-closure.

The model is built for a case organization which is nearing the end of its mining operations, and needs to start planning for closure related aspects in the immediate future. The study was successful in creating a model and a timeline for financial planning of mine closure, and opens an aspect of closure planning that is seldom visited in the research of mine closures.

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Hakusanat: Taloussuunnittelu, budjetointi, kaivosteollisuus, kaivoksen sulkeminen

Kaivoksen elinikä on aina tietyn mittainen, ja se tiedetään jo kaivoksen aloituksesta asti. Kaivoksen elinikä voi muuttua useasti kaivostoiminnan aikana, jos malmireserviin tulee lisää louhittavaa, tai reservistä poistuu malmia heikon kannattavuuden takia. Tämä tutkielma käsittelee taloussuunnittelua kaivoksen lyhyen eliniän näkökulmasta.

Epävarmuus kaivoksen eliniän pituudessa aiheuttaa ongelmia taloussuunnittelussa. Tulevien investointien suunnittelu, toiminnantaso, ja jopa laitteiston kunnossapito voi olla ongelmallista, jos kaivostoiminnan aikaikkuna muuttuu jatkuvasti.

Tutkimuksen tavoite on rakentaa malli taloussuunnittelulle kaivostoiminnan myöhempiä vaiheita varten. Rakennettava malli auttaa kaivosorganisaatiota suunnittelemaan kaivoksen sulkemiseen liittyviä seikkoja.

Malli rakennettiin case organisaatiolle, jonka kaivos lähestyy eliniän loppua, ja sulkemiseen liittyvien seikkojen suunnittelu on aloitettava. Tutkimus onnistui luomaan mallin sekä aikajanan taloussuunnittelulle ja avaa tutkimusalueen, jota on harvemmin käsitelty kaivoksen sulkemiseen liittyvissä tutkimuksissa.

Foreword

A learning experience is one of those things that say, "You know that thing you just did? Don't do that."
Douglas Adams

My road towards Master's Degree has been long and winding. The two years of active studying in the Master's programme was full of enjoyment, fatigue, long nights of studying, and doubled my usual consumption of caffeinated drinks, but all in all I feel it was well worth it. I worked full time while studying, moved across Finland, changed jobs, and my second daughter was born amidst it all. Let's just say I'll let out a sigh of relief once this is all over.

Nevertheless, I'd still do it all again if I'd have to!

All the hurdles I've crossed to be here, until this very moment, have only fuelled the fire for continuous learning and self-improvement. What's next? I don't know yet, but at least I know if I start something, I have the capability and willpower to finish it!

Joensuu, 27.8.2017
Harri Nikkonen

Table of Contents

Abbreviations

EBIT	Earnings Before Interest & Tax
EVL	Finnish Business taxation act
GAAP	Generally Accepted Accounting Principles
LOM	Life of Mine
LOMP	Life of Mine Plan
TUKES	Finnish Safety and Chemicals Agency
Up	Unit of Production

1 Introduction

This study revolves around the problem of financial planning in a short life of mine (LOM). Life of mine plan (LOMP or LMP) is a calculated estimate of the duration of mining operations with the available mineral reserves and projected scale of operations. The problem with the concept of LOMP is that the volume of the mineral reserve is a finite resource and any changes in the scale of operations will affect the longevity of the reserve. On the other hand, the volume of the reserve is based on an evaluation of the mineral resources which have deemed a portion of the resource economically and technologically extractable. However, the line between economically and technologically viable reserve and non-viable resource may change over time, due to changes in global and local circumstances. Once the inevitable end of the mining operations starts to loom over the everyday work, multiple issues will appear. Such as the fact that equipment need to be maintained, renovated, or even replaced every now and then to keep on the set level of operations, when financially the investments put in to the equipment will never have the time to get them fully repaid. (Paalumäki, et al., 2015; PricewaterhouseCoopers, 2012)

1.1 Background

The entire operation at a mine revolves around the concept of LOMP, which describes the projected lifetime of the mine. It is based on the estimated volume of the ore body and the estimated grades of the mined minerals in the ore. Based on the geological data, an economical model of operation is formed, which outlines the preferred level of operation, as in how many tons of ore need to be excavated and processed for the operation to be profitable. These aspects will give a life of mine plan, which infers the length of operation in years and months. (Paalumäki, et al., 2015; PricewaterhouseCoopers, 2012)

The basis for a LOMP is the geological data of the ore body. However, in the early stages of mine planning, the geological data is rough and cannot give an exact estimate of the entire ore body or the mineral grades of the ore, although the more geological data is available on the ore body the higher confidence level the estimates have. Once in operation, geological surveys in the mine will enhance the geological data and will give a more accurate estimate for the LOMP, or the duration of the mine. Uncertainty in the geological data and changes in the level of operation may lead to either

lengthening or shortening of the LOMP. This aspect of mining operations causes problems in financial planning. (CRIRSCO, 2012; PricewaterhouseCoopers, 2012, pp. 13-14)

1.2 Objectives and scope

The objective of this study is to form a framework for financial planning purposes, where the changes in mineral reserves and the length of LOMP are taken into consideration. The study revolves around financial aspects of the planning of the closure of a mine, which include pre-closure and post-closure financial plans for the operation.

Research questions for the study are

- *What are the mining industry specific aspects in financial planning, when the mine is in the latter stages of operation?*
- *What financial aspects need to be considered in the wind-down stage of a mine?*
- *How should the end of mining operations be considered in long-term planning?*

Based on information gathered during every day accounting activities and informal interviews before the start of the study, mining industry has its own distinct methods for financial planning and budgeting. Although every mine has a designed life of mine from the early stages of starting mining operations, the gravity of certain aspects of financial planning and budgeting take a more significant stance as the closure of the mine draws nearer. The first research question covers these aspects, as the more imminent the closure is the more detailed the planning of these aspects needs to be.

Stemming from the first research question, the second question proceeds in finding the aspects to be taken into closer consideration as the wind-down to closure has begun. In this stage, certain parts of the mining operations are stopped or run at a lower level of operation. The research question seeks to identify the affiliated financial aspects.

Relating to the first and second research question, the third question seeks to cover the planning aspects found from the preceding questions in the frame of long-term planning, as the identified aspects will have significance in financial reporting and results, which in turn requires these aspects to be covered in the planning of future financial periods.

This study covers only the financial side of planning for mining operations in the short-term and long-term. Planning for the actual operation of the mine, including mining, stoping, milling, and exploration, is excluded from the study. Implementation of the framework created in the study is excluded from the scope, and the study mainly approaches the problem from a theoretical point of view.

1.3 Methodology

Research in economics can be categorized to five main categories: concept analytical, nomothetic, decision methodological, action-oriented, and constructive approaches. The five research approaches are positioned relative to each other in Figure 1. The positioning is based on the theoretical nature of the research, and whether the research is descriptive or normative, although action-oriented and constructive approaches are not strictly limited to their individual boxes. (Kasanen, et al., 1991, p. 317; Olkkonen, 1993, p. 61)

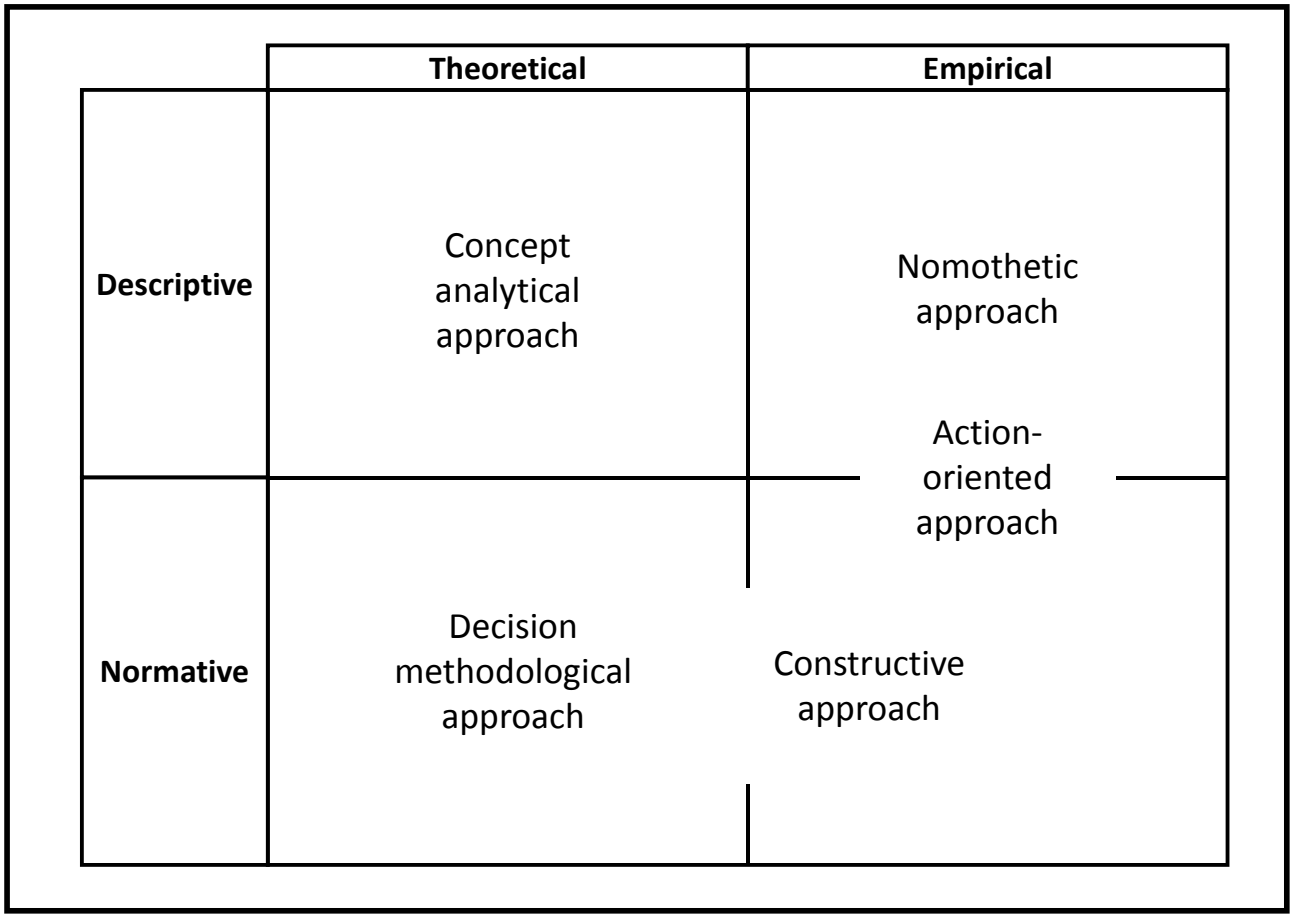

Figure 1. Relative positioning of research approaches in business economics research (Adapted from Kasanen, et al., 1991, p.317).

Concept analytical approach aims to produce a concept system, which is based on previous concept analytical studies or empirical research. This type of research is more focused on argumentative reasoning and not so much in verification of conclusions. The area of the study may concentrate on facts, values, or norms and conclusions may be declaratory and descriptive, or suggesting and recommending. (Olkkonen, 1993, p. 61)

Nomothetic approach centers on explanatory study of causalities. According to Olkkonen (1993, p. 61) this approach is ideal for research in natural sciences with a great emphasis on the empirical portion of the study. Nomothetic approach is heavily controlled by methodological rules, and the results and conclusions are essentially laws.

Decision methodological approach revolves around research in decision making and improving problem solving methods. Ideally this type of research in concentrated on logic and mathematics. Empirical portion of the study is usually an exemplary application of the theorem, and the results are solutions to the explicated problems. Decision methodological approach has its base on theoretical derivation of normative results. (Olkkonen, 1993, pp. 61, 76)

Based on Olkkonen's (1993, p. 76) research methodological review, constructive approach is clearly normative in its goals and targets, and its basis is in developing problem-solving methods, and as such it is closely related to the decision methodological approach.

Another way of viewing research approaches is to aggregate the research approaches to quantitative and qualitative approaches. Quantitative and qualitative approaches are concerned with the type of research material and how it is handled for the purposes of the study. In qualitative research, the research material is mostly in a verbal or visual format. Quantitative research in turn has research material representable in a numerical format. The choice between qualitative and quantitative research approach depends largely on the nature of the phenomenon that is being researched. The researched phenomenon may be singular or generic in its nature. A singular phenomenon is a specific, identifiable effect, event, or a chain of events. A generic phenomenon refers to a category of effects or events. Basically, a singular phenomenon cannot be statistically researched, since it is a one-off event, but a generic phenomenon can be quantified and statistically researched as the generic phenomenon holds a number of similar events. A singular phenomenon could be a single conflict of war, whereas a generic phenomenon is war as a phenomenon itself and a number of conflicts could be statistically reviewed and researched. (Uusitalo, 1991, pp. 78-80)

A constructive research approach rises from the concern that academic management accounting, especially the research conducted around the subject, has diverged from the actual needs of business management, and management accounting in this sense is in crisis. Constructive approach is especially meant for research in business management and accounting. Constructive research refers to research that seeks to build a model, method, or a plan for problem solving, which is referred to as a construct. Constructive approach has a great emphasis on the practicality of the solution, which helps to close the gap between academic research and the practical needs of business management. In this sense, constructive research is a type of an applicative research method. (Kasanen, et al., 1991)

Figure 2 shows the components of constructive research, where the result of the research is the construct used for problem solving.

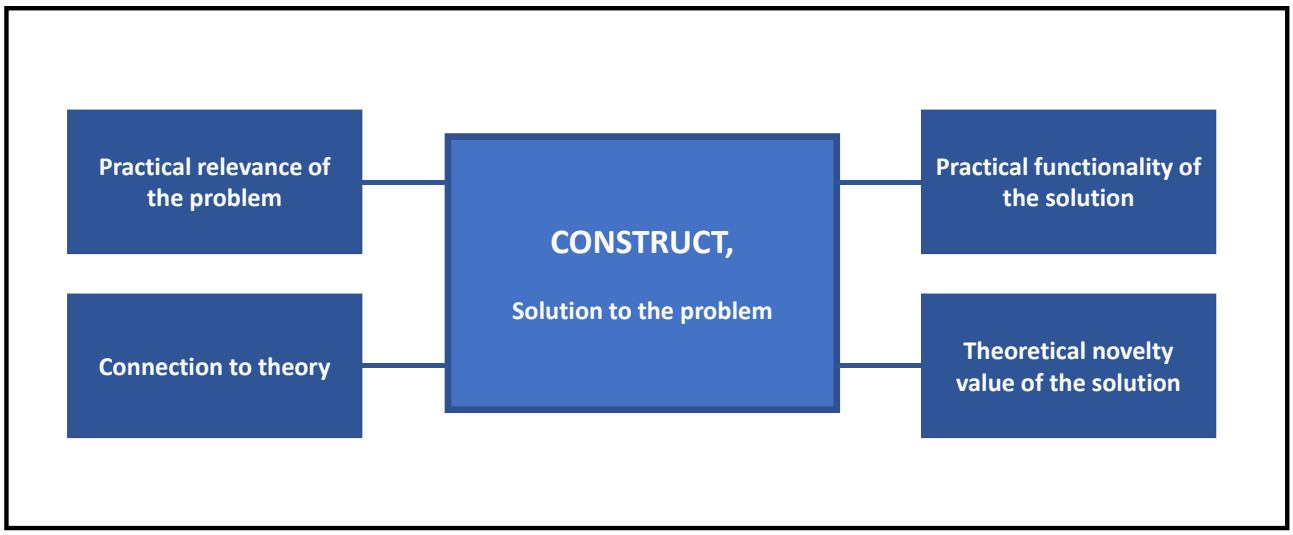

Figure 2. Components of constructive research (Adapted from Kasanen, et al., 1991, p. 306).

The constructive approach can be split into six individual phases as follows (Kasanen, et al., 1991, p. 306):

1. Searching for the relevant research problem
2. Gaining preliminary understanding of the problem
3. Innovation phase
4. Testing the solution
5. Demonstrating the theoretical connections of the solution
6. Reviewing the breadth of the solution's suitability

The principal structure of a constructive research is shown in Figure 3. The key aspect of the structure of constructive research is the testing and revision of the solution model, and demonstrating the usability and novelty of the constructed model.

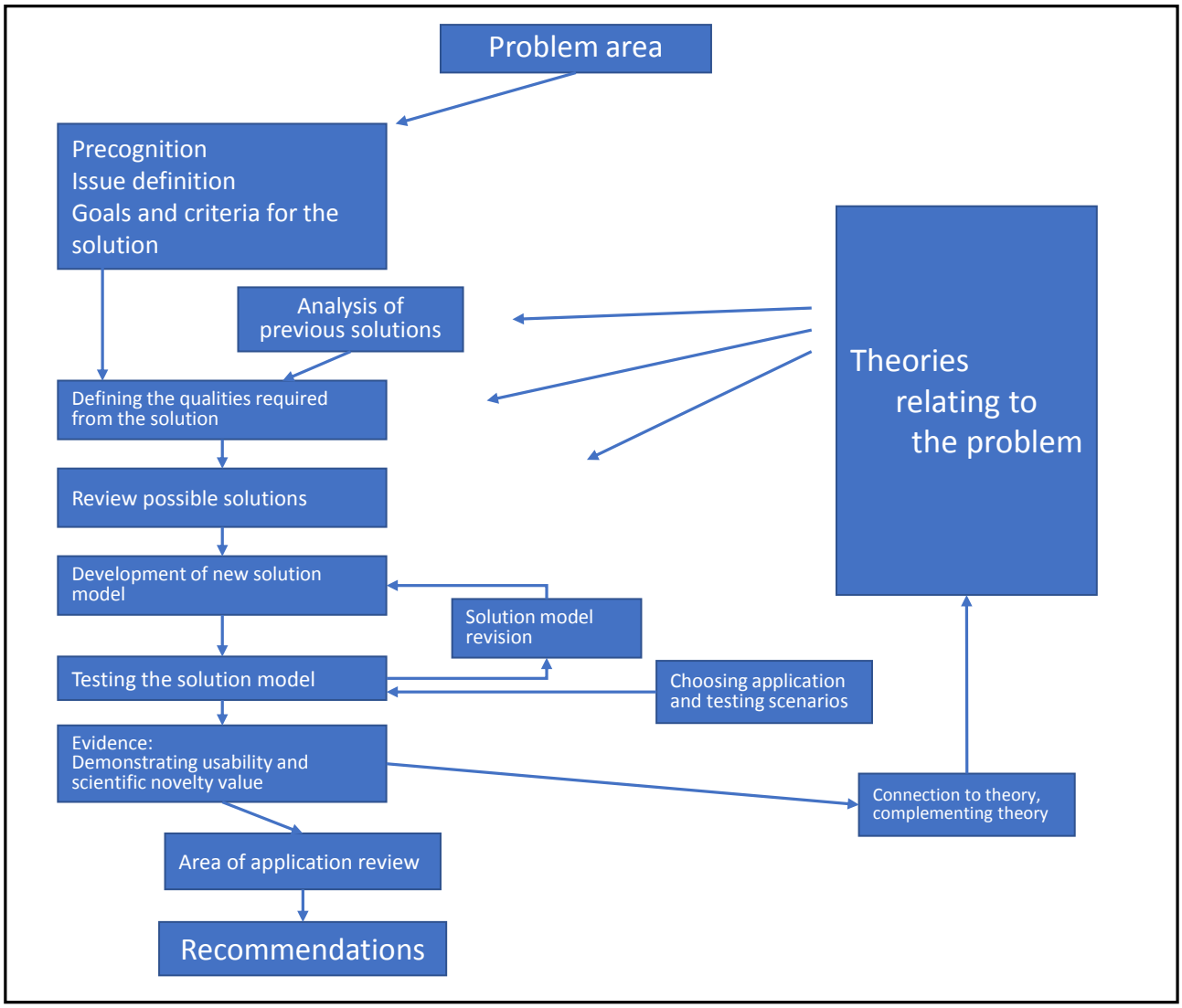

Figure 3. Principal structure of constructive research (Adapted from Olkkonen, 1994, p. 79).

