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OPEN INNOVATION METHODOLOGY IMPLEMENTATION IN CHILEAN CODELCO COPPER MINING COMPANY

Master's Thesis

Examiners: Prof. Marko Torkkeli

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ABSTRACT

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Title of the thesis: Open Innovation Methodology Implementation in Chilean CODELCO Copper Mining Company

Year: 2020 **Place:** Ylistaro, Finland

Master's Thesis, Lappeenranta-Lahti University of Technology, School of Engineering Science, Industrial Engineering and Management, Global Management of Innovation and Technology

80 pages, 21 figures, 6 tables, 2 appendices.

Examiners: Professor Marko Torkkeli, Assoc. Prof. Daria Podmetina.

Keywords: open innovation, mining industry, CODELCO, copper mining, Chile

The purpose of this thesis is to (1) assess how CODELCO, Chilean copper mining company, is implementing Open Innovation methodology as part of its innovation strategy and (2) to determine how CODELCO's Open Innovation implementation has affected projects' results.

The thesis is presented as a single-case study, where the empirical data is collected through semi-structured interviews to CODELCO's staff. Managers as well as executives representing both northern and southern divisions are selected for interview in order to gather relevant and representative information of the corporation. A total of nine interviews are executed through phone calls. The analysis of the results is based on pattern matching techniques that compares the empirical results to predicting theories developed in the theoretical framework of chapter 2.

The study describes how CODELCO is implementing Open Innovation across the organization. Collected data from interviews shows how the firm has dedicated time and resources to adapt the organization to utilize of Open Innovation methodology in innovation projects. Such has been the impacts in the results, that CODELCO is institutionalizing OI as the main project implementation mode. Additionally, this study present recommendations for a better implementation of OI that would help seize better the benefits of OI methodology.

TIIVISTELMÄ

Tekijä: Nicolás Martínez

Työn nimi: Chileläisen kaivosyhtiö CODELCO:n Avoin Innovaation menetelmän toteutus.

Vuosi: 2020 **Paikka**: Ylistaro, Suomi

Diplomityö. Lappeenrannan-Lahden Teknillinen Yliopisto, LUT School of Engineering Science, Tuotantotalouden koulutusohjelma. Kansainvälinen innovaatio ja teknologian johtaminen.
80 sivua, 21 kuvaa, 6 taulukkoa, 2 liitettä.
Tarkastajat: Prof. Marko Torkkeli, Prof. Daria Podmetina

Hakusanat: avoin innovaatio, kaivostoiminta, CODELCO, kuparikaivos, Chile

Diplomityön tarkoituksena on tutkia miten Chilen valtion omistama kaivosyhtiö CODELCO on toteuttanut avoimen innovaation menetelmää osana yhtiön strategiaa. Tämän lisäksi selvitetään avoimen innovaation vaikutusta CODELCO:n projektien tuloksiin. Onko toteutettu menetelmä tuonut menestystä CODELCO:lle?

Työssä käytetään tapaustutkimusta, jossa empiiriset tiedot kerätään osittain jäsenneltyjen haastattelujen avulla. Työssä myös haastatellaan ensisijaisesti kaikista maantieteellisistä jaostoista innovaatioprojekteihin liittyviä projektienjohtajia ja yksikönjohtajia, jotta vastaukset edustaisivat kattavasti yhtiötä.

Tutkimus kuvaa CODELCO:n avoimen innovaation implementaatiota organisaatiotasolla. Haastatteluista kerätty aineisto selostaa, miten firma on käyttänyt sekä aikaa että resursseja organisaation avoimen innovaation menetelmän käytön sopeutumiseen. Vaikutus tuloksiin on ollut niin positiivinen, että CODELCO on omaksunut avoimen innovaation käytön projektien toteuttaessa. Lopulta, tutkimuksen analyysi tarjoaa neuvoa firmalle avoimen innovaation implementaation parantamiseen siten, jotta tämä hyötyisi paremmin menetelmästä.

ACKNOWLEDGEMENTS

After working for approximately eight years as a field technology project manager in Codelco, I decided it was time to finish my master's thesis. For a long time, I have been postponing this undertaking due to corporate responsibilities, but some particular events provided me with the opportunity to concentrate on this task. I must recognize it was not easy to write an almost 80 pages study, yet I was finally did it, and hereby I gladly present the results.

I would like to thank my guide professor Marko Torkkeli and associated professor Daria Podmetina. Professor Torkkeli guided me throughout all the writing process and helped me to understand case study methodology. Professor Podmetina provided valuable comments that helped me shape my thesis to its final form. I particularly appreciate the help provided by prof. Torkkeli, who stood by me, introduced me to Open Innovation, and spoke on my behalf to university staff.

In addition, I would like to show my appreciation to my wife Saija and to my children Milian, David, Rosie, and Isak, for supporting me with their love and comfort, and for giving me away-time for writing my thesis.

Finally, I would like to thank Jesus, for giving me hope that there is light at the end of the day, there is a sun behind all the clouds, and there is life beyond death.

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LIST OF ABREVIATIONS

CM	CODELCO's Head Quarters
CODELCO	Copper Corporation (Corporacion del Cobre)
CSF	Critical Successful Factor
DAN	CODELCO's Andina Division
DCH	CODELCO's Chuquicamata Division
DET	CODELCO's El Teniente Division
DGM	CODELCO's Gabriela Mistral Division
DMH	CODELCO's Ministro Hales Division
DRT	CODELCO's Radomiro Tomic Division
DSAL	CODELCO's El Salvador División
GDP	Gross Domestic Product
FDI	Foreign Direct Investment
FMT	Fine Metric Tons
IP	Intelectual Property
LME	London Metal Exchange
OI	Open Innovation
PES	Performance Evaluation System
R&D	Research and Development
SF	Success Factor
SME	Small and Medium Size Enterprise
VTAP	Vice-presidency of Technology, Automation, and Projects

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1 INTRODUCTION

Open Innovation has been for some time a trend topic among scholars, and now it has become more popular among firms (Torkkeli & Mention, 2015; Subtil et al, 2018; Lichtenthaler, 2011). This methodology is credited to accelerate innovation processes at low costs, allowing firms to generate and maintain business competitiveness (Chesbrough 2003a, Silje et al, 2019). Furthermore, Brunswicker and Chesbrough (2018) present a large-scale survey where about 80 percent of participating firms utilize OI in their processes. This innovation paradigm has proved to be, not only a trend or fad, but also a phenomenon that has arrived to stay (Chesbrough & Brunswicker, 2014; Brunswicker & Chesbrough, 2018; Chiaroni et al, 2009)

Since OI has proved to be an effective way to generate results, Chilean Government has identified it as a viable way to attain high levels of competitiveness for its local economy. Such has been government's interest, that on the year 2020 was established the Ministry of Science, Technology, Knowledge, and Innovation. Its first task was the creation of a Public Innovation Policy (Minciencia, 2020).