This study seeks to improve financial planning in the mining industry through research of literature, with an application for a case organization as a result. In this set up, the study should have a constructive research approach, which seeks to build a framework for financial planning. As this study is now deemed to be a constructive research, the six phases approach will be adopted in the research.

1.4 Structure of the study

The structure of this study includes the following chapters: introduction; mines, mining, and the mining industry; financial planning and control; building the framework for planning; results and discussion; conclusions; and summary. The structure is shown in Figure 4, where the chapters are grouped to literature review and empirical study.

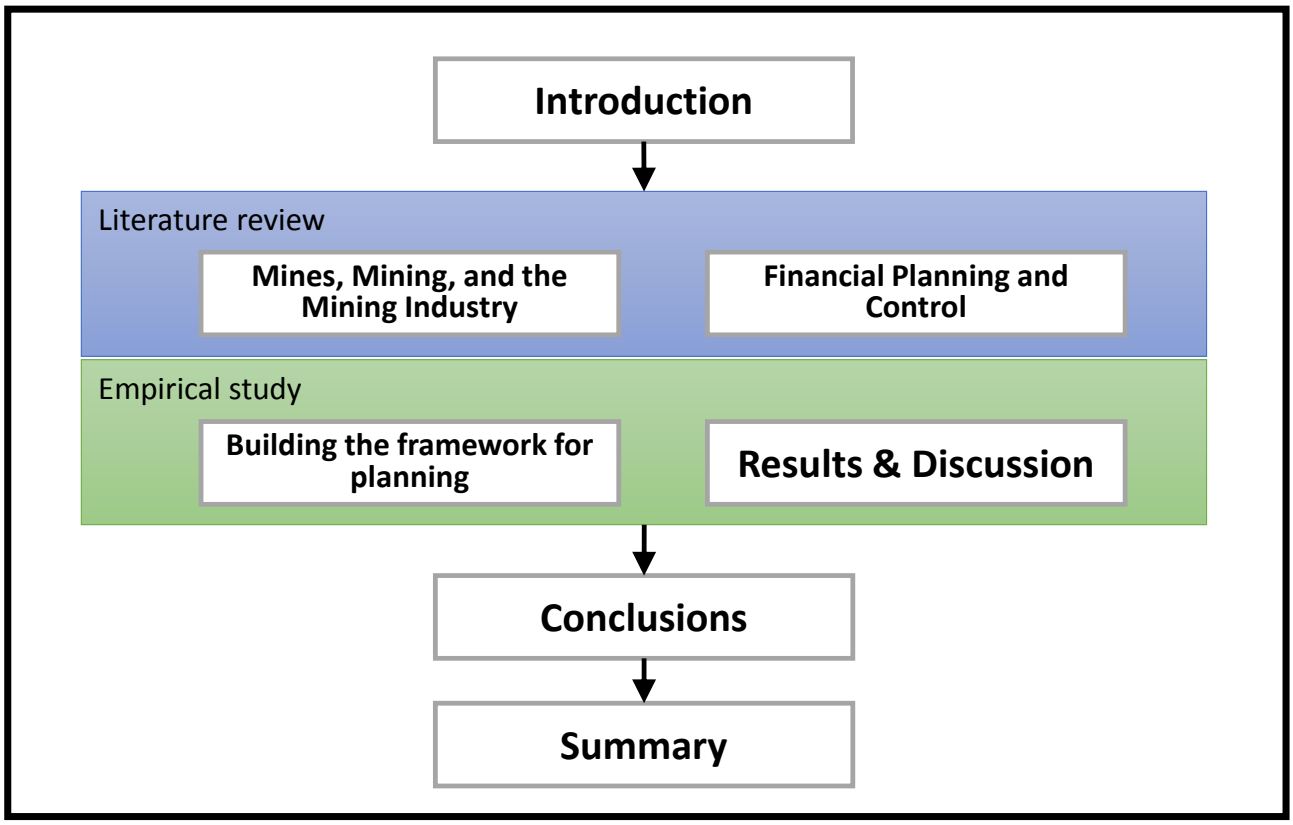

Figure 4. Structure of the study.

The introduction conveys the background for the study and outlines the specific problem that will be handled in the study. The chapter also presents the theoretical outlines, research methodology, and the research questions.

The chapter "Mines, mining, and the mining industry" introduces the industry where the study is placed, and offers an overall explanation on mining, and the mining industry specific circumstances affecting the outcomes and planning specific aspects that need to be taken into consideration at various points in the study.

Financial Planning and Control covers aspects of financial planning in accordance with the mining industry specific aspects, but also provides a broader view of the related topics, so the framework being built will incorporate enough breadth to be a theoretically viable option for planning.

The chapter “Building the framework for planning” will introduce the case organization and the specific problem with a more detailed explanation of the facts that have led to the problem in the first place. The current state of planning at the organization is covered, and is also viewed in comparison with the aspects found from the theory review. The chapter also creates the framework that will be used at the case organization to plan for closure and financial aspects of the process.

“Results and discussion” will cover the results achieved through the built framework and how it will affect the future of planning in the case organization. The chapter also covers the theoretical gravity and significance of the study, and the research questions are reviewed in the view of the concluded study.

“Conclusions” will analyze the observations and the achieved results from the study, and summarizes the conclusions drawn from the results. The chapter also gives recommendations on the topics that should be covered in future studies into the subject area, and how the results can be used in the industry.

“Summary” will recapitulate the study, review how the objective of the study was met, what kind of framework was created, and how the research questions were answered.

2 Mines, mining and the mining industry

Finland has a long history and tradition of mining, as the earliest documented mine, the Ojamo iron mine, was founded before the year 1530 in Lohja. Since then Finland has hosted mining operations of international quality, including the world class mineral deposits of carbonite-hosted apatite deposit in Siilinjärvi and chromite ores in Kemi. (Heikkinen, et al., 2008, pp. 17-18)

A mine is an excavation made into the ground to extract minerals whereas mining itself is described as an activity, an occupation, and an industry concerned with the extraction of minerals. Humankind has practiced some form of mining since the Stone Age. Since prehistoric times, humans have used different types of minerals for tools, weapons, ornaments, currency, and so forth. Mined minerals are categorized as metallic ores, nonmetallic minerals, and fossil fuels. (Hartman, 1987, pp. 1-2)

Mining as an activity refers to the extraction and enrichment or refinement of metallic ores, coal, and industrial mineral deposits. The commodities exploited by the mining industry fall into four categories in Finland (Heikkinen, et al., 2008, p. 11):

1. Metallic ores
2. Industrial minerals
3. Gemstones
4. Marble and soapstone

Metallic ores consist of ferrous metals (such as iron), base metals (among others, copper and zinc), precious metals (for example gold and silver), and radioactive minerals (for example uranium). *Nonmetallic minerals* are also known as industrial minerals. Industrial minerals are not used in the production of metals. Such minerals include for instance phosphate, sand, gravel, limestone, sulfur. *Fossil fuels* are also known as mineral fuels. They are organic mineral substances, which can be utilized as fuels. Such substances include coal, petroleum, natural gas, tar sands. Apart from other types of minerals, petroleum and natural gas have evolved into an extraction industry of their own, that are not incorporated into the traditional concept of mines and mining. (Hartman, 1987, pp. 3-4)

Comparing the definitions provided by Heikkinen et al. (2008, p. 11) and Hartman (1987), The Finnish Mining Act (261/2011) covers only metallic ores and industrial minerals, as categories 2 to 4 are all grouped into industrial minerals in Hartman's categorization. With the exception of marble

and soapstone, other natural stone commodities are covered in the Land Extraction Act of Finnish law (Land Extraction Act 555/1981). In the revised Finnish Mining Act (Mining Act 261/2011), mining minerals are group into three categories: chemical elements, minerals, and rock types. In this categorization, marble and soapstone are grouped into the rock types category. In the new legislation, the gemstones category is grouped into the minerals category along with the other minerals with industrial applications.

2.1 Definition of mineral resources and reserves

The Committee for Mineral Reserves International Reporting Standards (CRIRSCO) standardizes the terminology used to define the way the mining industry reports available mineral resources. *Mineral resource* is a deposit of material of economic interest, which is of such quality that can be reasonably extracted from the Earth's crust. Mineral resources are divided into categories based on increasing confidence of geological data. The mining of ores revolves around *mineral reserves*, which are defined as economically mineable part of a measured and/or indicated mineral resource. (CRIRSCO, 2013)

Geological data on the mineral deposit is scaled on the level of geological knowledge and confidence to *inferred*, *indicated*, and *measured*. These define the overall volume of the mineral resources. (CRIRSCO, 2012)

When a part of the mineral resources is deemed viable for economical mining operations, the mineral resources are turned into mineral reserves, which are scaled as *probable* or *proved*. *Modifying factors* affect the point, at which a mineral resource may be turned into a mineral reserve. Such factors could be, for instance, infrastructural, if the area surrounding the mineral deposit is being developed, which in turn diminishes the amount of needed infrastructural development on the part of the mining company. The correlation between geological and mining technical terminology on mineral deposits are described in Figure 5. (CRIRSCO, 2012 & 2013)

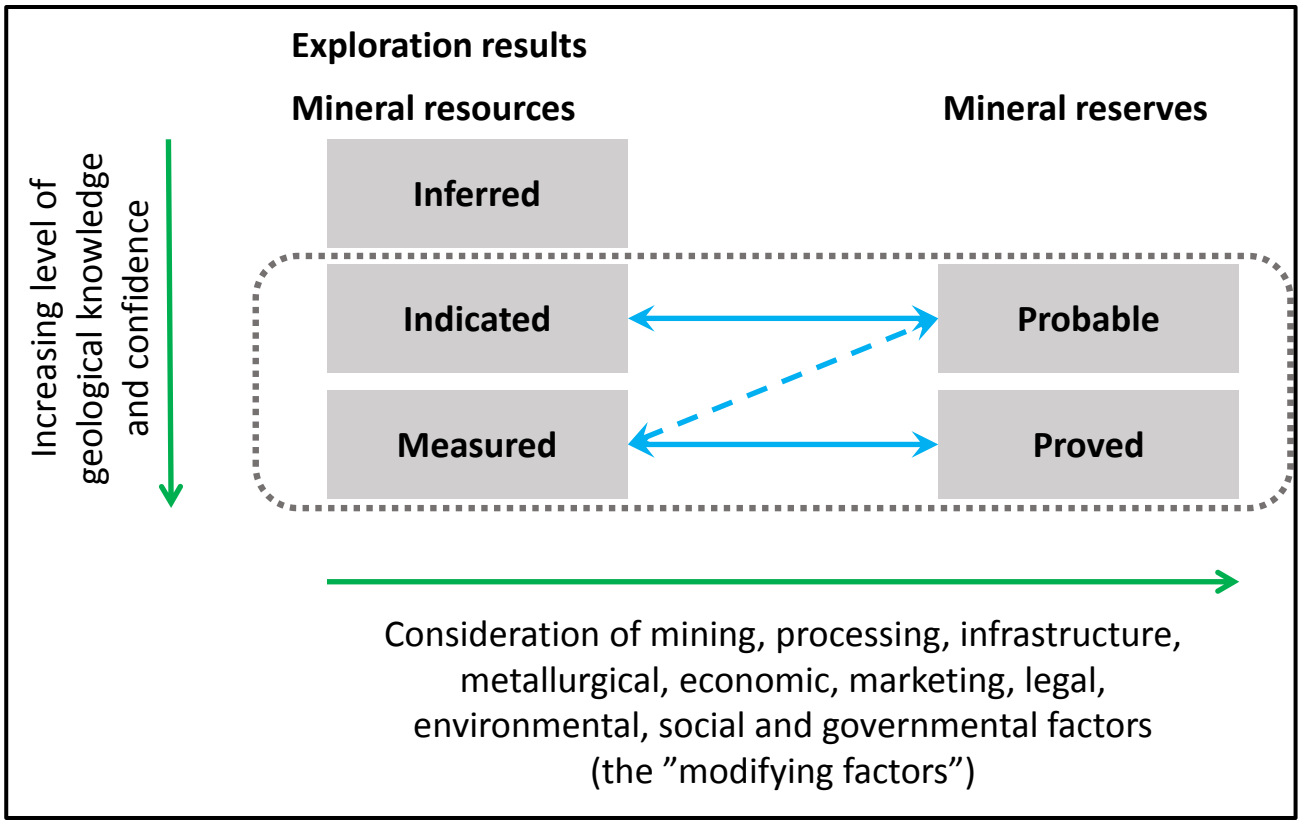

Figure 5. Mineral resource and reserve definitions (Reproduced from CRIRSCO, 2012, p. 2).

Plummer et al. (2010, pp. 544-545) specify the difference between indicated and measured to inferred, as the difference between direct measurement of mineral resource by drilling or mining to statistical modeling and logical guesswork. In this context, inferred mineral resources have a higher level of uncertainty compared to indicated and measured resources. The size of a mineral resource does not change over time; in essence, its value is fixed. However, the portion of the mineral resource that is economically mineable (i.e. the mineral reserve) may change over time, due to changes in economic modifying factors, such as metal prices.

In the early 20th century, copper mines were profitable only if the copper concentration in the rock was above 5 %. By the 1980s the percentage of profitable mining of copper had dropped to 0.5 %. The effect of improvements in mining, processing, and enrichment techniques, in addition to the overall effect of global metal prices changes the volume of global mineral reserves in metals. This gives a volatile and erratic overtone to the mining industry and the metals market. Although these effects are clear, there always seems to be an abundance of iron and aluminum, moderate reserves of copper, lead, and zinc, and only a limited amount of gold and silver available. Mineral extraction and processing takes a lot of energy to produce mineral concentrate as an end product. This leaves the mineral extraction industry closely connected to the global energy market and prices. Since

mineral extraction is an energy-intensive industry, rising energy prices may diminish the global mineral reserves correspondingly. (Plummer, et al., 2010, p. 545)

Mineral reserves and resources are an indispensable source of income and a vital economic asset for any mining company. The reserves and resources also form the basis for acquiring financing for a mining project. Changes in the reserves and resources have a universal effect on the financial statements of said mining entities. Such effects are as follows (PricewaterhouseCoopers, 2012, p. 16):

- Charge for depreciation and amortization.
- Calculation of stripping adjustments.
- Determination of impairment charges.
- Expected timing of future decommissioning and restoration, termination and pension benefit cash flows.
- Allocation of the purchase price in business combinations.
- Capitalization of exploration and evaluation costs.
- Accounting for financial instruments.

Costs for exploration, evaluation, and development may be capitalized based on the accounting policies of the mining entity (PricewaterhouseCoopers, 2012, pp. 39-40).

2.2 Workings of a mine

Mining is roughly divided into two types of mining operations: surface mining and underground mining. The difference between the two is whether excavation used for mining is entirely open or operated from the surface, or if the excavation consists of openings allowing human entry below the surface. (Hartman, 1987, p. 4)

Primary surface mining type is the open-pit mine. The basic layouts of an open-pit mine and an underground mine are described in Figure 6 and Figure 7. The mining operations in these two types have common items, such as the rock crusher, concentrator, tailings pond and clarification pond. The actual mining method is vastly different, as are also the type, grade and volume of the mined ore. (Boliden, 2016)

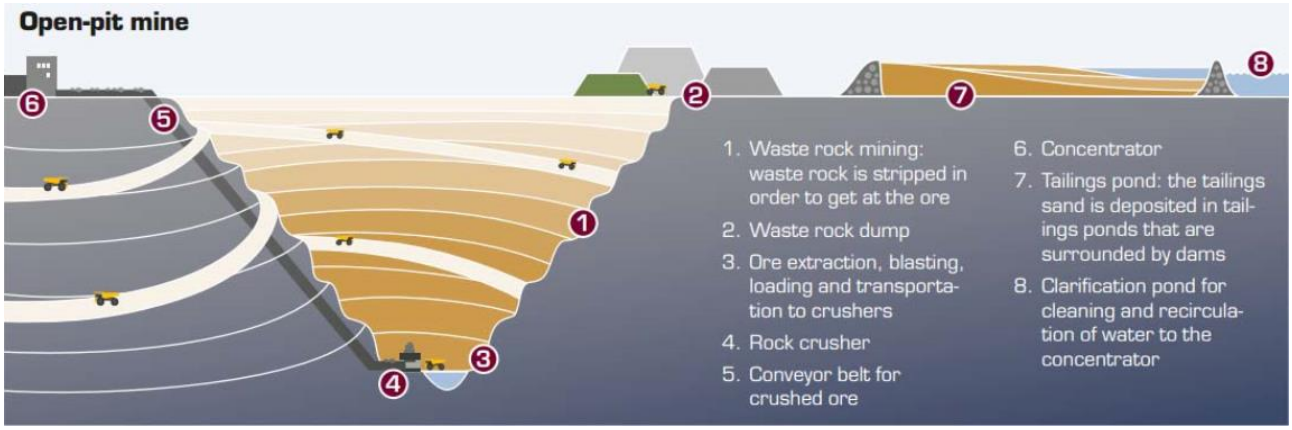

Figure 6. Layout of an open-pit mine (Boliden, 2016).

Open-pit mining, or quarrying, is usually more profitable, and technically easier to operate than underground mining, with the exception of underwater mining or areas with unusual top soil or geological formations above the mineral resource. Compared to underground mining, the volume of mined waste rock is much larger, and needs substantially larger areas for landfill. (Paalumäki, et al., 2015, pp. 107-108)

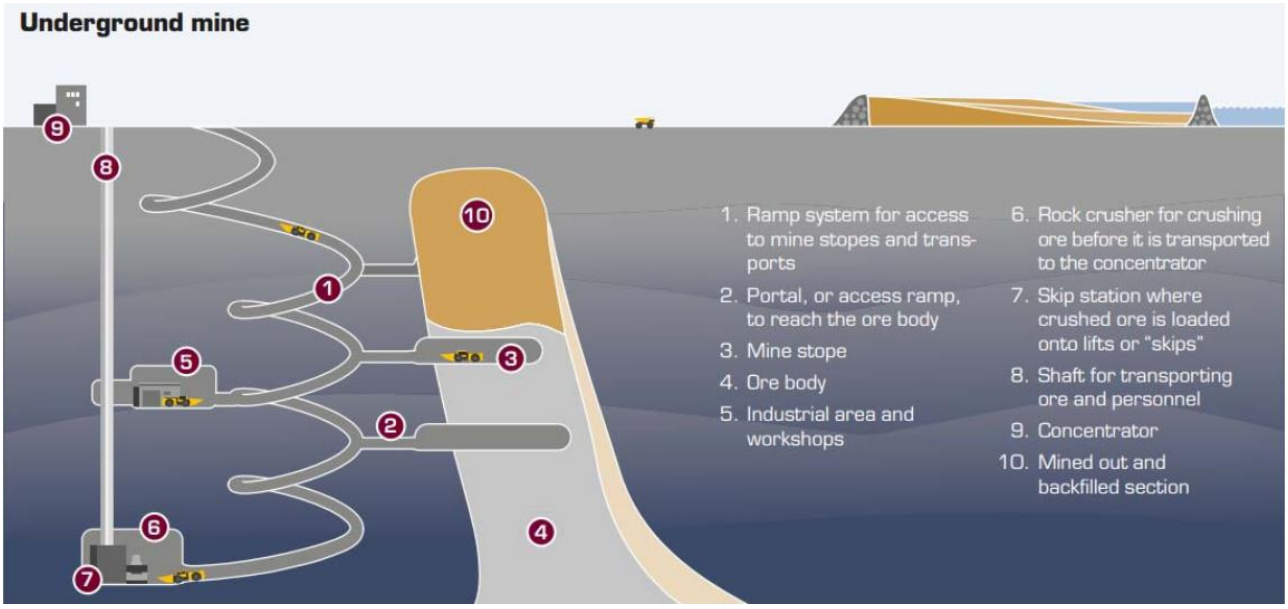

Figure 7. Layout of an underground mine (Boliden, 2016).

The parts of the ore that reach surface should be mined using the open-pit method. The open-pit method is more cost efficient, the ore gets excavated more accurately, and the ore production starts sooner than in underground mining. However, beneath a certain depth, the cost of open-pit mining exceeds the cost of underground mining, and the volume of waste rock rises the deeper the

excavation proceeds. The volume of waste rock is much smaller in the underground mining method, which in turn has a smaller environmental impact than the open-pit method. If the ore body is narrow, less than 50 meters wide, underground mining is the cheaper option starting from a depth of 100 meters. With over 50 meters wide and 500 meters long ore bodies, the open-pit method is cheaper even at a depth of 200 meters. However, the optimal depth for the open-pit method needs to be considered case by case, due to the difference in circumstances between mine sites. (Paalumäki, et al., 2015, pp. 115-116)

2.3 Life cycle of a mine

According to Paalumäki et al. (2015, pp. 438-439) the life cycle of a mine is divided into six primary stages: exploration, profitability evaluation, mine construction and establishment, mining operation, mine closure, and aftercare. However, according to Laurence (2006, p. 285) the mine life cycle consists of only four stages: exploration, development, production, and closure. Paalumäki et al. have defined stages in the life cycle that have major impact overall and have raised them to independent stages of their own. Evidently Laurence includes profitability evaluation into exploration stage, and aftercare into mine closure stage. According to Heikkinen et al. (2008, p. 11), the mining life cycle only consists of three main stages: exploration, production, and rehabilitation. The model of LOM Bennett et al. (2016, p. 34) suggest includes seven phases: exploration, feasibility, planning & design, construction, operations, decommissioning & closure, and post-closure management. As the study of Bennett et al. (2016) revolves around the topic of mine closure, it is understandable that the later stages and phases of mine life should be split to more detailed level. PricewaterhouseCoopers (2012, pp. 13-14) categorizes the mining operation and life cycle to five phases, taking the middle road in the number of phases in the reviewed publications. According to their findings, the five most common phases are exploration, evaluation, development, production, and closure & rehabilitation. While simplifying the topic of LOM, it seems feasible to consolidate certain stages or phases into one. The more detailed stage categorization may provide additional possibilities for different types of planning, so depending on the need of the study, the number of stages may vary accordingly.

Exploration is usually a long-term process, lasting a few years or even decades. In the latter stage of exploration phase, the viability of the found deposit is evaluated through test mining and sample enriching. Exploration costs are incurred from discovering the possibly exploitable mineral resource, and evaluation costs from feasibility and viability studies conducted on the discovered

resources. Costs from exploration and evaluation activities can be either expensed or capitalized, based on the accounting policy of the entity conducting the activities, although expenditure incurred before the legal right to explore are generally expensed with the exception if the legal right has been purchased as an intangible asset. (Paalumäki, et al., 2015, p. 440; PricewaterhouseCoopers, 2012, pp. 18-19)

After the exploration and evaluation activities have produced an economically exploitable mineral reserve, the opening of a mine may commence. The first stage of opening a mine is the construction phase, where various preparatory works are carried out. Large portion of the preparatory work consist of construction of the surface infrastructure. This include local road network, electricity, structures for ore handling, processing and management, maintenance and office buildings, structures for extractive waste management, and water management systems. If the concentrator is also to be situated at the mine site, there's also a need for concentrate tailings management area, mainly a tailings pond. The mine construction phase takes around one to two years to complete, which largely depends on the already available infrastructure and general location of the mine. Among the key decisions during the construction phase are the solutions to handle emissions and the environmental impact of the mine. These decisions have a long-term effect on the surrounding environment, as for example the decisions affecting extractive waste handling and water management structures cannot be changed at a later stage. These decisions also have an impact to the closure stage of the mine, so the affected time period could be decades long. (Paalumäki, et al., 2015, pp. 440-441)

In the production stage of the mine life cycle, the ore is extracted from rock by stoping. The ore is then crushed and milled for the enrichment process. The minerals and/or metals are then separated from the ore using either suitable chemicals or mechanical separation. The enrichment process is done in a concentrator at the mine site, or the ore is transported to an offsite concentrator. The mining and enrichment processes are described in Figure 8.

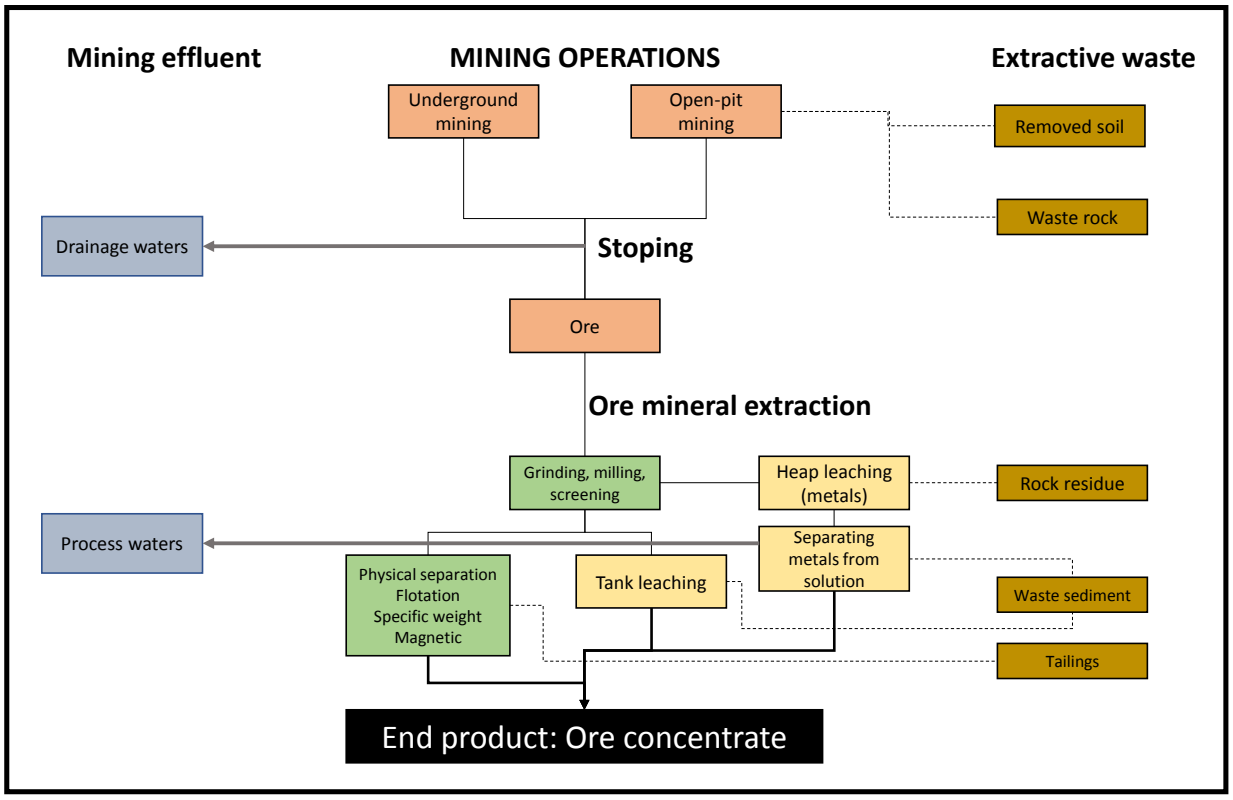

Figure 8. Overview of mining processes (Adapted from Paalumäki, et al., 2015, pp. 441).

The ore mineral extraction phase is largely determined by the type of metals needed to be extracted from the ore. This affects the chemicals being used in the process and if leaching is needed for the extraction. After the ore mineral extraction phase, the end product is produced, which is the metal concentrate. (Paalumäki, et al., 2015, pp. 441-442)

After the production stage, the mine closure begins. Mine closure is defined as the final stage of mining activity, as the production and processing have ceased and the mine will be decommissioned. Activities directly related to the closure of the mine, such as site rehabilitation and after operations monitoring, will begin at this stage. Mines may close for various reasons. Closure may be final or temporary, if the operation is thought to continue at some point in the future. Often mines close for geological reasons, meaning the ore reserves have depleted, but mostly the remaining known resources are not economically mineable. Other reasons for closure may include adverse geotechnical conditions, major equipment failure, regulatory reasons due to environmental or safety breaches, or even policy changes due to governmental activities. A major affecting factor may also be societal or communal pressure, which is a constant affecting factor in modern day society. (Laurence, 2006, pp. 286-288; Heikkinen, et al., 2008, p. 21)

Bennett et al. (2016, p. 1) define mine closure as a narrower concept, that does not include mine completion, relinquishment, nor post-mining land use. However, this stage is viewed as a part of LOM and is called post-closure management. Relinquishment refers to the stage of mine completion where mine completion criteria are viewed as met and the mining company receives a formal approval from the regulating authority for final mine closure. (Bennett, et al., 2016, pp. 1, 114)

As mining and exploration permits and other concessions are in the heart of any excavation activity, they are a valuable commodity even in the closure stage of a mine. Although the mineral reserve might be depleted in this stage, there are usually minerals still left in the resources which were previously deemed as not economically mineable. Based on the interview with geodata project engineer at the case organization, there are three most common practices for the handling of concessions during or after mine closure:

1. The mining company owning the concessions is kept alive as a shell company, until a new operator is found, or the concessions expire.
2. The concessions are sold, or are handed over to another company.
3. Premature expiration of the concessions is requested from the Finnish Safety and Chemicals Agency (TUKES).

After the concessions have expired, the properties are returned to their respective owners in full, and final measures are taken according to the latest up-to-date legislation. Environmental monitoring is carried out based on the environmental permit given to the mining entity, even after the expiration of the concessions.

According to the Mining Act (621/2011), the mining operations cease once the mining permit is cancelled or expires. Within two years of the end of mining operations, the mine operator needs to restore the mining area and the mine auxiliary area to a condition complying with public safety, look after the cleaning, rehabilitation, and landscaping of the area, and carry out the measures stated in the mining permit and the mining safety permit. As with the general rehabilitation of the area, mined minerals and buildings need to be removed from the mining area within two years from the end of the operations. After two years, the minerals and buildings are transferred without compensation to the landowner, who may require them removed from the property at the expense of the operator. The operator needs to inform the mining authority of the completion of the mine area

rehabilitation. After the completion, the mining authority is responsible for the final inspection of the mining area. The operator is still responsible for the monitoring and aftercare of the mining area and the associated costs, even after the completed rehabilitation. If the operator no longer exists, the land holder or the mining authority are responsible for the said tasks. If the land area has been returned to the landowner, the mining authority is responsible for the aftercare and monitoring. (Mining Act 621/2011, 143-144§, 150§)

Costs associated with mine closure should be considered over planning, execution, and monitoring periods, and should at least cover the following aspects and steps in closure management (Slight & Lacy, 2015, pp. 123-124):

- Site closure planning costs, including staff, research, investigations and analysis, to develop the closure plan and carry out progressive rehabilitation activities.
- Transition to closure takes place during the last 24 to 60 months of operations, during which detailed closure planning, preparation and implementation works are started.
- Closure execution (active closure) usually starts when operations and production have stopped. Decommissioning, demolition, and rehabilitation works start at this point.
- Post closure monitoring and maintaining (passive closure) is the post closure period, that leads up to the final relinquishment of the mineral tenements. The post closure period may take up to 30 years, and in some cases, may never be truly achieved.

Early incorporation of closure planning and recognition of closure costs integrates closure into mine planning decisions, while implementing progressive closure and rehabilitation strategies reduces long-term liability during operations. Deeply-rooted closure planning and cost estimating process guarantees that investments, development, and operating decisions are made with the full recognition of the financial impacts of closure to the operations. (Slight & Lacy, 2015, p. 124)

2.3.1 Mine closure types

Mines may close for various reasons, some more probable than others, but all in all, the probability of closure should be taken into consideration in the operational planning of a mining organization. This section will take a brief look at some recorded mine closures according to Laurence's study (2006) in the subject area.

Closure due to economic reasons may happen at a significantly fast pace. According to Laurence (2006, p. 287), this type of closure originates from the mining company losing its profitability due to a significant drop in the metal prices at the global market. Economic closure may happen due to the company operating the mine going bankrupt, which in turn leads to an unplanned closure and leaving the mining site without proper rehabilitation and aftercare. Without proper rehabilitation and reclamation, the mine site is left with potentially environmentally hazardous materials, and in turn will greatly affect the local population, flora, and fauna.

Closure due to geological reasons refers to premature closure of the mine due to over-estimation of ore reserves. The ore reserves are evaluated on the tonnage and grade of the ore; however, the volume and the quality of the ore reserves are only best guess estimates based on the data attained by various examination methods. Even a slight over-estimation of the grade of the ore will directly lead to a greater effect on the profitability of the mining operation. Although the over-valuation of the ore reserve has a dire effect on the operational outcomes, closure due to geological reasons is a much more controlled closure than an economic closure. (Laurence, 2006, p. 287)

Closure due to geotechnical reasons according to Laurence (2006, p. 287) refer to the geotechnical environment of the mined rock mass. Rock is rarely homogenous material, which leads to an always changing working environment. Imperfections in the rock in the form of geotechnical features may cause failures in the rock mass. Failures in the rock mass have caused numerous pre-mature closures, for example in the form of inrush of water to the mine, which in turn has led to filling in of the mine. Inrushes have also caused casualties in the mining industry, so the geotechnical failures have high potential to cause at least a temporary closure.

Closure due to equipment or mechanical failure at a mine could be among the most catastrophic types of failures, as most underground mines are heavily dependent on machinery, such as water pumps and ventilation equipment. Laurence (2006, p. 287) recounts one gruesome example in this closure type from the United Kingdom in the year 1862, when a Cornish Beam pump at the Hartley mine collapsed into a ventilation shaft. This lead to the deaths of 199 miners at the mine, and subsequently ended in the closure of the mine.

Closure due to regulatory pressure refers to governmental pressure towards the mining company for environmental or safety breaches. Governmental regulatory bodies can close mines for said breaches and stock exchanges can stop trading the stocks of the company. Such actions have been

taken even in the recent years, for example a cyanide spill in a Romanian Baia Mare gold mine caused wide spread environmental effects and took two years for the local ecosystem to start recovering. (Laurence, 2006, p. 287)

Closure due to government policy is imminent when governmental regulatory policies change. According to Laurence (2006, p. 287) such policies may regulate or inhibit certain types of mining altogether, for example the mining of asbestos, or policies that prefer national parks land use over mining operations.

Closure due to community opposition: in the present day, the mining industry receives much attention from the general populace. Public opinion tends to be against the mining operations when mining a controversial mineral, such as uranium or asbestos, or when the planned mining location has scenic value and the potential to have endangered species living in the vicinity. (Laurence, 2006, p. 288)

Closure due to other reasons are anything other than the previously described reasons. Based on Laurence's findings (2006, p. 288) such reasons could be for example that the new owner of the mine purchased the mine site for real estate purposes.

2.3.2 Risks of mine closure

Basic mine closure types are useful for evaluating the risk of mine closure from most commonly known types. Although the most typical closure types can be categorized, due to the nature of the mining industry the list of types is not conclusive, and new closure-related issues will undoubtedly appear occasionally. Knowing the possible risks help counter or reduce the impact of the events, which leads to a risk management model called Closure Risk Model. Companies with multiple mining sites may use the Closure Risk Model the produce a Closure Risk Factor (C_{RF}) for comparing different mine sites on their total closure risk. Closure Risk Factor uses quantitative and qualitative measurements to capture the risk components of mine closure. (Laurence, 2006)

Closure Risk Factor can be calculated using the formula

$$C_{RF} = \sum(R_E + R_{SH} + R_C + R_{LU} + R_{LF} + R_T), \quad (1)$$

where R_E refers to environmental risk, R_{SH} refers to safety and health risks, R_C refers to community and social risks, R_{LU} to final land use risk, R_{LF} to legal and financial risks, and R_T to technical risks. (Laurence, 2006, p. 288)

Although it is valuable for an organization to know the risks of a single mine closure, due to the purposes of this study, the closure risk factor will not be included in this study, as the study is targeting the closure process of a single mine. The closure risk factor is a valuable piece of information for a mining corporation that manages multiple mining sites in varying social and economic environments. (Laurence, 2006)

2.4 Mine Planning

The utilization of mineral resources relies heavily on the profitability of the mining operation. That is the main reason why cost estimates and profitability calculations are a central part of mine planning. Decision making in mining operations is heavily based on certain presumptions on cost conditions. Such cost conditions are for instance the estimated metal price of the mined metal for a set time frame, or the total costs of investments needed before operations can start. Such investments are mainly mine construction and establishment related costs, such as civil engineering and earthworks with machinery and equipment purchases. (Paalumäki, et al., 2015, p. 85)

According to Paalumäki et al. (2015, p. 85), the primary input to mine planning is the geological model of the mineral reserve. The geological model describes the geometrical continuation of the mineral deposit, mineral content of the ore, and the petrographic makeup of the rock.