Mining industry has had an important role in Chilean economic growth and social development in the last decades (Lardé et al, 2008). It has accounted for an average of 11,3% of Chilean Gross Domestic Product (GDP) between the years 2009 and 2019, of which the most important mined product is copper. See Figure 1 for mining impact in Chilean national Gross Domestic Product (Sustainable Copper, 2017; Cochilco, 2020).

Since copper industry represents so much for the economic development of Chile, this master's thesis focuses on the study of the implementation of Open Innovation in the biggest copper mining company of this country: CODELCO.

1.1 Background for the study

In 2019 Chile produced approximately 5,82 million of fine metric tons (FMT) of copper, which accounts for 28,4% of the world's production, positioning it as the largest copper mining country

in the world. CODELCO, Chile´s biggest copper mining company, is responsible for 28,23% of the country's production, that is 1,58 million FMT of copper (Sernageomin, 2019).

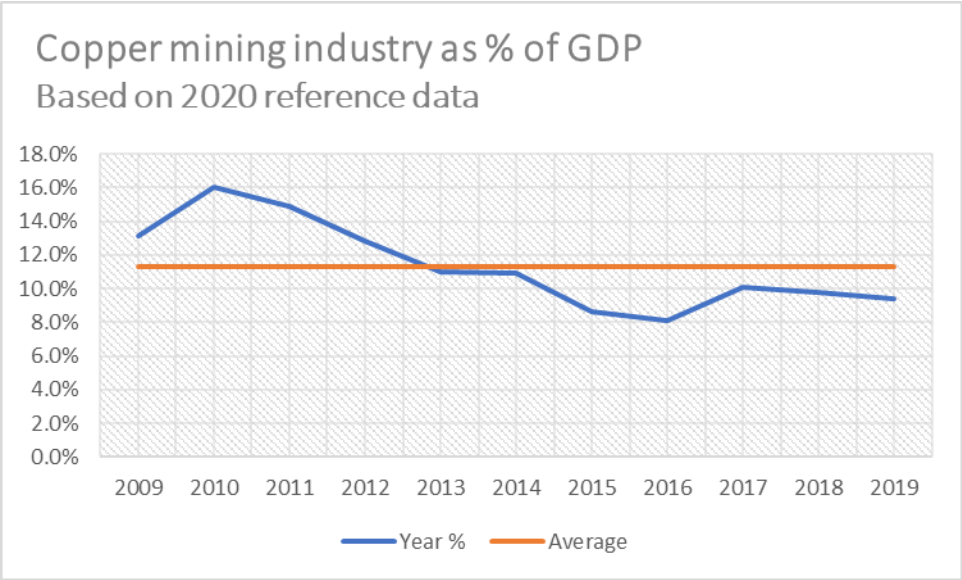

Figure 1: Mining Industry Contribution to Chile's GDP (Cochilco, 2020)

Between 2005 and 2019, Chilean mining industry has suffered from decreasing ore grades, and increasing operational costs, mainly energy and labor, which has directly impacted the profit margins of the state-owned CODELCO, and thus the GDP of the country (Betancour & Maldonado, 2013; Castillo & Cantallopts, 2016; Sernageomin, 2019). According to the information provided by the London Metal Exchange (LME), between the years 2011 and 2020 copper price has decreased a little more than 50%, from a maximum of 4,54 US$/lb to a low of 2,31 US$/lb, thus weakening profitability margins (LME Copper, 2020). This market scenario has imposed a new reality to mining companies that obliges firms to innovate in order to keep competitiveness and avoid business default (Valencia, 2019).

CODELCO has recognized the necessity to innovate as a formula to achieve better production through improved processes, and to maintain, or in the best of cases, reduce operational costs. Sebastian Carmona, Innovation Unit Manager, reveals that CODELCO has adopted an innovation strategy that comprises three main fronts: disruptive innovation, incremental innovation, and the

incorporation of automation, robotics, and remote controlling technologies. The executive also indicates that Open Innovation is key to attain the firm's goals aided by alliances and partners that would provide external knowledge and innovations (Portal Minero, 2018).

Open Innovation methodology, which purposely benefits from internal and external knowledge in order to accelerate innovation processes, may adjust to the needs of CODELCO for the incorporation of innovative solutions in the short term. It has been shown that open innovation is much more than just a trend, it is an imperative for change on how firms benefit from new ideas in the development of products and services (Chesbrough, 2003a; Chesbrough & Brunswicker, 2014).

This thesis assesses the implementation of Open Innovation methodology in CODELCO and it describes, from a theoretical point of view, organizational factors that can be improved in order to benefit more from this methodology. Secondly, OI projects are reviewed as a percentage of general innovation projects to contrast the utilization of Open Innovation compared to closed innovation paradigm.

1.2 Research Questions

The first objective of this thesis is to assess the level of incorporation of OI in CODELCO. This implies the investigation of the processes and structures through which CODELCO is enabling the use of OI methodology. The second objective of this study is to determine how the utilization of OI has affected innovation projects. Thus, the research questions are set as following:

1) How CODELCO is implementing Open Innovation methodology?

2) How CODELCO's Open Innovation implementation affected projects' results?

The research questions will guide the study narrowing down the search of information and construction of interviews for obtaining empirical data.

1.3 Research Proposition

Additionally, an initial proposition is presented in this chapter, that will help focus during the examination of the research questions and analysis of the results.

Proposition: CODELCO identifies the necessity for innovation to maintain competitiveness, however it has not been able to implement a successful innovation strategy, let alone Open Innovation. Innovation comes as ready-to-use packages provided by external sources, with little to non-existent development participation of CODELCO.

1.4 Research Design and Methodology

This thesis is designed using Yin's (2018) Case Study Research recommendations. The case study focuses on Chilean state-owned copper mining company CODELCO. Five steps are defined in order to build logically a strong case study: 1) definitions of the research questions, 2) research proposition, 3) unit of analysis, 4) logical link between data and the proposition, 5) interpreting criteria of the findings (Yin, 2018).