The selection of the extraction method is one of the most important technical and economic decisions of mine planning. If the ore reserve reaches surface, the decision between open-pit and underground, or a hybrid of the two is up to mine planning. If the operation starts as open-pit, the transition to underground mining is made on an economic basis, once the cost of underground mining is exceeded by the open-pit method. (Paalumäki, et al., 2015, p. 87)

2.5 Mine Closure Planning

According to Jones (2011, pp. 107-108) and Slight & Lacy (2015, p. 122), the most effective way to plan for mine closure is to plan right from the start of the entire mine project. Also, Heikkinen et al. (2008, p. 26) suggest that mine closure planning should be started as early as it is practically possible, even as early as during the mining concession application process or latest during the technical feasibility studies. A thorough closure planning process and planning of related costs will ensure that the operating, investment and development decisions are made with the full view of the potential impacts to the inevitable mine closure. According to the report by PricewaterhouseCoopers (2012, p. 14), expected costs from mine closure are linked to employee severance, restoration and rehabilitation, and environmental expenditures.

Closure planning consists of three closure plans that are developed in different stages of the mine life. **Conceptual closure plan** is prepared before the mining operation starts. **Operational closure plan** is prepared during operations, in which the conceptual closure plan is developed into a regularly updated plan. **Final mine completion plan** consists of a mine closure plan and a mine decommissioning plan. The mine decommissioning is comparable to the startup construction of a mine in its complexity and resource intensity. Figure 9 shows the approximate timeline for each closure plan type. In this figure, final closure plan includes mine closure plan and mine decommissioning plan. It should be noted, that during most of the LOM the updated plan is a conceptual closure plan, and an actual operational closure plan is formed from the conceptual plan with five years of mine life left. (Jones, 2011, pp. 107-108)

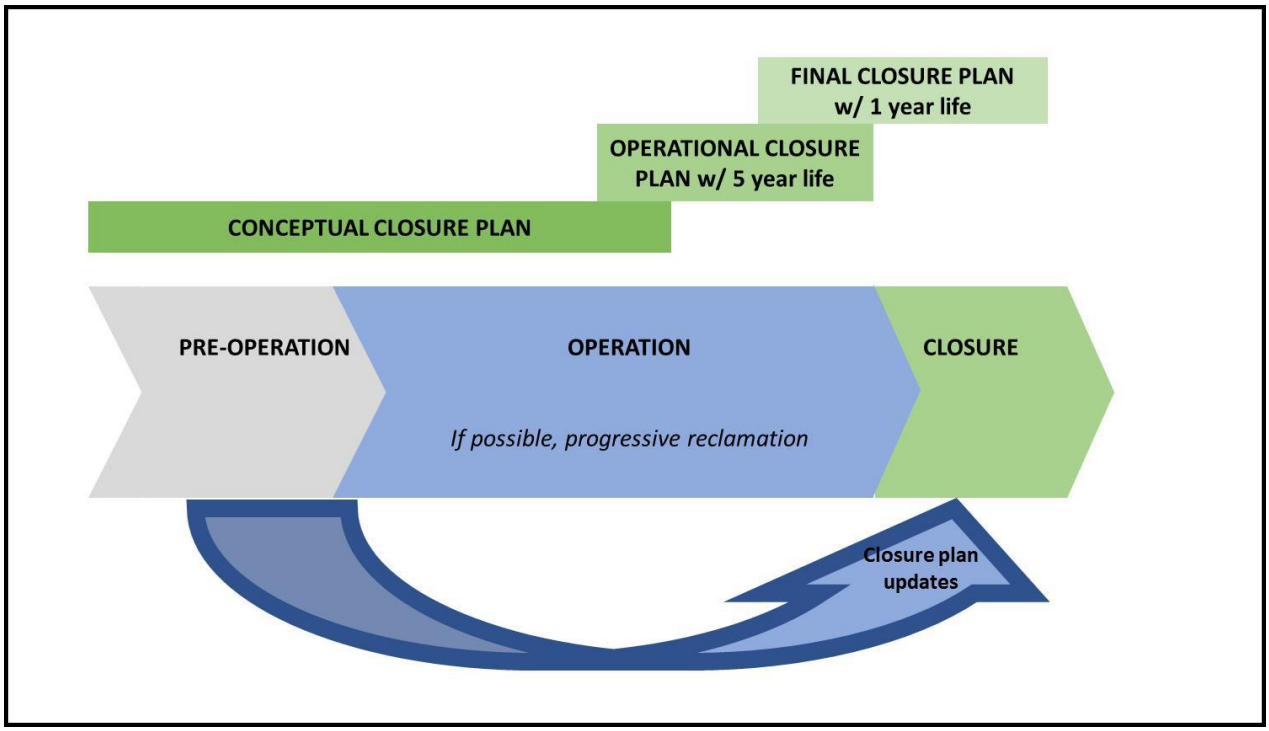

Figure 9. Timeline for closure plans in terms of mine life (Adapted from Jones, 2011, p. 107).

In closure planning, geological, engineering, financial, and ecological principles, as well as geomorphological processes need to be taken into consideration. The mine site will continue to exist well into the unforeseeable future after the mining operations have ceased. Ecological and geomorphological aspects center on the problem of the former mine site integrating back into the surrounding environment, where the landmasses left behind must be stable, nonpolluting, and even aesthetically acceptable. Geomorphological maturity of the mining waste placed near the mine is not the same as the surrounding landmasses. This means that the newly formed landmasses are more susceptible to rapid changes by weathering and erosion. Such structures include mine waste dumps, tailings structures, and open pits. Careful planning of mine closure during the operation of the mine will greatly enhance the after-operation transformation of the mine site back into the natural stage. (Jones, 2011, pp. 108-109)

Due to the nature of mining operations, it is difficult to avoid having at least some effect on the local environment and by that same nature it is virtually impossible to restore the mine site back to its former state. With advanced closure and rehabilitation techniques, and careful planning, it is possible to establish a functioning and diverse ecosystem to the former mine site. (Heikkinen, et al., 2008, p. 16)

In some cases, the local community may be largely dependent on the mining operations, as the local impact of a mine not only include the mining company personnel, but in many cases also a significant network of subcontractors and suppliers. Mine closure may have severe effects in the job market and the local economy, so a mine closure is not only the actual closing of a mine but a much larger undertaking altogether. Mine closure and completion require a significant amount of planning and careful consideration to account for all the effects that are caused by it. (Heikkinen, et al., 2008, p. 16)

If the mine and mill are a part of a mining company, whose primary task is running and operating the mine, at the end of the mining operations and closure, the company needs to be closed as well. Closing, or dissolving, a limited liability company requires going through the following procedures (Finnish Patent and Registration Office, 2014):

- Going into liquidation by decision of the General Meeting.
- Merger.
- Demerger.
- Bankruptcy.
- Deregistration, or liquidation by order of the authority.

In view of a mine closure, the likely options for closing a mining company are liquidation, bankruptcy, or deregistration. If the total debt of the company outnumbers the total assets, the closing of the company is handled through a bankruptcy process. However, according to the answers by the interviewees, if the mining company is a part of a larger mining group, the likely option is to keep the company alive as a shell company. The shell company would then still hold the mining and exploration permits and the associated liabilities, up until the permits expire, are sold, or a new operator is found.

3 Financial Planning and Control

Financial information forms the core of decision making in business operations, as it is a key input for making any sound decisions. Without financial reports, management cannot get the information needed to evaluate the performance of an organization or a company. In the evaluation of internal performance, cost accounting plays a central part in reporting of financial and non-financial performance measures. (Horngren, et al., 2012, p. 3; Kimmel, et al., 2004, pp. 2-3, 6)

Accounting is divided into financial accounting and management accounting. Some sources categorize cost accounting as a field of its own, but most categorize it as a function of management accounting. Financial accounting is centered on reporting the organizations financial position to external parties, such as government agencies, banks, and investors. Financial accounting provides financial statements that are based on local or international generally accepted accounting principles (GAAP). Management accounting tracks and analyzes financial and non-financial information for management, which helps management develop and implement strategy. Management accounting mainly provides information to internal stakeholders. Cost accounting gathers, analyzes, and tracks cost information relating to costs acquiring or using resources in the organization. Cost accounting provides information for financial and management accounting. Management accounting responds to managements information needs. Management reporting is split to three functions: cost accounting, target and control calculations, and alternative calculations. Cost accounting includes product and service pricing, and customer profitability. Target and control calculations include financial and operations planning and control, and process and operations development. Budgets are a planning tool for target and control function. Alternative calculations are used for comparison between alternative decisions and investment planning. (Horngren, et al., 2012, pp. 3-4; Horngren, et al., 2014, p. 7; Jormakka, et al., 2015, p. 13)

3.1 Financial Planning

Financial planning is a way to create a plan to achieve an organization’s strategic goals. Through financial planning an organization can decide how to manage financial resources, what the needs for human resources are, and how capital investments are managed. Financial planning revolves around a number of financial projections. Such projections include global or local trends, the competitive situation of the organization, profit margins, expenses, and other economic indicators which layout the foundation for the operating environment. Financial planning incorporates

planning of income, operational expenses, cash flow management, and capital investments. (Boone, 2010; Foley, 2010)

Investments and operating costs depend greatly on the quality and nature of the mineral resource of the mine, chosen level of operation, and rock mechanical circumstances. Mine investments are usually related to the mine opening costs, equipment purchases, and construction of the external and internal infrastructure of the mine. Equipment replacements during operations are also booked as investment costs. Mine operating costs can be divided into labor costs, operating supplies, and other operating costs. Labor costs can amount to 45 – 55 %, and supplies to 30 – 35 % of the total operating costs. The rest are other operating costs, such as external services. (Paalumäki, et al., 2015, p. 60)

Capital expenditure, or capital expense, are costs associated with acquiring or updating an asset. Capital expenditure is used to undertake new projects or investments by a company or an organization. If an expense is incurred from a purchased asset, or from upgrading an existing asset, the expense is considered capital expenditure and needs to be capitalized. This capitalized cost needs to be spread across the useful life of the asset. This method of spreading the cost is called depreciation or amortization, depending on whether the asset is tangible or intangible. The acquisition cost of the asset is subtracted with a periodical sum in the income statement. The amount of capital expenditure a company is likely to have, depends largely on the industry the company is operating in. Some industries are considered capital intensive industries, such as oil exploration and production, telecommunications, and manufacturing. (Investopedia, n.d.; Jormakka, et al., 2015, p. 73)

Operating costs are viewed as an opposite of capital expenditures. Operating costs are expenses that are used for day-to-day operations, such as rent, utilities, insurance, and operating supplies. Capital expenses on the other hand are from purchasing assets, which have a useful life of more than one year. For instance, purchasing office supplies is considered an operating expense, as the office supplies usually last for one year at best. Some office related purchases, such as office furniture, are thought to last for longer than a year, so the costs should be considered as capital expenses and the furniture itself as a fixed asset. (Murray, 2016)

The unit of production depreciation method (UoP) is used in the mining industry for depreciating capitalized cost associated with acquiring the mined ore (Jyrkkiö & Riistama, 2008, p. 113).

Capitalized costs from exploration, evaluation, and development are amortized over the expected total production period. In terms of a single mineable ore body, the period used should be the life of mine plan (LOMP). The unit of production method is an appropriate method for mineral extraction industry, as it reflects the pattern of reserve consumption and the wear and tear imposed on production machinery by the consumption of said reserve. However, straight line depreciation may still be a valid method used on assets more affected by the wear and tear caused by time rather than the mineral extraction process. There are a number of different options to choose for the basis of UoP calculation. Some common commonly used methods are (PricewaterhouseCoopers, 2012, pp. 39-40):

- Total quantity of material extracted from the mine (including waste)
- Total quantity of ore extracted from the mine
- Total output

Total quantity of material extracted is an appropriate method for depreciating equipment that are directly linked to the extraction of rock, where the wear and tear suffered by the equipment is better described by the total volume of extracted rock rather than just ore. Total quantity of ore extracted is appropriate for depreciating the cost of the mineral deposit itself and equipment linked to the early stages of ore processing, such as crushers and conveyors, where wear and tear is linked to the processed ore volume. Total output is an appropriate method for depreciating processing plant and equipment, that is linked to the latter stages of processing (such as smelters and refineries) where the wear and tear is more closely linked to the actual valuable output of the production chain. For assets that have a shorter economic life than the LOMP, depreciation calculations need to be conducted using an estimated productive capacity of the asset rather than the estimated capacity of the mine. (PricewaterhouseCoopers, 2012, p. 40)

Unit of production depreciation requires a reserve and resource base for the basis of calculation. The selected base needs to be considered in accordance with the actual life of mine plan and the costs to be incurred for the economic exploitation of said reserves and resources for determining the amortization charge for the period. Commonly used bases are either proved and probable reserves, or reserves and a portion of resources expected to be converted into reserves. Whichever base is chosen, the used base should only consist of reserves and resources that are actually planned for mining. Proved and probable reserves as a basis for depreciation calculation is common, as the

proved and probable reserves are usually the best estimate for the actual life of mine. (PricewaterhouseCoopers, 2012, p. 40)

Depreciations and amortizations are handled differently depending on whether the purpose is for taxation or accounting. The Finnish business taxation and accounting acts have different regulations for the subject matter. In depreciations and amortizations for tax reasons, maximum yearly depreciable charge depends on local tax laws and on the commodity type of the asset. According to Finnish business taxation act, the maximum yearly depreciable charge is 25 % of the remaining balance of the asset. However, there are commodity types that are depreciated with a significantly slower rate, such as office buildings (4 %) and storage or factory facilities (7 %). Short-term expenditures that have an economical lifetime maximum of three years may also be fully depreciated during the year of acquisition. According to Finnish accounting act, depreciable assets are to be depreciated during their useful life. This varies based on the asset, like how assets are depreciated for taxation. Depreciations according to the accounting act will see the asset balance reaching zero, if no residual value is left after the depreciation period, but depreciations according to business tax act will never reach zero asset balance since the depreciation charge is always a percentage less than 100 of the asset balance. (Hokkanen, 2017; Antikainen, 2016)

Budgeting is a crucial method of planning and control in business operations in any field. However, criticism against traditional budgeting and its shortcomings have given rise to alternative budgeting methods, which still leave the core idea of planning for the upcoming financial year intact. Forecasting is a method of planning for the future which helps to form an idea of the future level of activity based on the available data. As budgets and forecasts are viewed as an essential part of financial planning, budgeting and forecasts are covered in the following chapters of their own. (Horngren, et al., 2012, p. 184; Shim, 2009; Sandalgaard & Nikolaj Bukh, 2014, pp. 409-410)

3.2 Forecasting

There are a number of different types of forecasts available for business management needs. According to Shim (2009, pp. 6-8), the most typical forecast types are:

1. Sales forecasts
2. Economic forecasts
3. Financial forecasts
4. Technological forecasts
5. Forecasts for Supply Chain Management

Sales forecasts give an expected level of sales for the organizations products, goods or services throughout a set time period in the future. **Economic forecasts** give foresight on the future business conditions at a larger scale. Organizations can use economic forecasts as a basis for sales forecasts through the provided external business outlook. Economic forecasts are usually given by governmental agencies or private economic forecasting firms. **Financial forecasts** are separate from sales forecasts, although most financial decisions are based on the sales forecasts, as financial forecasting takes part in the organizations requirement for external financing options and cash flow management. **Technological forecasts** estimate the technological progress at a certain technological field, usually the one that the organization is operating in. Technological forecasts are important for organizations operating in a high-tech field, where small technological advances may give an edge over the competition. **Forecasts for Supply Chain Management** are a combination of forecast types, where fluctuations on sales demand affects demand on materials. Supply chain forecasting is mostly concerned with communication of forecasts between different parties in the supply network. This will lead to less stock-outs and faster response time to demand fluctuations. (Shim, 2009, pp. 6-8)

Forecasts are planned within a set forecast horizon. Forecast horizons are typically divided as short-range, medium-range and long-range horizons. Time spans for the different length horizons are as follows: short-range horizon deals in weeks, medium-range deals in months and long-range in years. (Shim, 2009, p. 5)

Sales forecast tells operations what kind of volumes or amounts are projected to be sold in the given planning horizon. Sales forecast is the basis for capacity planning, inventory planning, production

planning and so forth. Sales forecast also gives the background for the scale of operations. In this context, sales forecast is the first and foremost input in preparing an operational budget. (Shim, 2009, p. 15)

3.2.1 Forecasting techniques

There are numerous ways of preparing a forecast for various purposes. Forecasting techniques are generally divided into two approaches: qualitative and quantitative. According to Shim (2009, pp. 8-9), the techniques and their corresponding approaches are:

1. Qualitative approach – forecasts based on judgment and opinion
    a. Executive opinions
    b. Delphi technique
    c. Sales force polling
    d. Consumer surveys
2. Quantitative approach
    a. Forecasts based on historical data
        i. Naïve methods
        ii. Moving averages
        iii. Exponential smoothing
        iv. Trend analysis
        v. Decomposition of time series
    b. Associative (Causal) forecasts
        i. Simple regression
        ii. Multiple regression
        iii. Econometric modeling
    c. Indirect methods
        i. Market surveys
        ii. Input-output analysis
        iii. Barometric forecasting
        iv. Forecasts based on consumer behavior – Markov approach

Quantitative techniques are largely statistical analyses of demand data. Quantitative techniques work well, when there are little to none of systematic change in the frame of reference. When

patterns or relationships change, the quantitative approach has little use. The qualitative approach bases forecasts on observation of existing trends, which help to counter the effects of a paradigm shift. Although there are many weaknesses in the qualitative approach, it can identify and interpret the effect of a systematic change more quickly than the quantitative approach. The connections between different forecasting techniques, corresponding to their approach, are shown in Figure 10. (Shim, 2009, p. 9)

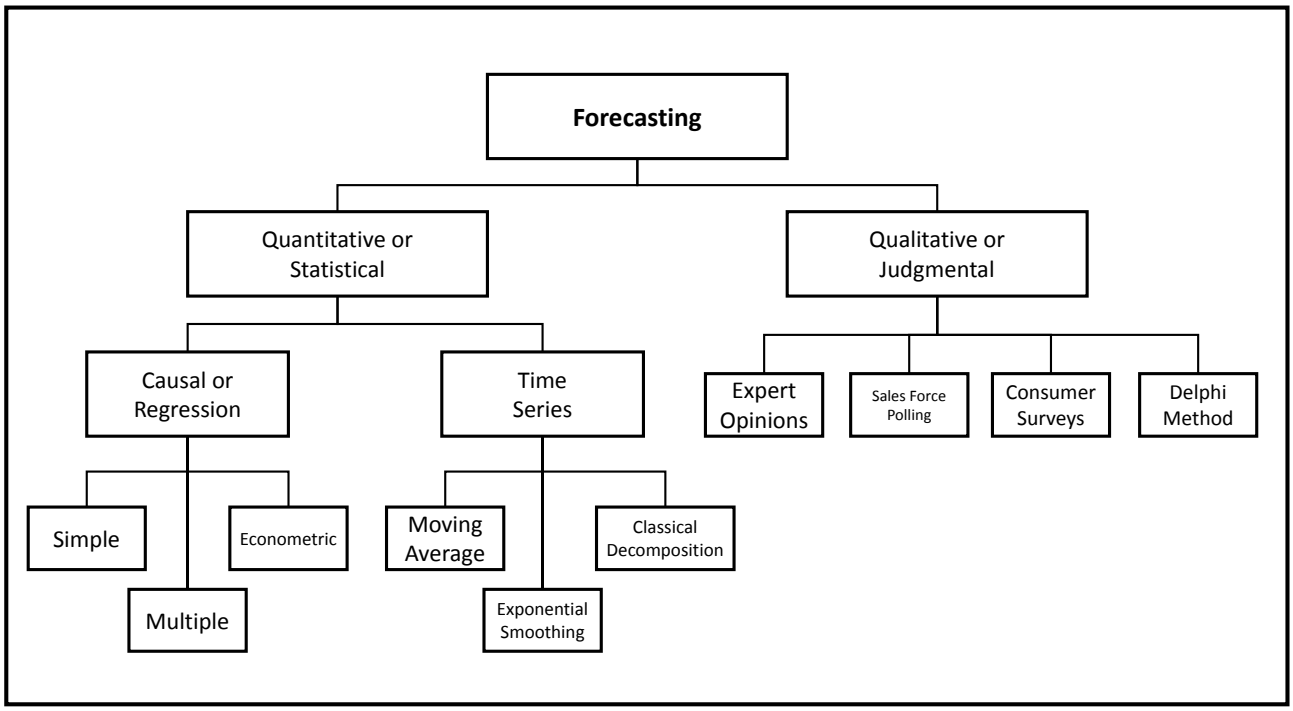

Figure 10. Forecasting techniques (Reproduced from Shim, 2009, p. 9).

Naïve forecasting methods, moving averages, and exponential smoothing produce forecasts based on historical data, which in turn make them easy to operate and inexpensive. However, these methods do not consider any underlying causal relationships. Causal relationships are analyzed in regression analyses, although these methods are more resource heavy to implement. Time series analyses include trend analysis and classical decomposition, where the data is broken down to components. Trend analysis can be linear or nonlinear, and it may require a substantial amount of historical data to be calculated. (Shim, 2009, pp. 29-87)

3.2.2 Choosing the suitable forecasting method

The selection of the proper forecasting method depends largely on the product, organization, or the industry, for which the forecast is being prepared for. Also, the possible techniques need to be

viewed in terms of complexity and cost, as techniques vary from simple and inexpensive to extreme complexity and resource costly. Some techniques are best suited for short-term forecasting, and some others are better for intermediate- to long-term forecasting. (Shim, 2009, pp. 9-10)

According to Shim (2009, p. 10), the criteria for forecasting technique selection are as follows:

1. What is the cost associated with developing the forecasting model compared with potential gains resulting from its use? The choice is one of benefit-cost trade-off.
2. How complicated are the relationships that are being forecasted?
3. Is it for short-run or long-run purposes?
4. How much accuracy is desired?
5. Is there a minimum tolerance level of errors?
6. How much data are available? Techniques vary in the amount of data they require.

Levary & Han (1995, p. 14) list main factors affecting the forecasting technique selection for technological forecasts:

1. Money available for development of technology
2. Data availability
3. Data validity
4. Uncertainty surrounding the success of technological development
5. Similarity of proposed and existing technologies
6. Number of variables affecting the development of technology

Although Shim (2009) has a more general approach for forecasting technique selection, and Levary & Han (1995) strictly concentrate on technological forecasting, there are number of similarities in their selection criteria. The complexities of relationships between forecasted entities are directly affected by data availability and validity.

3.3 Budgeting

Budgeting is a paramount activity in any business operations, where financial gains are the driving force behind every action. Horngren et al. (2012, p. 184) define a budget as the quantitative expression of a proposed action plan by management for a specified time period, which also helps

to coordinate what actions need to be taken in order to achieve the outcomes in that plan. According to Fontinelle (2017), budgeting is viewed as a way to manage incomes and expenses within varying planning horizons. Also, Stein (2014) agrees with this, as his view is that a budget is defined as an estimate of costs, revenues or resources over a given time period. On the other hand, a budget is viewed as a tool for both planning and control, where a budget is management's formal statement of expectations in the organizations operating environment (Shim, 2009, p. 15). Alhola & Lauslahti (2003, p. 272) define budgeting more strictly temporally as an organization's verbal and numerical action plan for the duration of one year. Jyrkkiö & Riistama (2008, p. 226) define budget as an action plan for profit or cost center, which has been planned to be executed at a set time frame with lowest viable cost level, or a probable level of profitability.

Åkerberg (2006) takes a different stand towards budgeting as a tool for financial planning and control. Budgeting is often viewed as a time-consuming activity, that the organization routinely indulges itself in. If budgeting is not done right, or the method has not been thoroughly implemented in the organization, it is extremely time consuming and costly. In addition, the gains from budgeting rarely exceed the work put into it. Although Åkerberg is strongly against traditional budgeting, he still states it is a good tool for financial planning. Åkerberg suggests giving up budgets and budgeting to wake up the leadership and revitalize the planning process, but at the same time emphasizes that there are cases where budgeting is the most suitable way to plan for an organizations finances. (Åkerberg, 2006)

A budget generally holds financial and non-financial aspects, and it gives a background upon which to measure and follow the upcoming planning period. Budgets are consequently categorized into two major types: **operating budgets** and **financial budgets**. A financial budget holds the managements views on what are the incomes, cash flows, and the financial position during the set planning period of the budget. Similar to preparing financial statements for past periods, budgetary financial statements can be prepared for upcoming periods, the components of a financial budget being balance sheets, income statements, and cash flow statements. Financial budgets have their foundation on non-financial budgets, called operating budgets, which hold non-financial figures such as units manufactured or sold, number of employees, or numbers of new products being introduced to the market. (Horngren, et al., 2012, p. 184; Atkinson et al., 2012, p. 422)

3.3.1 Budgeting methods

Budgeting is roughly divided into two distinct methods: top-down and bottom-up. Jormakka et al. (2015, p. 182) refer to these methods as **authoritarian** (top-down) and **democratic** (bottom-up). Top-down budget is a management driven budget, which is usually compiled by finance manager or controller along with the management. Top-down budgeting is fast to make and costs allotted to operations is under control. The downside of top-down budgets is that the personnel might have a hard time adjusting to the budget as they have not had any say in the planning of it. Compared to the top-down method, bottom-up budget is costly to make and the planning takes a lot of time to complete. On the other hand, personnel and middle management usually can stand behind the budget as they have had their input. (Jormakka, et al., 2015; Alhola & Lauslahti, 2005)

Traditional budgeting is viewed as stale, outdated, and non-responsive to the constant changes of the business environment. Rising from this criticism, alternative budgeting methods have been developed in the recent years, such as rolling budgets and beyond budgeting method. Rolling budgets always have an updated budget for the next 12 months, as when the periods progress, new budget months are added to the end of the planning horizon. Rolling budgets can be maintained on monthly or quarterly levels. As a continuation of rolling budgets, beyond budgeting consists of rolling budgets and rolling forecasts to make up a complete budgeting method. As traditional budgets are based on fixed plans and targets, in beyond budgeting the targets are stretch goals that can be reviewed and modified if necessary. Stretch goals can be tied to peers, competitors, or key benchmarks, and make up a more motivational goal for managers, as they are directly tied to the competition rather than internal goals. However, organizations have found it difficult to switch over to beyond budgeting, although strictly speaking, it is still budgeting at heart: the change to beyond budgeting is a change in the fundaments of the already familiar planning process. It is still vital to keep fixed targets in budgeting, as the lack of internal benchmarks affects the capabilities of the organization to deliver expected results. (Kaplan Financial, 2012; Sandalgaard & Nikolaj Bukh, 2014; Atkinson, et al., 2012, pp. 458-459)

For budgeting discretionary expenditures, such as spending on research and development, there are generally three budgeting methods available for organizations: **incremental budgeting**, **zero-based budgeting**, and **project funding**. Incremental budgeting compares period's expenditure on a discretionary item against the expenditure of the previous period. If the total budget for all discretionary items increases by 10 %, the budget for each discretionary item can increase by 10 %.

In zero-based budgeting, the starting point for expenditures is zero, and each expenditure needs to be justified by the proponents of the discretionary expenditures. Project funding is a solution between incremental budgeting and zero-based budgeting, and should be used for activities of a specific schedule. (Atkinson, et al., 2012, pp. 456-458)

Democratic budgeting starts with the planning of the department budgets, which will eventually make up the master budget of the organization. Before the sub-level budgets are accepted as a part of the master budget, they are treated as budget suggestions. As with Alhola & Lauslahti (2005), Jormakka et al. (2015) also emphasize the fact that the authoritarian method takes less resources from the organization as the budgeting process employs only a few people to compile the master budget, compared to the democratic method where more resources are needed. On the other hand, a democratically prepared budget has a better backing from the organization as the ones who will eventually be responsible for carrying out the budget have had their say in the process. Most organizations use a combination of these two methods called the **collaborative** method, where the department heads take part in the preparing of the budget of the area of their responsibility and top management gives targets for profitability and sales. (Jormakka, et al., 2015, p. 182)

According to Shim (2009) the major steps in preparing a master budget are as follows:

1. Prepare a sales forecast.
2. Determine expected production volume.
3. Estimate manufacturing costs and operating expenses.
4. Determine cash flow and other financial effects.
5. Formulate projected financial statements.

The sales forecast is the first step in preparing a budget and an operations plan for the organization. Sales forecast is needed to give an idea on the expected production volumes, which in turn will give an estimate of production costs and expenses. This cost accumulation will then be needed for cash flow management. The final step is to form the projected financial statements, based on the data received from previous steps. Correspondingly, these steps will form the basis for various types of sub-level budgets, for example the sales forecast to the sales budget. (Shim, 2009, pp. 15-16)

A budgetary system refers to the system of budgeting process and budget monitoring. The budgetary system incorporates the following aspects: (Jyrkkiö & Riistama, 2008, p. 227)

- Directives and instructions on how budgeting responsibilities and budget monitoring are split between different parts of the organization.
- Instructions for gathering and managing necessary data for budgeting purposes.
- Information on the forms and templates to be used, reporting periods, reporting content, and distribution.

To make organizational operations planning more efficient, the organization prepares operative action plans, where goals and targets are conveyed by using operational factors, such as order book, market share, operating ratio, purchasing spend, and human resource requirements. While planning for operational figures, internal and external performance aspects need to be taken into consideration. A budget may include operational quantitative figures, such as purchasing amounts, inventory levels, and sales volume, but it must include all the costs and incomes that will be set as financial targets in the operations plan. (Jyrkkiö & Riistama, 2008, p. 227)

As with Atkinson et al. (2012) and Horngren et al. (2012), Jyrkkiö & Riistama also set the distinction between financial and operational budgets. The two types of budgets have a clear correspondence with each other, although the presented figures are not directly comparable, as operations mainly deal with volume-based numbers and financial plans deal with monetary values. However, these sets of numbers are translatable for the purposes of each other, and have a clear and distinct effect on each other. Conclusively, Jyrkkiö & Riistama describe this connection as a coordination method between management and operations. This connection is represented in Figure 11. (Jyrkkiö & Riistama, 2008, pp. 227-229)

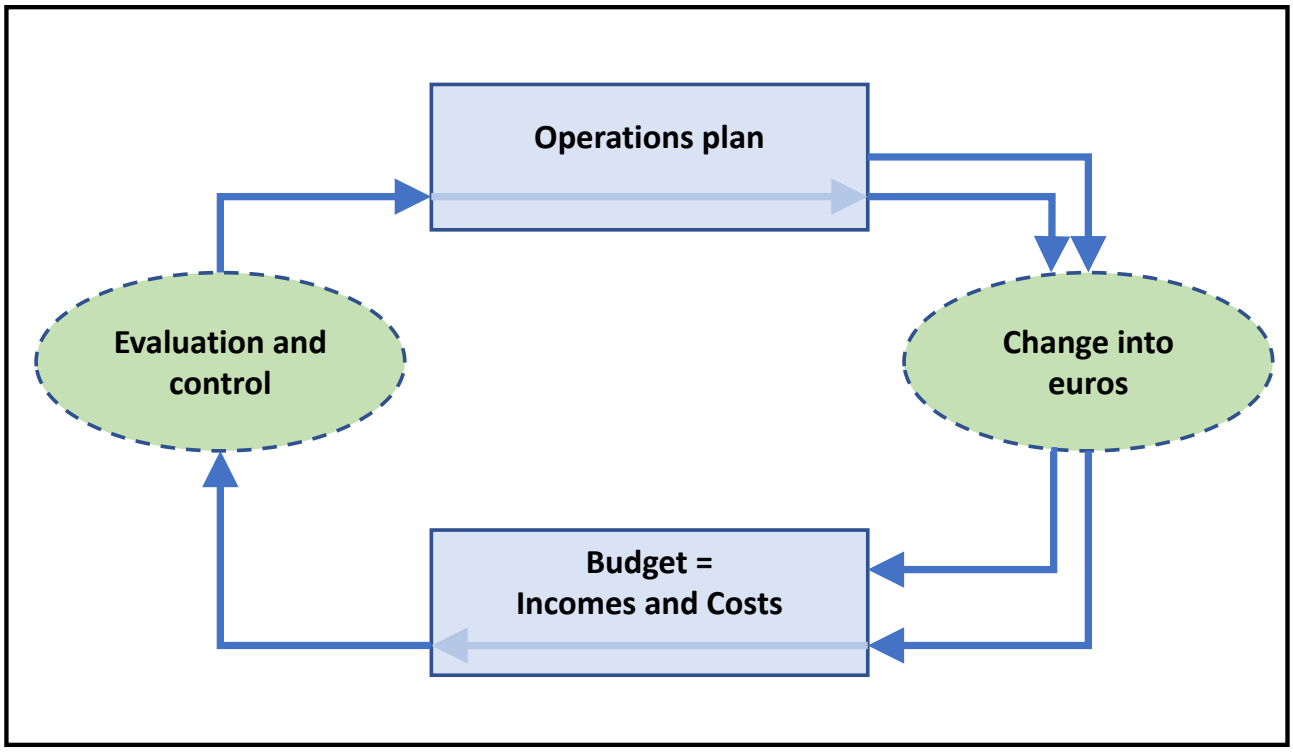

Figure 11. Interaction between operations plan and budget (Adapted from Jyrkkiö & Riistama, 2008, p. 228).

3.3.2 Elements and components of a budget

According to Riistama & Jyrkkiö (2008, pp. 226-227), a budget includes financial goals for operations, so it is vital for the persons responsible for the operations, or the individual sections and the departments, to have accepted the budget on their behalf. With this it is evident, that Riistama & Jyrkkiö also support the collaborative method as specified by Alhola & Lauslahti (2003) and Jormakka et al. (2015), although they do not specify the actual method by which the budget should be prepared.

Atkinson et al. (2012, pp. 421-422) define the elements that need demand forecasting in order to create the basis for a budget:

1. Flexible resources that create variable costs
2. Intermediate-term capacity resources that create fixed costs
3. Resources that, in the intermediate run and long run, enhance the potential of organization's strategy
4. Long-term capacity resources that create fixed costs

Flexible resources are typically operating supplies, which are required to produce the end product, such as tires for an automobile factory. In essence, they can be easily acquired or disposed of in the short-term. Intermediate-term capacity resources are for example storage spaces that can be rented on a fixed-term contract. Resources that enhance the potential of organization's strategy are discretionary expenditures, which may include research and development, employee training, maintenance of equipment, and advertising. Enhancing resources do not provide capacity or affect the level of activity. Long-term capacity resources may include new operational facilities, and will potentially take several years to be completed and used. (Atkinson, et al., 2012, pp. 421-422)

A comprehensive master budget consists of several sub-level budgets, which are formulated based on a corresponding forecast, for example a sales budget is built upon a sales forecast. On the other hand, some sub-level budgets can only be prepared once a preceding budget has been completed, for example the production budget can be prepared after the sales budget has been completed. The different sub-level budgets of the master budget are shown in Figure 12. (Shim, 2009, pp. 16-22)

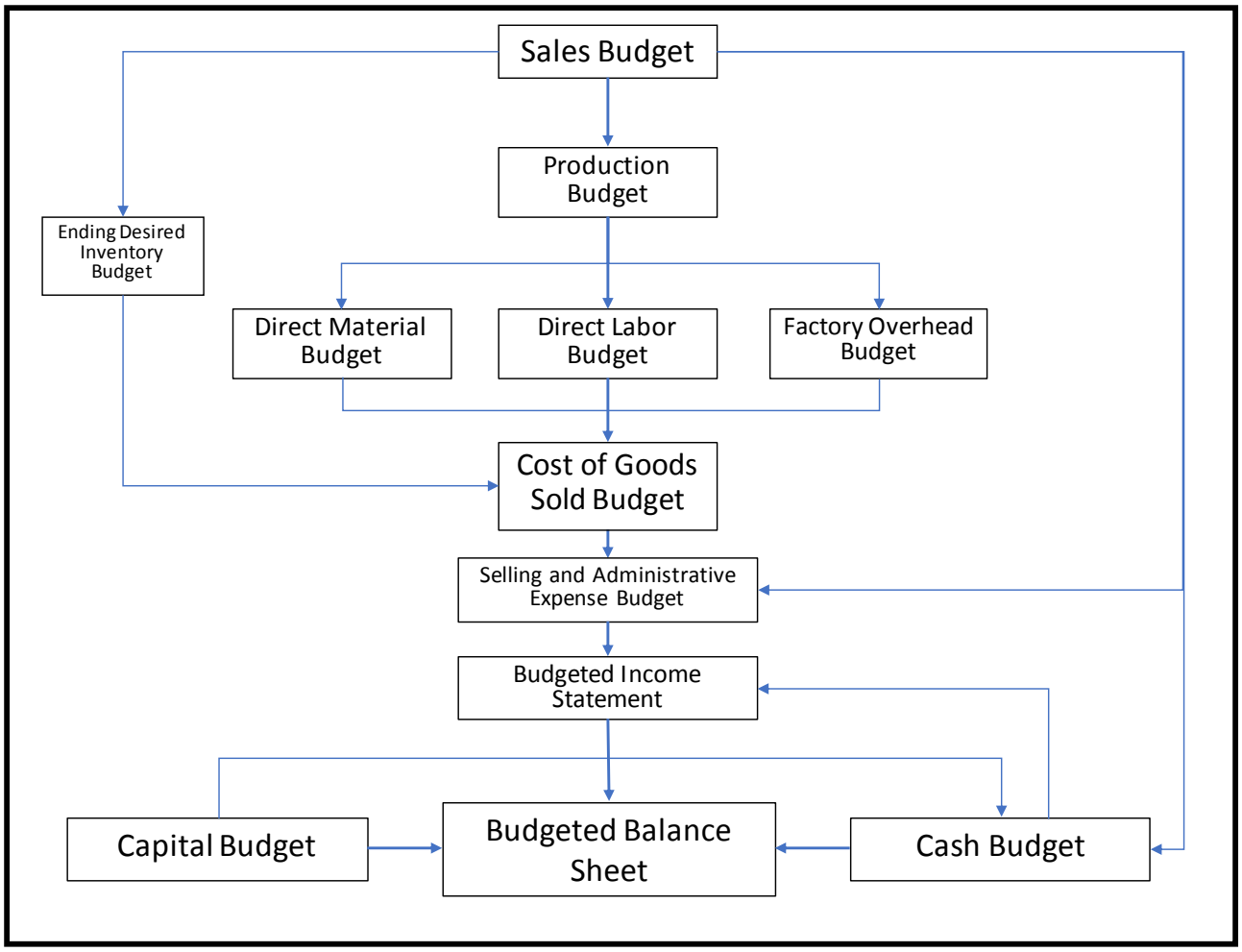

Figure 12. Comprehensive master budget (Reproduced from Shim, 2009, p. 16).