The research methodology meets the criteria of a single-case study, where the research questions are in the form of why and how, focusing on contemporary events within the scope of Chilean Mining Industry. Information and data for this study is collected from a disparate number of sources such as books, presentations, newspapers, web pages, and available video interviews. The empirical data required for answering the research questions is gathered from semi-structured interviews that are carried out via phone call due to current Covid-19 pandemic restrictions.

Reliability in data collection is ensured by choosing respondents considering the following aspects:

a) Divisional and geographical representativity
b) Participation in innovation projects
c) Relevant management responsibility

Divisional and geographical representativity was achieved by considering respondents from all operational areas i.e. northern operational vice-presidency, southern operational vice-presidency, and transversal services that managed projects for the whole corporation. Since the study focused on Open Innovation, interviewed workers had to be related directly or indirectly to innovation project management. Finally, interviewees were chosen from managerial or executive positions, ensuring that answers would represent the operational unit to which they belonged.

Validity of this work was attained by using pattern matching that compares the results obtained from empirical data to predictive theory frameworks presented in chapter 2. Chapter 2.6 summarizes the theoretical frameworks utilized in the empirical study analysis. Theory is developed with the purpose of recognizing different patterns within the results that described the implementation of Open Innovation and OI effects in innovation projects' results.

The analysis of the results is done using explanation building technique, which is a type of pattern matching. In this case, the following items are developed as a casual sequency narrative throughout the thesis:

- An initial proposition is presented
- The data collected from the interview is compared to the initial proposition
- Modification of the initial statement
- Comparing other details of the case
- Iterate this process if necessary

1.5 Structure of the Study

Chapter one presents an introduction to the research of CODELCO Open Innovation case study. It gives general information about the company and the market environment where it operates. It also develops the research questions, and the structure of the case study research along with the data analysis techniques that will be utilized in the thesis. The main sources of information are case study research methodology books, copper mining articles and books, and newspapers.

Chapter two develops the theoretical foundation of the research. It presents theories and frameworks that explain the basics of Open Innovation, the processes involved during OI execution, organizational provisions, and prerequisites for OI, factors impacting OI implementation, successful project framework, and OI moderation elements. The main sources of information are books, articles, and research papers.

Chapter three presents the results of the semi-structured interviews. It shows the data collected arranged by different variables using charts, and analyzes the data applying the theoretical single-case study framework presented in chapter one. The main sources of information are CODELCO's own webpages, online resources, official annual reports, firm statements, and semi-structured interviews.

2 THEORETICAL FRAMEWORK

In this chapter, a theoretical framework will be presented to the reader in order to bring formal background information on the topic of open innovation.

2.1 Definition of Open Innovation

The old paradigm of innovation development was portrayed as a fortified castle where no one came in, and no one came out. Such was the case of closed innovation at the beginning of the XX century. The landscape was defined by the availability of knowledge, which was dearly protected by firms. Research and Development (R&D) occurred within the walls of the organization, and all the new knowledge generated was carefully stored and secretly kept from outsiders. Whether this information was utilized for further product development or not, it was kept secret within the libraries of the firm. Figure 2 shows the closed innovation paradigm. It begins at the research and development stage, which was a closed process, and it ends either with an idea being stored in a repository or a product being launched to the market (Chesbrough, 2003a; Penrose, 1995).

In the United States, after the Second World War, US politicians noticed the huge technological advancements made during the war, and with that in mind, they decided to interpolate the research and development mechanism to the rest of the industry. This decision led to further investment in public schools, consequently increasing the number of engineers and scientists available in the labor market (Chesbrough, 2003a; Bush, 1954)

The post-war availability of knowledge led to a more dynamic labor mobility, making it difficult for firms to keep break-through finding to themselves. Skilled workers were hired from one firm to another, bringing along specialized knowledge that would enable companies to compete against old innovation giants with large R&D laboratories. Even start-ups were enabled to compete in the innovation markets. This new ability, to bring knowledge from outside the company and being able to benefit from it, is what evolved into which today is known as Open Innovation (Chesbrough, 2003a; Bush, 1954; Yong et al, 2001).

Chesbrough (2006) defines Open Innovation as the utilization of internal and external information, knowledge, and ideas in order to accelerate internal innovations, and the expansion of the markets for external use of innovation. That is to say that OI is the process through which innovation occurs beyond the boundaries of a firm, benefiting from ideas generated in the inside or outside of the organization's own research units and laboratories. These boundaries become pervious, thus being able to receive and provide new input from and to the outer environment (Chesbrough, 2003a; West, 2014).

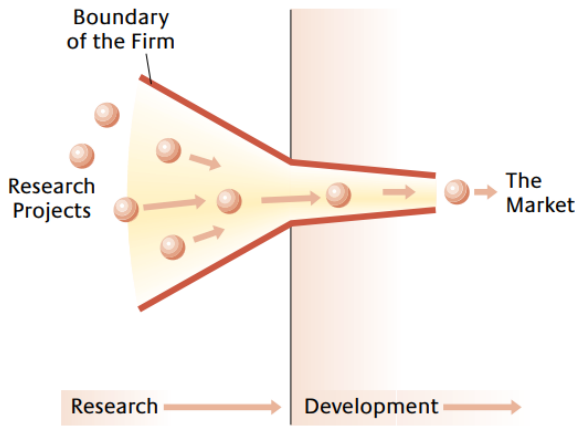

Figure 2: Closed Innovation Paradigm (Chesbrough, 2003b, p. 36)

Figure 3 shows the idea depicted by Chesbrough, where knowledge flows in or out at research or development stage, and only viable research projects are sent to development aiming for commercialization. The rest of the findings are provided to other counterparts that might benefit from this information in exchange for a fee.

In this new scenario, the availability of information, capital, and labor force have pushed firms to rethink whether closed research and development are viable anymore (Chesbrough, 2003a; West, 2014; Lichtenthaler, 2011).

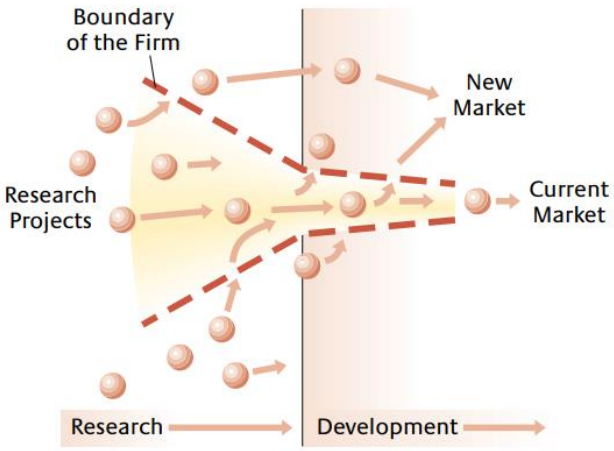

Figure 3: Open Innovation Paradigm (Chesbrough, 2003b, p. 37)

2.2 Factors Pushing for Open Innovation

As described in chapter 2.1, the strong investment in public schools and engineering programs changed the knowledge environment for many US companies. Alongside, the US implemented a strong immigration policy that increased the availability of knowledge workers and engineers. These changes in the labor market created pressure in the knowledge and science market context, making it difficult to keep findings enclosed within organizations walls, thus pushing towards an Open Innovation paradigm (Chesbrough, 2003a; Penrose, 1995).

The availability of venture capital was another interesting variable that supported and encouraged the generation of spin-off projects. Workers, that seeing the accumulation of knowledge in firm's closed repositories that did not see market light, suddenly saw the possibility to continue developing these innovations outside the company's borders financed by this venture capital. For many companies this was a nightmare since years of investigation and investment was lost suddenly (Chesbrough, 2003a).

These two major factors, that shaped Open Innovation paradigm, did not only bring bad news for closed innovator companies, but also it opened the possibility of knowledge and talent acquisition from labor markets. This way, companies were able to get innovation ideas and findings that

otherwise could have been impossible to attain. Availability of knowledge and ideas benefits firms in both directions, i.e. from within to the outside, and vice-versa (Chesbrough, 2003b; Yong, 2001).

2.3 Open Innovation Process

Lichtenthaler (2011) developed a framework that helps the understanding of Open Innovation processes in all its layers from an external and an internal point of view. The framework proposed distinguishes three layers for decision making in Open Innovation Process: (1) organization level, (2) project level, and (3) user or worker level. Each one of these levels approaches OI processes differently. Open Innovation processes are: first (a) exploration, when an organization is in search of knowledge, ideas, or new findings to input into the R&D pipeline. The knowledge can be obtained either outside-in or inside-out. It can be generated within the organization laboratories or it can be absorbed from the outer environment. In both cases, the organization must have certain capabilities to obtain this knowledge. Organization capabilities will be discussed later. Second, (b) retention is when the organization seeks a way to store their knowledge. Knowledge can be retained in two ways. According to this framework, it can be stored within the organization's walls, which requires indexing and maintenance, or it could be stored externally via interorganizational relationships. Third (c) exploitation is when the organization finds an approach to bring the innovation knowledge to the market. Exploitation occurs at the moment of development of a product or service, and the organization can take this knowledge to market internally, by doing development themselves or externally by means of giving the knowledge to another entity that will take it to the market (Lichtenthaler, 2011).

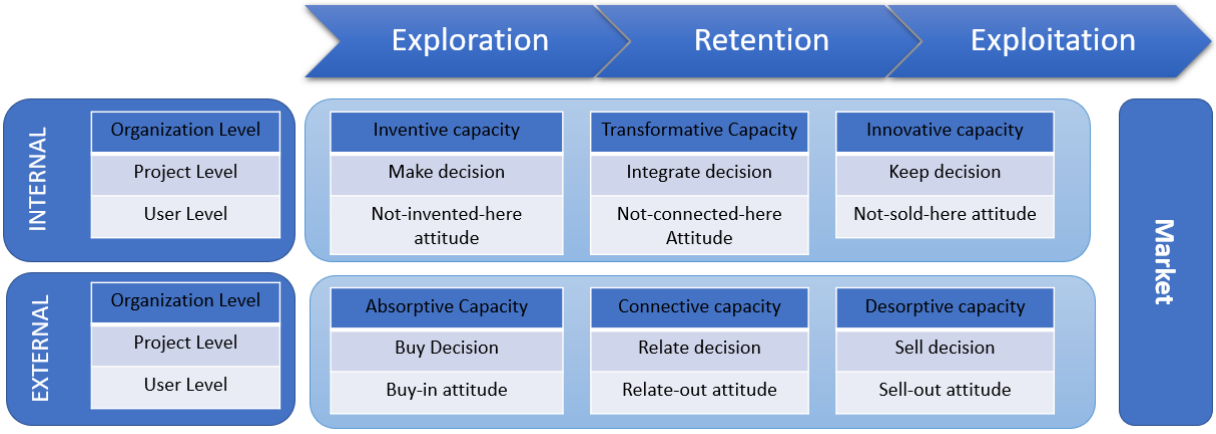

Figure 4: OI Process Framework (Lichtenthaler, 2011, p.80)

2.3.1 Knowledge Exploration

Figure 4 shows a descriptive model of the OI process framework. It has been discussed and criticized whether Lichtenthaler´s (2011) framework adds any value to previous work (di Benedetto, 2010; Groen & Linton, 2010; Linstone, 2010; von Hippel, 2010). Nevertheless, according to this framework, the research phase starts by exploring and searching for new ideas; knowledge that would allow the later development of an innovation. Research could begin within the organization, which requires a laboratory and engineers dedicated to investigation. This usually means financing the resources and constructing an inventive capacity within the firm. Moving on to a project-level exploration, a make or buy dichotomy must be addressed. Finally, at a user level, the organization may be prone to lean onto internal exploration due to not-invented-here attitude. The latter case requires cultural changes to take advantage of external information sources (Lichtenthaler, 2011; Chesbrough, 2003a).

Knowledge acquisition may be external, that is getting the information from outside the firm through alliances, joint ventures, patent databases, universities, etc. Usually this requires an absorptive capacity that has to do with the organization's ability to incorporate the new knowledge to the firm's repository or storage and later being able to transform it into a product. Some managers must develop plans and incentives for their workers to seek this knowledge from outside the company. At a project-level this is called a "buy decision ". At a user-level, it takes time to promote and develop a buy-in attitude towards knowledge (Lichtenthaler, 2007).

There has been developed theory on the whole subject of absorptive capacity. Studies demonstrate that hierarchical interorganizational cooperation and short gap diversity between firms is best suited for obtaining the best results out of innovation endeavors (Sampson, 2015).