The various sub-level budgets shown in Figure 12 are covered in more detail in the following segment.

Sales Budget

The sales budget is an outcome of the sales forecast. Sales budget, as is the sales forecast, is the starting point for the budgeting process and the formulation of the master budget, since the estimated sales volumes affect most parts of the master budgets and the operational plans within it. After the sales volume has been estimated, it should be multiplied by the estimated sales unit price. (Shim, 2009, p. 16)

Production Budget

According to Shim (2009, p. 17), after the sales budget has been prepared, the production budget can be formed. The production budget is based on the sales volume, as the projected sales volume needs to be somehow manufactured and prepared for sales, although inventory policies of the organization do have an impact on the manufacturing volume. So, in essence, the actual sales volume on the sales forecast and the budget may not directly translate into the production volume. With the help of the production budget, the manager can prepare direct material and direct-labor budgets.

Direct Material Budget

Direct materials refer to the materials required to meet the production volume. The direct material budget needs the planned end-of-period inventory level as per the organization's inventory policy, production requirements, start-of-period inventory, and the unit cost. With the help of the unit cost, these will give a monetary value for the direct material budget, but also the volume which is vital information to operations planning. (Shim, 2009, p. 17)

Direct Labor Budget

Similar to the direct material budget, Shim (2009, p. 18) tells that the direct labor budget is based on the projected level of output set in the production budget. The direct labor budget is affected by wages and the manufacturing process itself.

Factory Overhead Budget

The expenses listed on the factory overhead budget are indirect costs that cannot be assigned to a specific product. The expenses are subject to change according to the level of factory capacity, and are affected by the production requirements. Some expenses may vary as the production level changes, such as supplies, while others usually remain on their previous level, such as the depreciation charges. The net output of the factory overhead budget is a collection of indirect costs. (Shim, 2009, pp. 18-19)

Cost of Goods Sold Budget

Cost of Goods Sold budget primarily consists of information already available in previously mentioned budgets. The budget refers to the increasing level of inventory and the associated expected costs during the planning period of the budget. (Shim, 2009, p. 19)

Selling and Administration Budget

The way to budget and plan for selling, administration, and similar functions differ from business to business. Individual budgets are prepared for each function, but in some cases, there may be a need to produce a compound budget for sales, advertising and administrative purposes, with sales related costs specified as their own section in the compound administration budget. (Shim, 2009, p. 20)

Budgeted Income Statement

The budgeted income statement summarizes the revenue and cost projections set down in the various budgets prepared beforehand. The budgets can be divided and viewed in yearly, quarterly, or monthly dimensions for control purposes. Budgeted income statement then gives the estimated level of profitability of the organization for the upcoming planning period. Key indicators on the income statement are gross margin and net income before and after tax. (Shim, 2009, pp. 20-21)

Cash Budget

The cash budget is based on the previously prepared budgets and is used for cash planning and control. The cash budget represents the estimated inflow and outflow of cash for the selected planning period. Cash flow planning helps to minimize the level of idle cash and prevent possible cash shortages. Cash budget shows each month’s starting and ending cash balance, which are affected by sales and costs each month. Cash collection and disbursements are show based on the

agreed payment terms, which affect the period where the actual inflow and outflow will occur. (Shim, 2009, pp. 21-23)

Budgeted Balance Sheet

The budgeted balance sheet begins with the balance sheet of the previously ended financial year. The balance sheet is then adjusted based on the activities expected to take place during the upcoming financial year. The budgeted balance sheet shows the expected level of assets, liabilities, and equity items based on the changes estimated on the previously prepared budgets. From the budgeted balance sheet, management can review the probable status of each account at the end of the planning period. The budgeted balance sheet may show unfavorable financial conditions, highlight future resources and obligations, and helps to perform various financial ratio calculations. The budgeted balance sheet needs to be reviewed for the finalization and control of the budgeting process for the upcoming financial year. (Shim, 2009, p. 21)

Larger organizations, that have subdivisions, may produce individual budgets for each subdivision and then consolidate the subdivision budgets on the group level. The consolidated subdivision budgets may then be developed into a group level master budget or summed into company-wide compound budgets. Another way to plan for large organizations is to first produce the compound master budget, which is then allocated to the subdivisions. (Shim, 2009, p. 22)

Another way of reviewing the master budget is through financial and non-financial components of the budget. Figure 13 summarizes the different components of the master budget. The dotted line in the figure shows the collaboration within the budgeting process, as the tentative budget is reviewed by the management. The organizational goals are adjusted accordingly in the review process, if the results are not satisfactory to the organizations purposes. The initial tentative budgets may prove to be infeasible, if the organization does not have the capability to produce or sell the planned level of output. The tentative budgets may also be financially unacceptable, if the proposed plan does not meet the desired level of profits. (Atkinson, et al., 2012, p. 423)

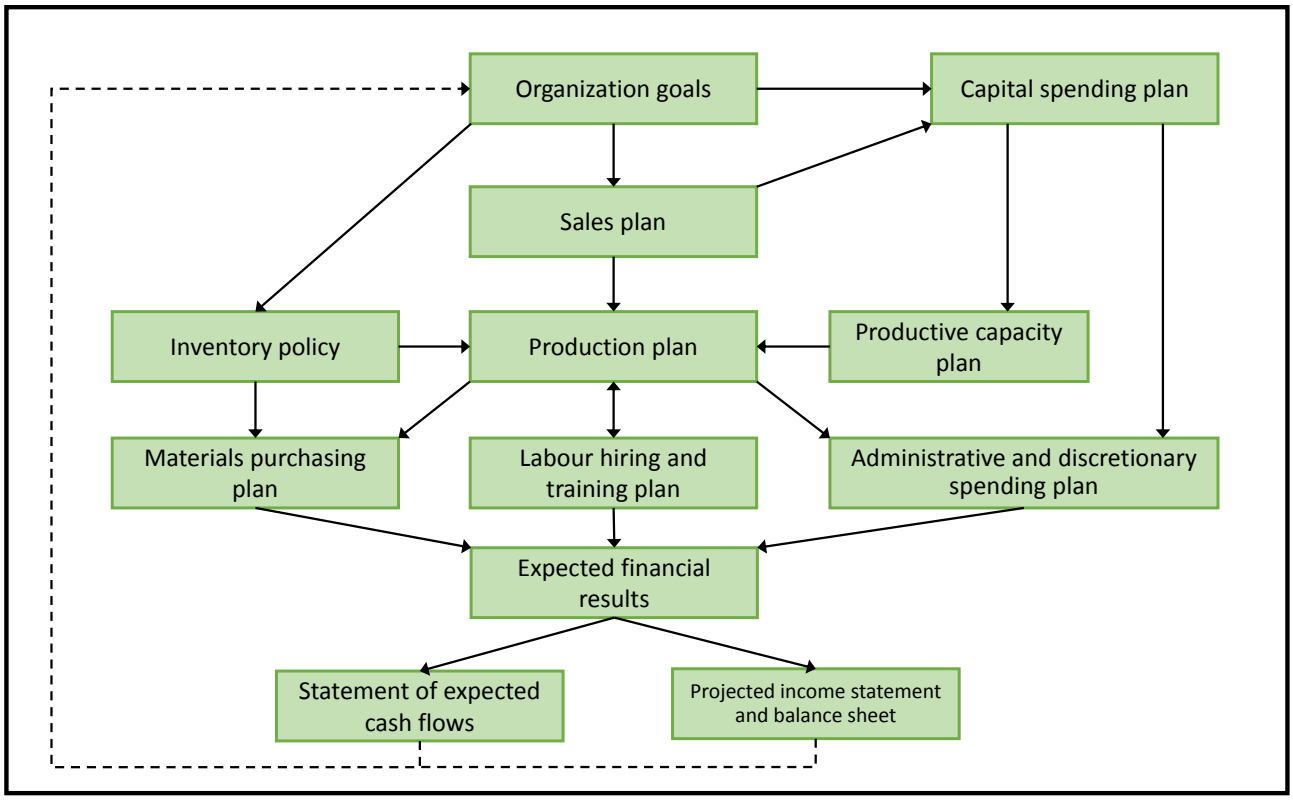

Figure 13. Components of a master budget (Reproduced from Atkinson, et al., 2012, p. 423).

A traditional budget is usually prepared for the upcoming calendar or financial year. When the budget is prepared for rolling 12 months (or a corresponding time frame significant for the organization) the method is called rolling forecasting or rolling budgeting. One benefit of this method is that the organization always has an estimate of the level of operations for the upcoming planning period, for example the next 12 months. The forecast is updated when new actual figures are available, so the rolling budget is updated more frequently than a traditional budget. Rolling budgeting may require fewer resources for updating, compared to a traditional budgeting process, as the required detail level in the budget may be downscaled, and the number of performance measures used may equally be fewer than in traditional budgeting. (Jormakka, et al., 2015, p. 183)

4 Building the framework for planning

This chapter presents the case organization, its specific field of operation, and the current problem it is facing under short life of mine and the issues it causes in financial planning. The chapter also covers the planning and building of the framework that is suggested as a solution to the problems that the case organization is facing. The solution will be a framework that is usable in the mining industry, but also in other extractive industries. The study uses data from the case organizations accounting and reporting system to create the framework, as well as informal interviews with key stakeholders at the case organization to get in-depth knowledge of the present stage of the planning processes.

As this study is a constructive research, the six-phase model of a constructive research approach will be used. Phases 1 and 2 are preliminary phases that frame the research problem and help the researcher to better understand the needs and requirements regarding the problem. Phase 1, searching for a relevant research problem, was undertaken through active participation in the monthly, quarterly and yearly planning processes of the case organization. This also gives a good start for phase 2, gaining preliminary understanding of the problem. Findings from phases 1 and 2 are covered in more detail in chapters 4.1 and 4.2.

The innovation phase of this constructive research incorporates the review of theoretical data revolving around the subject area, while weighing against the data available from the case organization. This collaboration of theory and available tangible data will produce the basis for suggested model for solution. When a solution model has been constructed, the model will be tested through the existing planning system at the case organization and informal interviews regarding the outcomes of the tested solution. Based on the outcomes and related interviews the suggested solution will be revised if needed.

Once the solution has been tested, phases 5 and 6 of the constructive research approach will be covered in chapter 5, where the theoretical connections of the solution and the breadth of the solution’s suitability will be reviewed.

4.1 Case organization presentation

The case organization is a mining company that operates an underground mine and an offsite concentrator. The mining company is a part of an international group of mining companies and smelters. The company produces mainly copper, zinc, and gold concentrates, copper being the main source of income at around 60 % of total revenue. The company started the mine construction and establishment in 2010, reaching operational readiness in 2012 with a 9-year LOMP, which would have indicated mine closure in 2021. However, at the time of the study, the expected life of mine lasted until the end of 2019. The case organization is facing problems with diminishing LOMP, due to an elevated level of production and newly unusable ore resources through poor metal value in the global market. Figure 14 shows copper metal prices from the beginning of the year 2012, up until the end of the year 2016. The figure shows that during the time of the mine's operation, the copper price has fallen by approximately 45 %. Despite of the constant exploration at the mine site and the surrounding region, no new exploitable ore deposits have been found. The two years' reduction in the LOMP has caused significant difficulty in financial planning, as the establishment of a mine is a significant financial burden in the form of capital investments. Capital investments are depreciated during the useful lifetime of the individual assets and according to group policy the assets are to be depreciated to their full value without any residual value left.

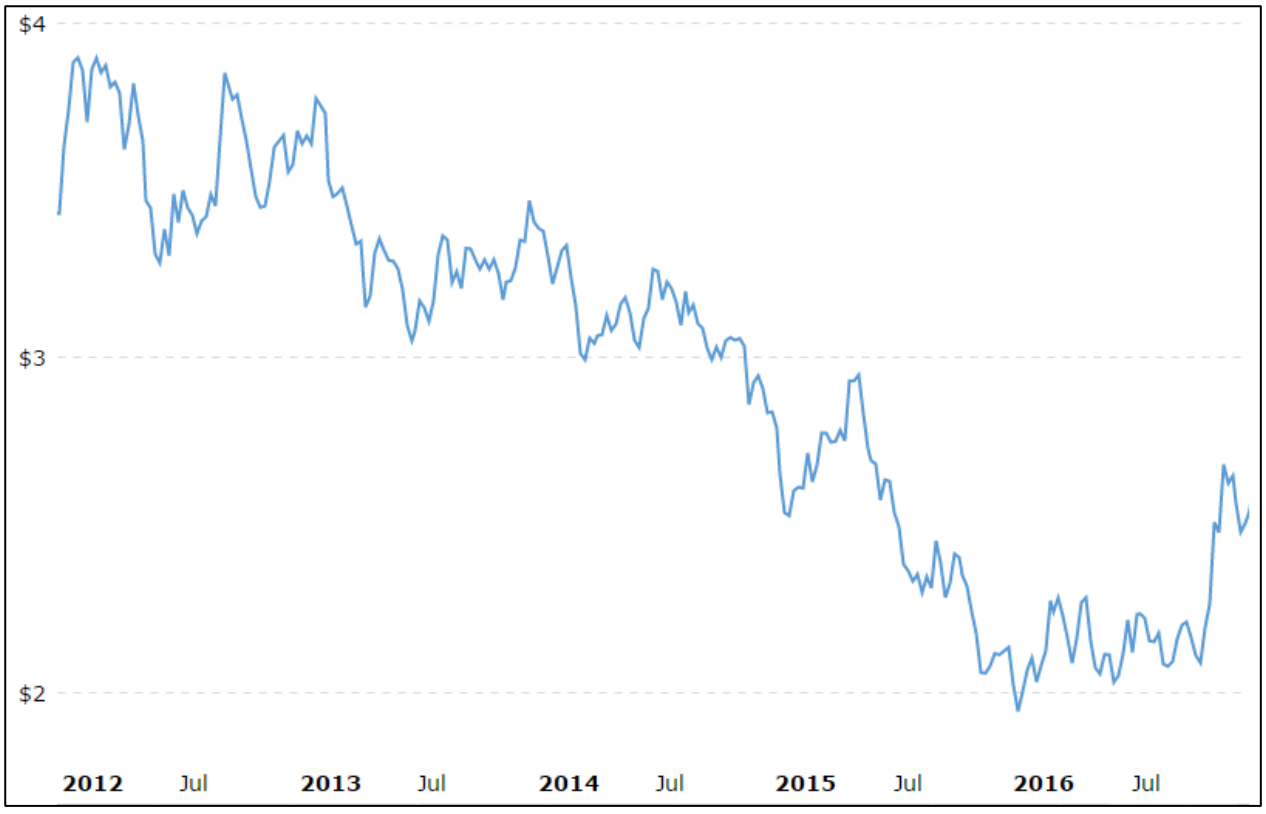

Figure 14. Copper metal price (USD/lb) from 2010 to 2016 (Macrotrends, 2017).

Since the start of the mine, metal prices have fallen globally and mine profitability has been managed through increased production volumes. Also, staff and labor force are given an incentive for surpassing the production targets, which in turn leads to higher ore depletion rates than is even budgeted. Depreciation and amortization calculations are based on proved and probable mineral deposits. While the deposits are being mined at a faster pace than originally planned, the life of mine plan changes length as well and periodical depreciation and amortization charges also grow beyond the originally planned level. Metal prices and the metal grade of ore affect the revenues received from the sold concentrate, higher level of production increases operational costs, and depreciation charges are also elevated. These aspects lead to diminishing profits, although the higher production level helps to alleviate the total effect of low prices and grades, and the high depreciation charges.

Since 2013, the percentage of depreciation charge from total costs has increased dramatically. In 2013, the depreciation and amortization charge accounted for 22,8 % of total costs, while in the full year forecast for 2017 they accounted for 33,6%. So, from less than a quarter of total cost to over a third in four years. Comparing the forecasted depreciation charge for the year 2017 to the actual depreciation charge in 2013, the charge has increased by 119,3 %, while production volumes have increased by 30% at the same time. As assets are depreciated during their useful lifetime, the useful lifetime for most mining machinery is basically the LOMP. Once the LOMP changes, the monthly depreciation charges decrease or increase depending on whether the LOMP is shortened or lengthened. One peculiar aspect of planning depreciations and amortizations at the case organization is that according to group policy, all assets need to be depreciated to their full value with no residual value left. Since the equipment used in mining are high cost machineries, the impact of this group policy increases the total depreciable balance significantly.

Table 1 shows the case organization’s split of operating costs by operating cost category. Repair and maintenance cost is a closely followed category, as the cost associated with sustaining the operational capability of the mining equipment increases when the equipment ages. It is necessary to recognize, that the costs calculated in the repair and maintenance category has some wages, salaries, supplies, and external services in it.

Table 1. Case organization's split of operational costs in 2016.

Operating costs by category	2016
Salaries & Wages	15,8 %
Operating supplies	20,1 %
External services	50,5 %
Repair & Maintenance	6,9 %
Other operating costs	6,7 %
	100 %

According to the 2016 figures shown in Table 1, the operating costs of the case organization are mostly made of external services (50,5 %), while salaries and wages are at 15,8 % and operating supplies at 20,1 %. Comparing the split by cost type to the averages presented by Paalumäki et al. (2015, p. 60), labor costs and supplies should make up 75 – 90 % of operating costs, while the case organization's figures are at 35,9 %. At the same time, external services and other operating costs should be around 10 – 25 % of the total costs, while the case organization's number is at 57,2 %. Although the repair and maintenance category consists of costs similar to the other categories, the overall effect on the compared categories would be insignificant to the purposes of this comparison. It is important to notice that the use of an offsite concentrator increases the total cost of external services as the transport of ore from the mine to the concentrator is needed for the process to work properly. The ore and concentrate transport costs make up 22,4 % and 7,9 % of the total operating costs respectively, which combined makes up the majority of the costs of external services. It is not clear if concentrate transport costs were included in the average operating costs set by Paalumäki et al (2015). Since mines are rarely positioned close to a smelter, the concentrate transport costs are something that every mine will face regardless of the setup of the mining process. However, the distinction between the case organizations setup and the average mine is that typically the concentrator is situated near the mine. This causes the transport costs of the case organization to rise compared to an average mining entity. Based on the 2016 figure, using an offsite concentrator may increase operating costs by almost a quarter, depending largely on the distance between the mine site and the concentrator. If the region around the concentrator would host more than a single mine site with a similar metal content of the ore, it is a more viable option to use a central concentrator rather than constructing a separate concentrator at each mine site.

4.2 Present stage of planning at the case organization

The planning process at the case organization mainly consists of a yearly budgeting process, a thrice-a-year updated forecast, and once a year updated life of mine plan. Significant weight is put on budgeting, as the process takes up to three months from the second half of each financial year. Depending on which process is currently being updated, the emphasized time frame differs. Forecasts focus on the currently running financial year and mainly on the months still left in the year. Budgeting focuses mainly on the upcoming year, although the next years are also planned on a rougher detail level. The LOMP update focuses on the foreseeable future defined by the known ore reserve, with the upcoming year on a monthly level, the next couple of years with a quarterly level detail, and the following years as yearly sums. The LOMP is updated in two parts during the financial year. The preliminary LOMP update is during the first half of the financial year, where the updated figures for the upcoming year form a basis for the budgeting process during the second part of the financial year. The final LOMP update is at the same time as the budgeting process, where the budgeting is centered on the upcoming year and the LOMP update on the following years.

Budgeting, forecasting, and LOMP processes start with the update of the ore reserve, depending on how the extracted volume of ore has reduced the reserve and if new resources have been added to the reserve. The mine production plan is revised based on the updated ore reserve and the production costs can be reconciled after that. After the production plan is updated, the mine and mill operations budgets can be calculated. Figure 15 shows the budgeting process of the case organization. Comparing to Shim's model (2009, p. 16), the case organization doesn't plan with individual material, labor, and overhead budgets, but these are incorporated into the mining, milling, and admin budgets.

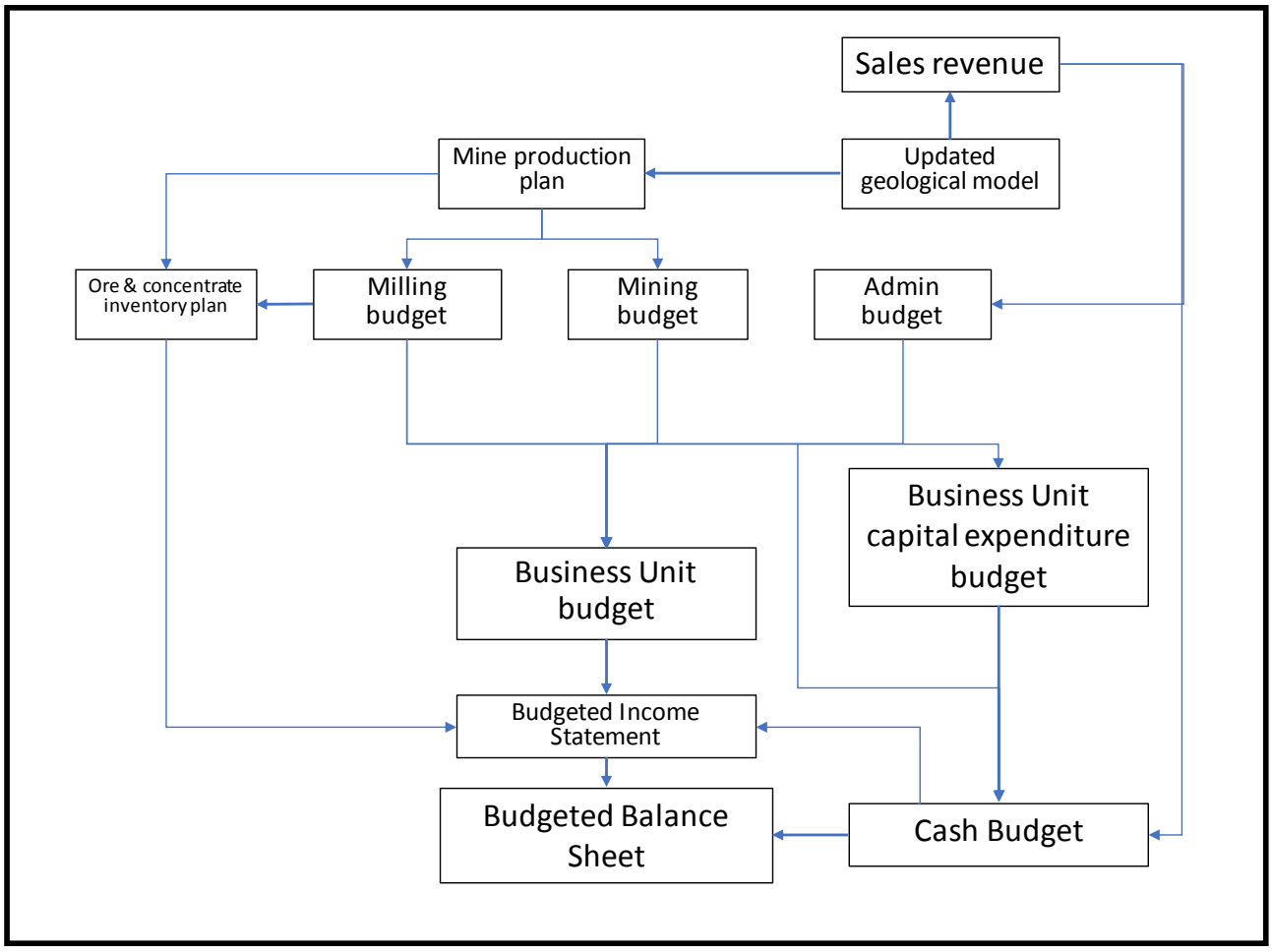

Figure 15. Current budgeting process in the case organization.

The mining budget covers mining personnel salaries and wages, operational supplies, maintenance, subcontractor usage, and the scale of actual mining activities, such as meters of tunnel development, drill meters, and tonnes of material excavated. These will make up the total operating cost for the mine. The milling budget covers mill personnel salaries and wages, operational supplies, the volume of milled ore, maintenance, and other aspects of the milling operations. These make up the total operating cost for the mill. The admin budget (shortened from administration) covers business unit overheads and common services, such as human resources and finance, and the business unit management and administration salaries. The business unit budget and the capital expenditure budget are separate, as the business unit budget only covers operational expenses. The sub-level budgets of milling, mining, and admin also have separate sections for the unit's upcoming investments. While consolidating the budgets to the business unit master budget, the capital expenses can be consolidated to the capital expenditure budget. The large number of variables and components making up the three main sub-budgets are made from informal assumptions and intuition. When discussing the inventory levels of the explosive material inventory with the blasting

engineer at the case organization, he claimed that most of the explosive material purchases had to be made based on intuition. The delivery times of the explosive materials are long and the needed explosive types for each blast cannot be estimated very accurately beforehand, as the blasting setup is planned right before the actual blast. Based on this, the volumes and the associated planned cost for explosive materials in the mining budget are evidently based on best guesses and intuition.

Compared to common business practices, operations in the mining industry cannot begin the budgeting process by preparing a sales forecast and a corresponding budget as the sales revenue depends on the ore extraction of the mining operations. As the sales revenue depends on the mining operations, the budgeting process must begin with a mining plan for the upcoming budgeting period. The mining plan on the other hand requires the most up-to-date geological model of the ore reserves as a basis for upcoming development and stoping. The geological data is also needed for approximation of the metal content in the ore, which is used for revenue calculation as it directly affects the volume of payable metal gained from the ore.

4.3 Forming outlines for planning

Since the aim of the study is to build a framework for financial planning in a constrained life of mine, the framework only needs to cover certain types of mine closures. Out of the different closure types Laurence (2006) covered in his study, the significant ones are closures due to economic reasons and geological reasons. Geotechnical aspects may have a certain significance in financial planning, but they may appear at a later stage of the mine's lifetime, or they may appear abruptly so that no amount of preplanning would help the situation when such problems appear. The other closure types, such as closure due to regulatory pressure or changes in government policies, are systematic risks by nature and cannot be reasonably planned for in the financial planning of a single mine.

As stated before, metal prices have a direct impact in the income of a mine. If the metal prices significant to the mine's operation change drastically from the level of pre-operation profitability analysis, the operative conditions of the mine may drop to a non-profitable level so that mine closure may be imminent. Temporary slumps in metal prices may be a reason for a temporary closure, but due to the sporadic nature of the metal markets, it is difficult to estimate which slumps are short-term and which are systemically transitioning changes. In long-term planning, metal prices

need to be forecasted to plan for a profitable level of operation. The planned framework needs to be able to cover this aspect of mine closure risk.

Geological aspects also have a direct impact on the life time of a mine and the potential income of the mineral reserve. Changes in the volume of the mineral reserve and the grade of the mined mineral in the ore directly affect the LOMP and the projected income of the mine. Therefore, it is vital to plan for these aspects during the entire life of the mine and especially during the later stages of the mine, when reserves are scarce and the possibilities for extensive financial planning have diminished.

4.4 Core planning aspects

Major planning aspects in the case organizations financial planning are revenues, costs, depreciations and amortizations, and earnings, which are all core aspects of an income statement. While earnings are a key outcome of a financial period, more specifically the case organization follows up on the earnings before interest and tax (EBIT).

Revenue is closely linked to the volume of mined ore and the metal content of said ore. To plan for revenue, the volume of the mined ore and the metal content needs to be planned.

Variable costs are directly linked to the level of operation, which means the volume of the ore to be mined during the planning period.

Depreciation and amortization charges mostly consist of assets depreciated with the unit of production method. This suggests that the level of operation directly affects the total charge from depreciations and amortizations.

Earnings before interest and tax are revenues deducted with operating expenses and depreciation and amortization charges. While interest and tax affect the financial outcome of the period, they do not give additional information regarding the financial performance of the organization, which is a key reason why EBIT is an important indicator for many organizations.

While analyzing the core planning aspects, it is evident that the mine production plan and the geological makeup of the ore to be mined will directly affect the financial performance of the company and should be the basis for any financial planning activity.

4.5 Forming guidelines for planning aspects

As revenue is directly affected by the global market prices for metals, the changes in revenue, while production levels stay the same, are systematic in nature. Local possibilities for managing the level of revenue boil down to changing the level of operation. However, increasing the level of operation will increase variable costs. If the level of the global metal price changes, the organization should seek for the optimum level of operation, which mitigates the effect of the lowering metal price while keeping variable costs at a reasonable level. The changes in metal prices and currency exchange rates may be forecasted through various methods, but there are expert organizations who give predictions on these subjects, so that small organizations have no specific need to undertake such forecasting activities themselves. Such forecasting organizations include Knoema, and Trading Economics (Knoema, 2017; Trading Economics, 2016). However, larger organizations may have their own economic forecasting function, usually located within the treasury function.

The mine establishment and development costs are made up of mostly capital expenses, and need to be carried out before any production activities may commence. The mine establishment phases consist of activities that will establish the external and internal infrastructure of the mine, and enable ore extraction from the rock. The mine is then a construction and as such is a depreciable commodity. Since the level of capital investments is significant before any production may commence, the amount of depreciable balance is also significant. Based on this, it is evident that mines with significantly short LOM will not have a very profitable existence, as the total capital expense needs to be depreciated during the useful lifetime of the mine. It is thoroughly important to carefully plan of any capital investments and the related depreciations and amortizations throughout the lifetime of the mine, as the depreciation charges may have a significant impact on the profitability of the mine. As the end of LOM draws nearer, the impact of a capital investment needs to be evaluated more carefully. In essence, the profits from a capital investment need to outweigh the depreciation charge effect within the time frame of the LOM.

4.6 Revised budgeting process

The case organization needs a revised budgeting process, where the imminent mine closure is more carefully taken into consideration. The organization also needs a way to plan for post-operation costs, as the current model only plans for operative costs, and post-operation costs are little more than a good guess, although most of these costs are well known and calculable. For instance, based on the interview with the finance manager at the case organization, starting from the beginning of the year 2017, occupational health services need to be provided to discharged employees for the duration of six months from the termination of the contract. Since the ending of the mining operations is a natural discharge point for most employees, the provided occupational health services will incur costs well beyond the point of profitable operations. The mining and milling budgets account for pre-closure operation and the units are not responsible for post-closure activities. Administration might have possibilities to plan for post-closure, but the current model doesn't account for anything past the length of the LOMP. Figure 16 shows a revised master budget model for the case organization, adapted from Shim's work (2009, p. 16).

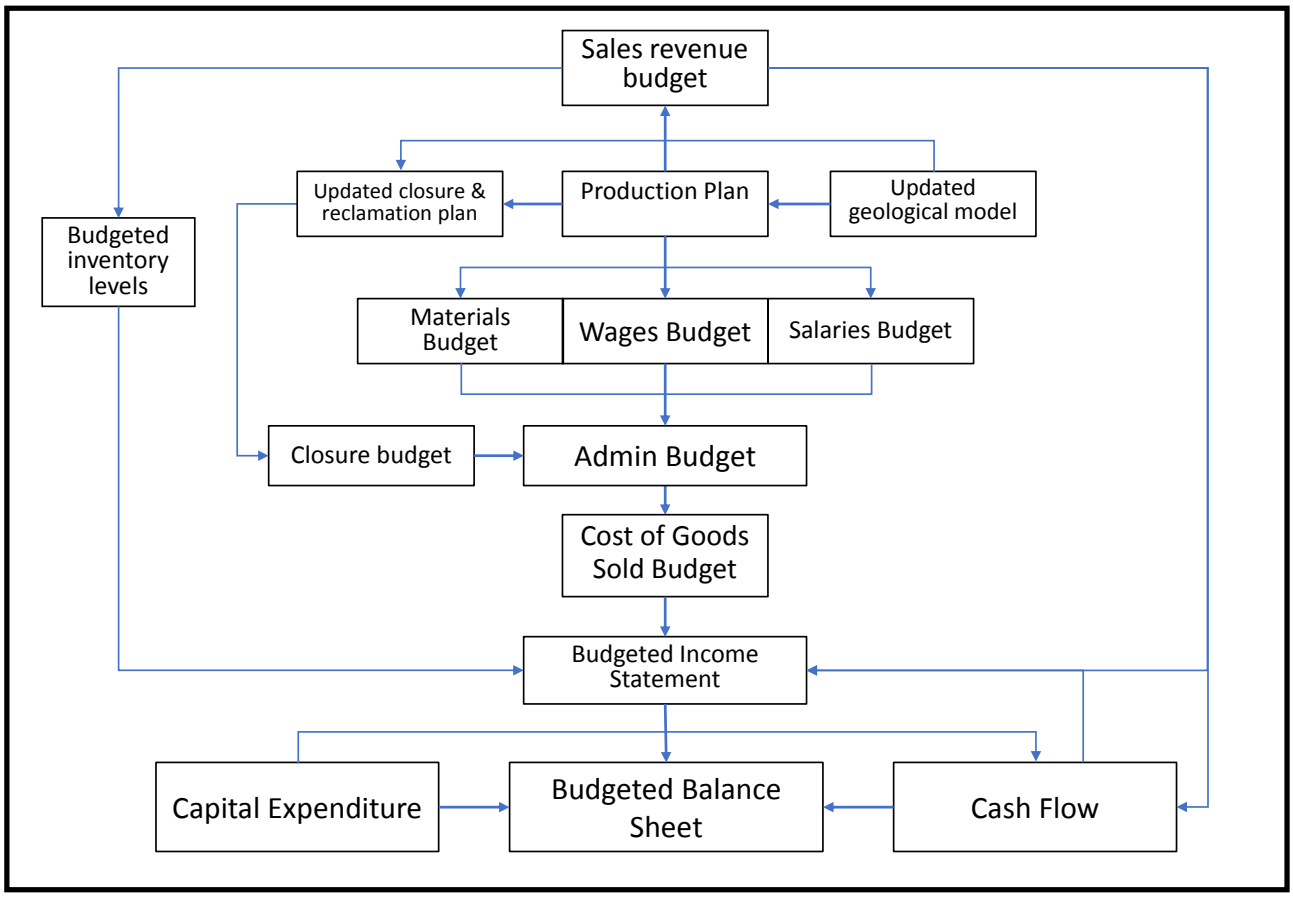

Figure 16. Revised master budget and budgeting process for case organization (Adapted from Shim, 2009, p. 16).

The updated geological model has a clear and distinct effect on the production plan and by proxy to the materials budget. Although some components of the materials budget can be calculated directly from the geological model and the production plan, some key components of the materials budget, such as explosive materials, should be more accurately presented if a forecasting method would be used for the planning of it. As the actual consumption of explosive materials in blasts depend largely on the rock type and area to be blasted, it would be beneficial to try to tie the historic consumption of explosives to the forecasted blasts. Therefore, the suitable forecasting method would be forecasting based on historic data. Such forecasting methods are called naïve forecasting models, which include moving averages and exponential smoothing as forecasting techniques (Shim, 2009, pp. 29-39).

The closure and reclamation plan is updated in process after the geological model and the production plan. This addition is included in the revised budgeting process shown in Figure 16. The updated geological model is already an input for the updated closure and reclamation plan, but in-depth production information is needed to carefully incorporate the specific schedule for ore depletion. Associated closure costs need to be planned, which is a flaw in the current planning model as there is no clear ownership of closure in the organization and specification of costs during the closure process. Closure related costs are only planned based on estimated rehabilitation costs that are handled through rehabilitation provisions. The provisions are based on a study conducted by an external consulting agency. The mill site has a major portion of the rehabilitation and aftercare total as the tailings dams need to be cared for long after the operations have ceased. However, the mine site also has a significant number of post-operation activities as the ore and waste rock fields, and the mining effluent ponds need to be rehabilitated. Administration has the decision-making power, but incorporating the closure planning into the administration budget would diminish the gravity of the closure process. Therefore, it is suggested that closure would be handled through a separate budget which will clear the possibility of confusion between operating and closure costs.

Budgeting process needs to be bottom-up, as the basis for the budget is built upon the geological model and the mine production plan. However, the decision for the level of activity should be based on financial decisions, and as such these decisions are made by the senior management. As the budget is based on production, the process of preparing the budget is naturally bottom-up. Once the budget is prepared, senior management can review the financial outcome of the proposed budget and decide on whether adjustments are needed on costs. The feedback process of the revised

budgeting process is shown in Figure 17. The senior management review is done based on the compiled master budget that holds the sub-level budgets for mine, mill, and administration. The suggested budgeting model is collaborative rather than purely democratic.