2.3.2 Knowledge Retention

One thing is the exploration and acquisition of knowledge, and another completely different is the retention of the same. Transformative capacity is the ability of the firm to store, maintain, and re-activate knowledge. Knowledge retention requires management and effort. Knowledge can be retained externally using different types of inter-organization relationship (Lichtenthaler, 2011). The most common of alliances are the ones seeking access rather than acquiring knowledge, in which case the knowledge is preserved and retained in its origin (Grant & Baden-Fuller, 2004).

2.3.3 Knowledge Exploitation

Exploitation refers to the ability to benefit from the knowledge retained by the firm. The organization must have the ability to recover stored information and ideas from its own repositories and integrate this knowledge with existing knowledge to develop a product or service to the market. The whole process of internal exploitation begins by the recovering of information from the firm's repositories, after which at a project-level the decision to keep this information must be made. Keeping innovative knowledge requires deep reckoning of the firm's own development capabilities, if the organization is not able to benefit from this knowledge or if it is not part of the core business, the knowledge or its intellectual property could be sold or licensed to an outsider partner for further market development (Lichtenthaler, 2011; Chesbrough, 2003a).

Besides from obtaining the knowledge from within the firm's own walls, the development team could strive to get fresh ideas and knowledge from the outside by licensing patents or allying with business partners (Lichtenthaler, 2011).

Summarizing from the OI process framework, the knowledge transaction activities may occur at any given stage of the innovation value chain, i.e. it could happen at the beginning, while exploring for new idea, it could be and the retention stage, when storing knowledge for later development, or it could happen by the time the development team is working on a product or service and the need for additional input is required to create more value for the costumer.

2.4 Firm's Organization for Open Innovation

Open Innovation is a spin-off of general innovation process, which focuses primarily on inbound and outbound information sharing (Chesbrough et al., 2006; Chesbrough, 2003a; Chesbrough, 2003b). Lichtenthaler (2011) proposed a framework for better understanding the in-coming and out-going knowledge exchange between organizations. This framework further explores the concepts of exploration, retention and exploitation of knowledge and information without losing focus on market commercialization (Lichtenthaler, 2011).

Since Chesbrough (2003a) coined the concept of Open Innovation and published his book "*Open Innovation: The New Imperative for Creating and Profiting from Technology*", the community has been more aware of this field of study. Firms have actively tried to implement OI in their innovation processes to boost or keep their competitiveness (Subtil et al, 2018; Silje et al, 2019; Zynga et al, 2018). Different firm's OI implementation efforts have made researchers aware of the need for understanding organizational factors underlying a successful implementation.

Firms' management focuses mainly on (a) preparing the organization for bringing knowledge from the outside, this is known as inbound OI (IOI), and for (b) processing this new knowledge within the organization (Silje et al, 2019; Zynga 2018; Bianchi et al, 2016).

2.4.1 Organizing for Bringing External Knowledge to the Firm

Acquiring new information and knowledge requires a bridge between the firm and the outside. This bridge is obtained through R&D outsourcing; usually by networking and relating out with suppliers, costumers, universities, government and public organizations, associations, and

intermediaries (Zynga et al, 2018; Bianchi et al, 2016).

According to Bianchi et al (2016), the involvement at the firm level of either external consultant (variable 1) or internal dedicated R&D unit (variable 2) moderate the relationship between firm's innovation performance and R&D outsourcing. The moderation effect is different for each one of the variables. For variable 1, the involvement of an external consultant, has a positive effect on innovation performance at lower level of R&D outsourcing, thus decreasing the need for expenses in external information. Then again, it has a negative effect in innovation performance when spent more on R&D outsourcing. For variable 2, the involvement of a dedicated internal R&D unit, the moderation effect is negative for innovation performance, but it allows larger expenses, in R&D outsourcing, bringing in more knowledge, without changing the performance trend. The managerial implications of the previous study suggest that organizing an internal R&D unit is more beneficial for firms that require large amount of knowledge. In the other hand, firms with low level of inbound open innovation, should benefit more from external consultants rather than dedicated R&D units (Bianchi et al, 2016).

Zynga et al (2019) suggest that organizational change from closed innovation to an open state occur in three phases of development level. The first phase is referred as "unfreezing", on which firms are in a closed innovation stage and its individual capabilities, organization structures and processes support only intra-organization collaboration. These capabilities are referred as micro foundations for OI. At this stage, firms acknowledge the potential of OI implementation for improving innovation performance (Zynga et al, 2019; Chesbrough, 2003a). The second level is called "moving", on which firms explore and experiment with OI projects and methodology. Attaining this phase, requires that the firm implement certain micro foundations such as individual and networking capabilities. At the individual level, the firms should have scouts, or people that seeks for external knowledge outside the organization, as well as gatekeepers, whose objective is to make available and understandable the external knowledge for the firm's own organization. Individual capabilities will develop networks and associations that will make knowledge available for the organization. This is known as Inbound Open Innovation (IOI) (Zynga et al, 2019; Bianchi et al, 2016). The third level is known as "institutionalizing", on which firms internalize the OI process as part of its innovation strategy. At this phase, the firm has implemented processes that deal with the external input and developed organizational structures that promote the acquirement

and use of inbound input (Zynga et al, 2019). See Figure 5 for an illustrative diagram of the phases of organizational change.

2.4.2 Organizing for Processing New Knowledge within the Firm

From the moment the firm starts acquiring external knowledge through inbound Open Innovation process, it requires absorptive capabilities to deal with this new information. According to Zynga et al (2019), the organization prepares to explore new knowledge through a scout, that seeks knowledge from external sources. According to Bianchi et al (2016), the firm can use R&D outsourcing as an exploration method, that should be moderated by external consultants or an internal R&D unit to get the most out of it. Notwithstanding, no matter how the firm organizes for external knowledge acquiring, it requires absorptive capacity to deal with the new information at retention and exploitation stages. Lichtenthaler (2011) points out that retention requires the ability to internally maintain knowledge over time, and exploitation requires innovative capacity to transform knowledge into a commercial product.

Organizational changes in structure and culture are required within the firm for building absorptive capacity, such as innovation teams, definition of individual responsibilities, incentives for dealing with OI, buy-in attitude development, and over all any organizational change that promotes learning from external inputs (Zynga et al, 2019; Lichtenthaler, 2011). Processes that select and integrate the most valuable information are also required to deal with IOI (Lewin et al, 2011).

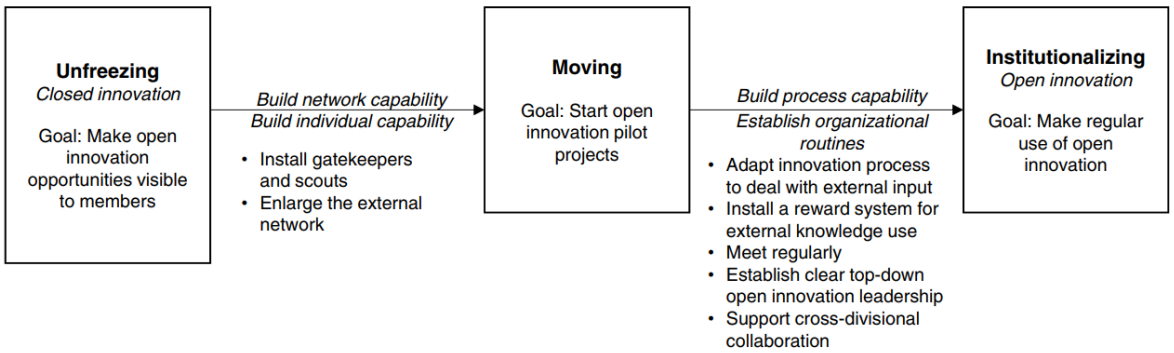

Figure 5: Organization Framework for Transformation to OI (Zynga et al, 2019, p. 23)

2.5 Successful Open Innovation Implementation

Open Innovation has been a natural choice for many companies that seek to maintain competitiveness in demanding markets (Chessbrough, 2003a; Lichtenthaler 2011; Huston & Sakkab, 2006). Despite the evident benefits of OI, its implementation has not been a straightforward line for many companies. Some companies have failed in their attempts, while others have abandoned the paradigm even after experiencing partial project success (Zynga et al, 2018). Finding a recipe for success in implementing Open Innovation has become the focus of some scholars in the last years (Subtil et al, 2018; Silje et al, 2019; Zynga et al, 2019; and Felin & Zenger, 2013).

2.5.1 Success Factors for OI Project

A project is defined as a "*unique process consisting of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including constraints of time, cost and resources*" (Oslo Manual, 2018). More specifically, an innovation project is a project that deals with the generation of an innovation. There are a few works that deal with assessing the Critical Success Factors for the implementation of Open Innovation projects in firms (Subtil et al, 2018).

Subtil et al (2018) describe a set of six categories present in successful OI projects. Notice that Critical Success Factors aim at defining a set of minimum variables to achieve positive results in Open Innovation Project implementations. These six major categories comprise 22 items that further break down the variables present in successful OI projects.

The first category relates to (a) *Leadership*, a soft skill that refers to the ability to cope with human resources, workers, and people. Managing teams and people has proved truly relevant as part of project management to success. Second, (b) *internal innovation capacity*, also mentioned in internal exploitation process, Lichtenthaler's (2011) OI process framework, deals with the ability of a firm to integrate external knowledge and transform it into an innovation. Contrasting to Lichtentaler's (2011) definition, Subtil et al (2018) treat internal innovation capacity also as the

firm's ability to receive and retain the external information. Internal variables such as dynamic capabilities, governance, workers' technical competence as well as external information inflow are part of the internal innovation capacity described above. The third part of the six-section category is (c) *network and relationships*. This part outlines the ability to create and generate effective relations with outer counterparts that effectively enable the sharing of knowledge in both directions. This ability comprises intellectual property management, relationships' management, the promotion of mutual trust, and seeking and benefiting from public programs for OI. (d) *Strategy Alignment* is the fourth item of the category. It deals with the firm's capacity to adjust its strategy to the previously mentioned innovation capability. It entitles internal development of absorptive capacity, the ability to effectively implement innovation, defining an innovation strategy according to the reality of the firm, and setting the necessary resources for open innovation. The fifth element is (e) *Technology Management*, which relates to dealing with external technology. That is to improve the management of technology, adequately evaluate technology transaction costs, and develop strategic technology networks. Finally, the sixth component is (f*) Culture*. This is important because the implementers of OI are workers subject to cultural bias. In this sense, a clear incentive structure and mechanism is required in order to promote the use of external information, indicators that help measure the desired behavior, the generation of organizational learning, and social cohesion towards working to a common objective (Subtil et al, 2018).

When successful OI implementations were studied, some of the 22 CSFs were observed in different literature, but not necessarily all of them were present at the same time. Nevertheless, the success in OI cannot be explained by only a few CSFs. There is no further information on how and into which extent these 22 CSF affect Open Innovation implementation (Subtil et al, 2018). As for the present, the Critical Successful Factors are just a reference for desired capabilities to develop in order to implement successfully OI projects.

Silje et al (2019) studied and described relevant successful factors (SF) in Norwegian metal industry companies. In contrast to Subtil et al (2018), this works recognizes only three main elements of Success Factors that affect the implementation of Open Innovation. The first element is *(1)information availability*, which comprises the relevancy and trustworthiness of the

information in the project, the availability of knowledge from previous projects, and mutual trust and partnership between the knowledge sharing counterparts; *(2)collaboration and networking*, that covers collaboration with external partners to design the solutions, coordination with outsider research and development counterparts, communicating to users and customers regarding the new innovation, and collaboration with users and customers to produce required solutions; *(3)organization management and teams*, dictates the need of common goals within a project, clearly defined roles and responsibilities, adequate resources for the development of the project at hand, appropriate participants' expertise within the project, inter-disciplinary solutions, plenty of meeting to enable reflection and development, clear communication, documentation of team work and developed solutions, proper arrangements for management, and innovation teams synergies (Silje et al, 2019).

Critical Success Factors are specific conditions that are present in accomplished projects. It is not clear whether all the CFSs are present at the same time or in different combinations. Current available studies offer little explanation on how much or to which extent each one of these CFS must be present in OI projects to achieve expected success. Silje et al (2019) present only three levels of presence of CFS in project: large, medium, and low. Exact quantities of CFS' involvement is left to interpretation.

Critical Success Factors categories presented by Subtil et al (2018) contain the SF three categories presented by Silje et al (2019). These results indicate that there is not a unique CSF framework that explain key factors for successful OI projects. Table 1 shows how CSF and SF are correlated.