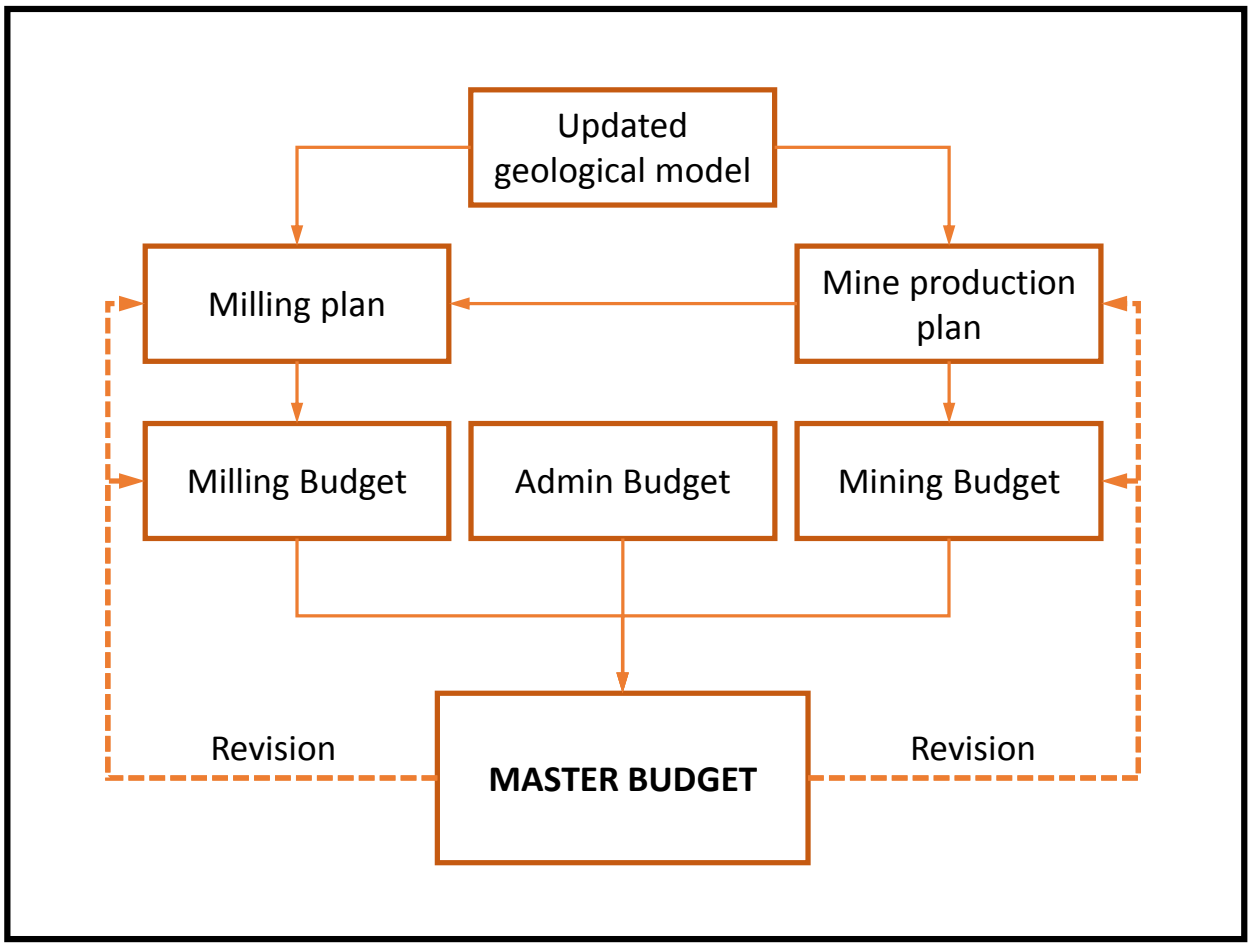

Figure 17. Feedback loop of the revised budgeting process.

4.7 Timeline for closure planning

Based on the closure timelines for mine closure planning presented in chapter 2.5, the following timeline in Figure 18 is suggested for the case organization. The timeline includes financial planning aspects that have distinct effect on the financial performance of the mining entity during and after the mining operations. The closure plans are shown above the five-stage timeline with a blue background, and the financial aspects below the timeline with a green background. The five-stage model with two post-operation stages suits the needs of the study best, as it is centered on the closure of a mine. The cost effects of the two post-operation stages are significantly different, as the closure stage incorporates active rehabilitation, and aftercare and monitoring stage mainly consists of monitoring and occasional aftercare. The pre-operation stages are in mainly because the

conceptual closure plan needs to be created during these stages. It should be noted, that the production stage in the timeline may take anywhere from five to fifty years or more, depending on the volume of the ore reserve and any new additions to it from new discoveries by exploration activities.

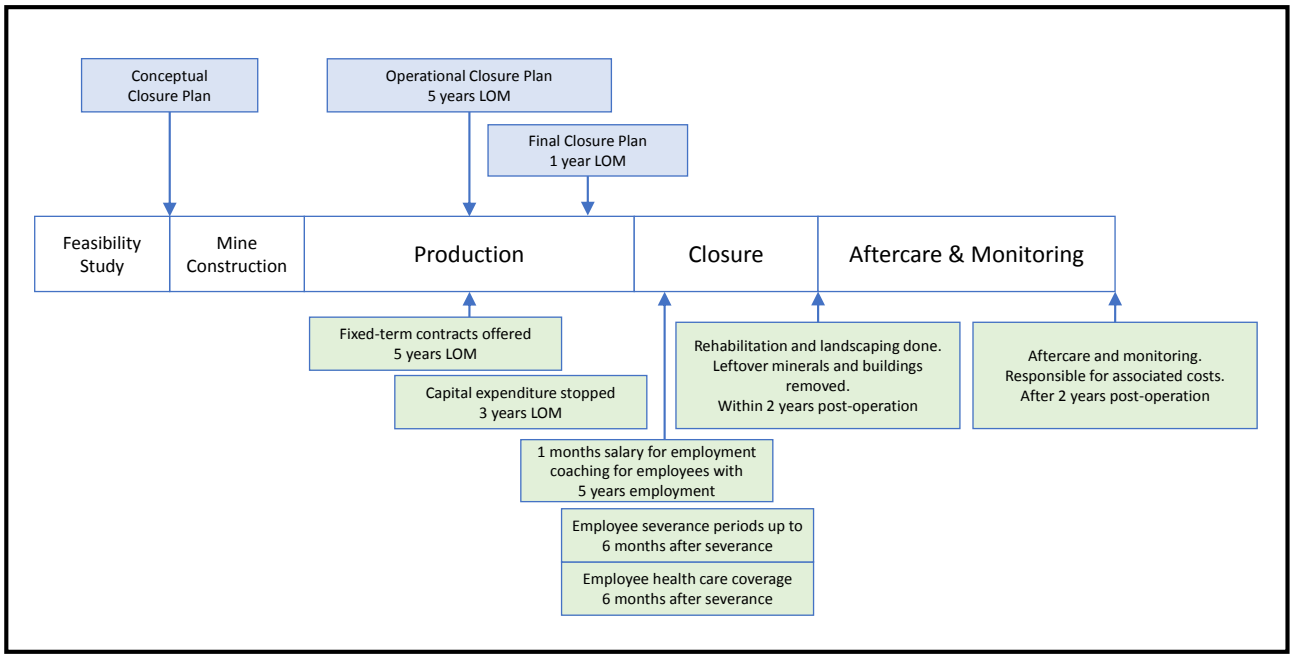

Figure 18. Suggested timeline for closure planning.

When capital expenditures are stopped, the equipment and machinery used in mining operations are only maintained and not replaced. In the case of major breakdowns, meaning the equipment or machinery are facing serious and costly repairs, the organization should consider options for replacing the equipment or machinery by leasing or similar arrangement for a shorter duration. Basically, the expenditure stopping point means a point in operations where every investment is viewed more carefully, and the effect of depreciation and amortization charges stemming from the investment are weighed against the remaining LOMP. For an investment to proceed at and beyond this point, the gain from the investment needs to mitigate or outweigh the effect of the depreciation and amortization charges.

When planning for human resources for the final years of active mining operations, employee severance related costs need to be taken into budgeting and long-term planning. In the Employment Contracts Act (55/2001, Chapter 7, §5) the general severance periods for employers and employees are set based on the time the employee has been working for the same employer, unless agreed otherwise in the employee's contract. Commonly, the agreed severance period can be any length up

to six months. Even if longer than six-month severance period is agreed upon, the six months' rule should be followed. Noteworthy is the recent change to the Employment Contracts Act while viewing it in the light of employee severance: employees of companies with more than 30 employees need to provide employment coaching for employees who have been employed for more than five years continuously. The coaching or training needs to be carried out within two months of severance, or the employer needs to pay the equivalent of said employee's monthly salary instead. These aspects are shown in the closure phase of the timeline in Figure 18. (Employment Contracts Act, 55/2001)

One more difficult HR related issue is that employees tend to start looking for another job once the possibility of employer initiated severance starts looming in the immediate future. Once the employee has left the company, it is difficult to find a replacement if the employment period is shown to be short at best, unless given as a fixed-term contract. According to the Employment Contracts Act (55/2001), every more than five-year fixed-term contract are to be viewed similarly to permanent contracts after five years of employment. When the length of LOMP has settled to a definite closure, without additional reserves to be added, the mining company should visit the option to create all new employment contracts as fixed-term once the LOMP has a length of five years or less. The Employment Contracts Act visits the possibility of fixed-term contracts without a definite end date, although in these cases the employer needs to notify the employee of the contract end date once known.

5 Results & discussion

This study was conducted for a case organization that is facing mine closure due to the mineral reserve running out of ore to mine. Although this is the natural end to any mine, the way this imminent end is considered in financial planning needed to be clarified and developed. The planning of financial aspects of mine closure is poor at best, and planning for post-closure is non-existent. However, most of the post-closure aspects have a cost effect on the profitability of the organization, which need to be considered to evaluate the true financial performance of the entity. Although the staff of the mine have decades of mining industry experience, this experience has not turned into specific actions to counter the effects of the mine closure. Provisions have been made for the rehabilitation portion of the mine closure, as these aspects are covered in the mining legislation and permits, but aspects caused by inevitable employee severance have not been considered. Similarly, a plan for the number of employees and staff present at each stage of pre- and post-operation have not been created, but basically the full volume of staff is planned to be present up until the last month of operation. A rough estimate of half of the staff is thought to be in active duty during the last remaining months of the year when the mining operations are planned to be stopped.

The produced models for budgeting and planning are not case specific, and can be used by organizations in similar situations. Although certain aspects are country specific due to local legislation, the basis for the budgeting and planning process is universal.

While testing the suggested solution for closure related costs, the changes in the planning of salary and wages cost change the total cost of the final year of operations by 7,1 % in the case organizations example. An increase of costs was expected, as the costs relating to mine closure have not been thoroughly planned. However, if the fixed-term contract model would be used for new employees within the five years of LOMP remaining, the effect of severance costs post-operation would diminish, as there are no additional severance costs associated after the agreed end date of the contract.

The effect of the change in the handling of capital expenditure within the three years of remaining LOMP is much harder to test, as the total capital expenditure has diminished naturally in the case organization during the past two years. The case organization has decreed that all capital expenditures are to be written down as operational expenses starting from the beginning of the year

2018. However, it is safe to assume, that any investment with a longer than three-year payback time would have been rejected beyond the point of the stop. The effect of changes in the length of the LOMP need to be considered within the three-year stopping period of the capital expenditures. A couple of months change in the LOMP will show a significant change in the depreciation charge, when the LOMP is around the three years mark. With the case organizations example, one month's change in LOMP will change the depreciation charge by roughly 4 %. However, the effect of LOMP change is not linear but exponential, which means if the LOMP decreases multiple months at a time the effect on monthly depreciation charge is more severe than a couple of months extension.

Research questions proposed in the start of the study were met and answered in the study:

What are the mining industry specific aspects in financial planning, when the mine is in the latter stages of operation?

Mining industry specific aspects were covered in Chapter 4, where capital expenditure and rehabilitation charges were the key components for the end of mine life planning. Capital expenditure is a major affecting factor in any mining activity. Even in the beginning of the mine, the company already carries a burden of pre-operation capital expenditure. Exploration activities and mine construction are vital pre-operation aspects that are needed to find the ore to be mined and to enable the mining operations.

What financial aspects need to be considered in the wind-down stage of a mine?

Due to the nature of investments and depreciations, for the expenditure to have an effect in income statements of the company, there needs to be time available for the depreciations and amortizations to run their course. This is the main reason behind, why capital expenditure needs to stop well before the end of the LOMP. Three years of remaining LOMP is viewed as a good median for time allowed for depreciations, although based on the commodity type this should be considered case by case. High cost mining machinery may have a much longer usability period than standard automobiles used for employee transportation within the mine site. The depreciation charge stemming from the investment needs to be proportional to the projected income and the total cost, as the increase in the depreciation charge will have a direct effect on the EBIT: the shorter the

LOMP is at the time of the investment, the greater the monthly depreciation charge will be. When nearing the three-year milestone, the planning of investments need to consider the investment's effect on the EBIT as the depreciation charge is proportional to the length of the LOMP and slight changes to it will have an exponential effect on the charge.

How should the end of mining operations be considered in long-term planning?

Long-term planning is not a specific concept and many companies tend to set the timeframe of long-term planning based on their business needs. The case organization sets long-term as anything past the next upcoming financial year, which is handled through the budgeting process. As a LOMP is a long-term concept, encompassing multiple years up until the projected end of the mining operation, the aspects previously mentioned for closure related planning also need to be considered in the long-term planning as well. The timeline proposed for closure planning shown in Figure 18 gives the basis for closure planning, although the aspects shown post-closure stem from Finnish legislation. However, similar aspects should be included in closure planning in any country, but the scale, gravity, and length of effect differ from country to country due to differences in the legislation. Employee severance related issues are covered in the Employment Contracts Act (55/2001) and reclamation related issues in the Mining Act (621/2011). While the operational closure plan is formed with five years of LOMP left, at the same time a plan for employee severance should be formed as well. While the severance plan would not be at a specific personal level at this time, a plan on employee category level would give a good basis for planning of salary and wages budgets at each point of the closure process.

6 Conclusions

The study indicated a significant need for more in-depth planning of financial aspects in the latter stages of mining operations. In the case organization, the planning for post-closure issues was next to non-existent and vague at best. Appropriate provisions have been made for reclamation purposes, as it's required by legislation, but aspects apart from that are not incorporated in long-term planning or budgeting. The constructed framework and the associated models will work as a support for incorporating mine closure related aspects to long-term planning and budgeting. Any industry with significant capital expenditure needed for the operation to commence should find the produced framework useful for the planning of operations. A mine has the ore reserve as a defining factor for the length of operational life, and thus the life time of the operations are known well in advance compared to other traditional industries. As such, the defining factor for the usage of the framework is that the company should be using a finite resource to power its operations. This in turn suggests a limited lifetime of the operations.

The subject field of the study was unusual, as most research in the topic mainly cover mining technical or geological aspects of mine closure. However, very little is done to cover the financial aspects of it. Also, studies revolving around the subject of socio-economic effects of mine closure have not been conducted in Finland, although such studies have been made in Australia.

The study covered the mine closure aspects for a single mine. A similar study should be conducted on a mining corporation level, where the corporation manages multiple mining sites. This would create company-wide guidelines for closure, where closure risks could be incorporated to the evaluation of new mining projects, and could be an integral part of mine closure planning.

As the public opinion usually tends to be against mining and the mining industry, it is vitally important for any mine working in Finland, or any other developed country, to take extra good care of the planning of the mine closure. Once a mine stops its operation, reclamation and socio-economic issues tend to rise to the front pages, as they most directly affect the surrounding environment, the society, and the local community. Keeping this in mind, a well-managed mine closure will not just benefit the mining company but will give a positive impact on the image of the mining industry to the public.

7 Summary

The objective of this study was to form a framework and associated planning models for a mining company affected by a relatively short life of mine plan. In essence, the company's capabilities for comprehensive financial planning are constrained by the life of mine once the end of the LOMP is closing in.

The study resulted in a suitable framework for the mining and extractive industry. Capital expenditure forms a major part of the operations spend. The management of capital expenditure and the associated depreciations and amortizations were found to be a central planning aspect in the planning of mining operations. The model prepared for the planning of capital expenditure compares the effect of the expenditure against the LOMP remaining and the effect of the associated depreciation or amortization on the projected income statement. Operating costs should be planned so that variable costs are on a reasonable level compared to the projected revenue indicated by the excavated metal's market prices. In essence, the level of operation needs to be changed based on the projected metal prices of the core metals that are being excavated by the mine. Closure related costs need to be planned as well. Rehabilitation and reclamation costs should be planned through a closure planning process, where the closure plan is updated regularly throughout the lifetime of the mine. While moving nearer to the mine closure, the closure plan needs to be updated more often. Post-operation costs, such as employee severance related costs need to be taken into the long-term planning.

The six-phase model for constructive research approach was used to frame the problem the case organization is facing. The innovation and framework building phase resulted in a combination of tools for the planning of closure related costs. The framework was then tested with the case organizations data and a distinct effect on the organizations closure related costs was found. The theoretical connections are shown during the building of the framework, as each model has a basis in the provided theoretical data. The breadth of the solutions suitability was shown to be dependent on the type of operations. The operations use of a finite resource is a key factor in the usage of the model, as the total length of the operations should be already known to some extent.

The framework consists of guidelines for planning aspects, a model for budgeting and the use of forecasting methods, as well as a timeline for the planning related to mine closure. The budgeting process with associated feedback and revision loop are described in Figure 16 and Figure 17

respectively. The planning timeline is described in Figure 18. The objective of the study was met successfully, as the formed framework and the associated models give the mining company better opportunities to plan for closure related costs.

The research questions suggested in chapter 1.2 were answered accordingly and a more detailed explanation is found from chapter 5.

What are the mining industry specific aspects in financial planning, when the mine is in the latter stages of operation? The aspects inquired in this research questions were found as capital expenses and the closure related costs, such as rehabilitation and aftercare costs.

What financial aspects need to be considered in the wind-down stage of a mine? As the previous question found capital expenses as a specific aspect, the associated depreciation and amortization charges are a financial aspect of this. Depreciation and amortization charges have a direct impact on the EBIT and in turn on the profitability of the mining operations. The framework suggests a planning model for the handling of capital expenditure and the associated charges through a more detailed evaluation of investments.

How should the end of mining operations be considered in long-term planning? The capital expenditures need to be planned in the long-term planning, relating to the length of the LOMP at a given moment. The employee severance related costs need to be planned for as well in the long-term planning, as they may have a significant impact on the profitability of the company in the final stages of the mining operations.

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