Table 1. Comparing Critical Success Factors

Silje et al (2019)	Subtil et al (2018)
NOT ADDRESSED	(a) Leadership
(1) Information Availability	(b) Internal Innovation Capability
(2) Collaboration and Networking	(c) Networking and Relationships
NOT ADDRESSED	(d) Strategy Alignment
NOT ADDRESSED	(e) Technology Management
(3) Organization Management and Teams	(f) Culture and Organization

Empirical SF analysis shows that the most relevant source of information and knowledge for OI implementing firms was their own customers. A second interesting finding is that firms must have a systemic and well-defined organization structure, and team work to achieve successful OI implementations. These results are limited by the case study focus on Norwegian Metal industry (Silje et al, 2019).

2.5.2 Defining Success for Open Innovation Projects

Critical Success Factors (CSF) or just Success Factors (SF) are variables that need to be present for a firm or organization to reach strategic success. It is somehow ambiguous to say whether a company has succeeded in embedding Open Innovation as a standard in its organization without acknowledging management of Open Innovation Projects. Innovation, as defined by Schumpeter (1947), is the "*doing of new things or things that are already done in a new way*" that create market value. Chesbrough (2003a) added to the concept the purposive use of inflows and outflows information to accelerate the creation of new things with market value. Thus, the creation of a new deliverable comes inherently in the form of a project (Silje et al, 2019; Subtil et al, 2018).

Thanks to the extensive works of Silje et al (2019) and Subtil et al (2018) we know what elements need to be present to succeed in Open Innovation Projects. Now it must be determined when and how an Open Innovation Project can be deemed successful. Traditionally, a project has been understood as successful when it meets the iron triangle elements of (a) time, (b) cost, and (c) scope. This view reflected a narrow operational focus, that has not been enough to understand whether an innovation project is successful or not. A project that meets its constraints does not guarantee that the deliverables will bring commercial success to the firm. In this sense, Kerzner (2019) indicates that a successful project can only be evaluated by its impact on the business value. Even at the limit of project failure, some may hold a project partly successful due to the knowledge created or acquired through the project management process. This knowledge can be later beneficial to future projects (Kerzner, H. 2019).

Defining a project failure can be more difficult than to define a success. Since many a project management process may leave useful information, only a few projects may be deemed a complete failure. The following definition provides four possibilities (Kerzner, H., 2019):

1) *Complete Success: Business value is obtained fulfilling all the limitans of time, cost, and scope.*
2) *Partial Success: Business value is achieved but not all the limitans or constraints are met.*
3) *Partial Failure: Only some IP or information is generated for later use.*
4) *Complete Failure: Constraints not met, and no business value originated during the project management process.*

Since an innovation project always holds tasks to develop, such that have never been done before and probably never again, the probability of meeting all the competing constraints is exceedingly small. Some project managers even define constraints with margin offsets, so the constraint may be met within acceptable margins. For example: a project must be completed within 100 days ±10%. That would mean that the project will still be successful even if completed in 110 days. However, a complete success maybe the exception rather than the norm (Kezner, H., 2019).

2.5.3 Choosing Governance Form for Success in OI

Felin & Zenger (2013) defined a framework that aligns firm's Open Innovation Governance from a problem-solving perspective, with knowledge availability or hiddenness as a moderating factor. The complexity of the problem defines the interdependency between the solution design choices. The more complex the problem, the more dependency found between the design choices and knowledge required for the solution. Finding a solution may be difficult to delegate to any given business unit or individual. Theory development is usually required for finding a solution for such complex problems. In contrast, simple problems have less interdependency between the solution design choices and knowledge. These are by nature decomposable in parts and, thus, appropriate for decentralized solution search by trial and error. Internal as well as external units may actively participate in finding an answer to a simple problem (Felin & Zenger, 2013).

The availability of knowledge is one dimension, and the hiddenness of the same is quite another. In some cases, firm's management knows where to find the appropriate knowledge for solving either a simple or complex problem. In other circumstances, it may be unknown the whereabouts of the holder of the knowledge required for solving it. Thus, depending on the hiddenness of knowledge, the search for it may be centralized in one of the firm's units or self-nominated and self-selected. The latter approach is necessary when there is no information on whom may hold the knowledge to address a specific problem, thus being required that the holder himself or itself, when it is an organization unit, reveals itself to the soliciting firm (Felin & Zenger, 2013).

Felin and Zenger (2013) made two propositions; the first is that the more complex the problem becomes; firms adopt governance that encourages knowledge sharing and participation to generate understand ding and theory for solution search. On the contrary, when the problem is simple, firms adopt governance that promotes autonomous trial-and-error search for a solution. The second proposition states that as problems need hidden knowledge, firms embrace governance that broadcast problems to external environment, where holders of information self-identify instead of the firm centrally searching and selecting them.

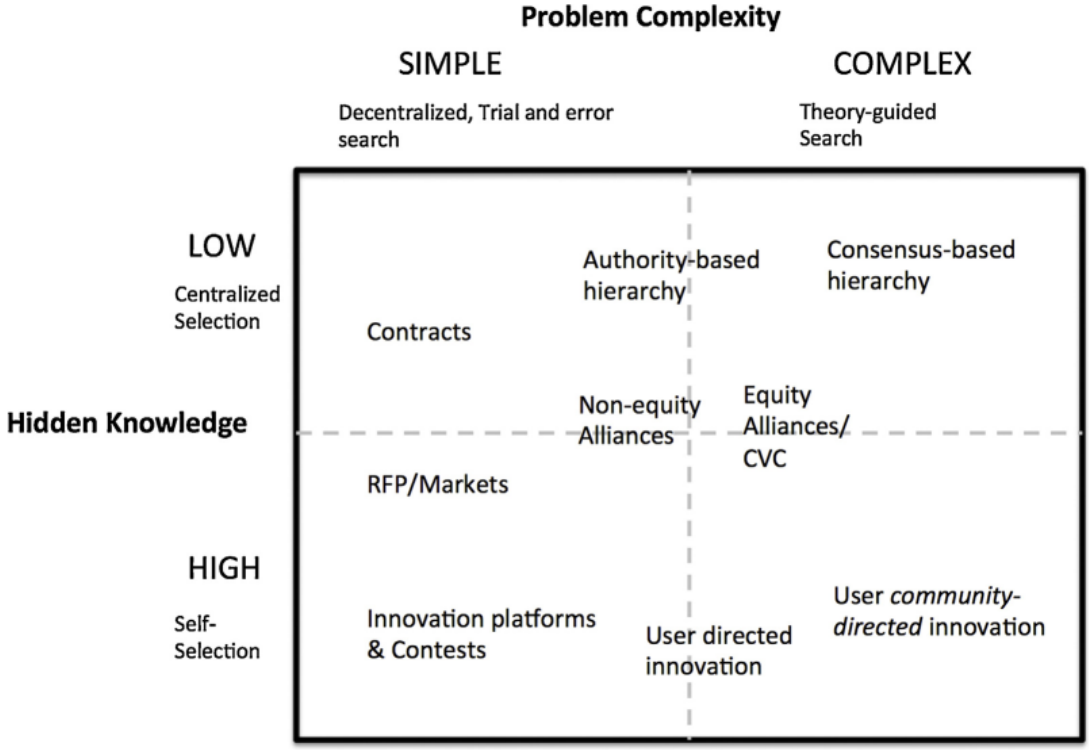

Figure 6: Governance for Open Innovation Framework (Felin & Zenger, 2013, p. 918)

Figure 6 shows the complete framework for choosing an appropriate form of Innovation Governance for the firm depending on problem complexity and the hiddenness of the knowledge required for the solution. Next, variable combinations will be analyzed one by one:

a) **Simple problem/Low hidden knowledge**: the nature of the problem allows for a decentralized solution search, with trial and error approaches. Knowing where to find the necessary knowledge for the solution design also makes it easier to centralize the selection of the information sources or exploration of the external markets (Felin & Zenger, 2013; Lichtenthaler, U., 2011; Chesbrough, H., 2003a, Chesbrough, H., 2003b; Bianchi et al, 2006). For this type of configuration, the best suited innovation governance approaches are contracts and authority-based hierarchy. Having identified the problem and those possessing the knowledge, the soliciting firm can make a call for those holding the knowledge, and in some cases having already solved the problem, to provide a product or service for sale (Felin & Zenger, 2013).

b) **Simple problem/High hidden problem**: Simple problems with hidden knowledge require self-nomination and self-selection of knowledge. For these cases, the best matching governance forms are Request for Proposal (RFP), markets, innovation platforms and contests. Calling for hidden knowledge holder self-nomination usually requires a platform that works as a communication channel between the focus firm and the problem solvers. Incentives are important for making participation attractive to the participating parts (Felin & Zenger, 2013).

c) **Complex problem/Low hidden problem**: Complex problems have a higher degree of interdependency between knowledge and variables, requiring a deeper understanding or theory for solution design. Thus, solution searching is theory guided. When knowledge is not hidden, then exploration and search can be centralized within the firm. Best suited governances are authority-based hierarchy, consensus-based hierarchy, partnerships, alliances, and corporate venture capital (CVC) (Felin & Zenger, 2013).

d) **Complex problem/High hidden problem**: This configuration requires a combination of theory-based solution searching and self-nomination and self-selection for knowledge discovery. Best suited governance forms are user directed innovations, and user community-directed innovation. These forms of problem solution design require a platform for broadcasting the problem necessity of the soliciting firm. Users involved oftentimes possess cutting edge knowledge and interest in solving these innovation problems despite that this type of governance lacks a proper incentive structure. Nevertheless, users participate with the sole purpose of benefitting from the use of the innovation product or service. This type of governance form is user-leaded rather than firm directed (Felin & Zenger, 2013).

2.6 Theoretical Base for the Case Study

The theoretical framework described from chapter 2.1 to chapter 2.5 is relevant for understanding Open Innovation concept and its methodological paradigm. It describes OI methodology and the benefits of its implementation in organizations. Lichtenthaler's (2011) OI process framework presents an important overview of Open Innovation processes and how these can be implemented in an organization internally and externally. This theory helps in understanding the capacity requirements, project level decisions, and users' attitudes necessary for the implementation of OI during exploration, retention, and exploitation processes.

The organizational phases for adoption of OI theory, from Zynga et al (2019), offers an interesting framework for recognizing the stage of any firm regarding the implementation of OI, thus contributing with decision-making information to firms' managers for the adoption of the right micro foundations elements to attain the desired organizational level for OI implementation. The elements of this theory will help in this thesis to recognize CODELCO´s level of organizational readiness for Open Innovation.

The theory behind Critical Success Factors explain the elements that need to be present in an organization for successfully implementing Open Innovation processes in a firm. Subtil et al (2018) proposed a comprehensive set of elements organized in six categories. In addition, Silje et

al (2019) arranged Success Factors in three categories that was later empirically tested in Norgewian metal manufacturing companies. CSF groundwork offers relevant information for understanding what elements may positively or negatively affect the performance of an OI project.

Kerzner's (2019) project management theory presents useful definitions for project success and failure, which shall be used to elucidate whether CODELCO's Open Innovation projects have been successful or not. Definitions from this theory will be shared with interview respondent to help them provide appropriate answer to the questionnaire.

Finally, Felin and Zenger (2013) propose a theoretical framework of matching a firm's problematic with a suitable Open Innovation governance. This framework will enable the analysis of used governance for CODELCO's projects in the second research question of this thesis.

3 CASE STUDY: OPEN INNOVATION IN STATE OWNED CODELCO

This chapter describes the case study of Open Innovation in CODELCO. The two research questions are addressed: (1) How CODELCO is implementing Open Innovation? and (2) How CODELCO's Open Innovation implementation affected projects' results?

First a short introduction and a historical review of CODELCO are presented to the reader, after which an organizational description is offered to aid the understanding of the current situation of the copper corporation.

3.1 An introduction to CODELCO

The history of copper mining in the north of Chile, specifically the second region known as Antofagasta, goes way back to the year 200 BC, when the local indigenous people mined for copper metal in the pampa of Antofagasta and Calama. Atacama people were the firsts to mine an old ore deposit known as Chuquicamata (CODELCO Historia, 2020).

Chuquicamata ore deposits were continuously exploited until Colonial times, after which interest in copper decreased and the focus turned to saltpeter, which was mostly exploited for warfare purposes. It was not until de XX century that the Chile Exploration Company, owned by Guggenheim Family, decided to invest in Chuquicamata ore mining. In parallel, another considerable ore deposit located about 130 km South of Santiago, Chile's capital, was exploited by North American Braden Copper Corporation (CODELCO Historia, 2020).

In 1971 Chilean parliament determined to nationalize the American owned companies, thus creating state owned CODELCO. The following divisions were incorporated to one company: Chuquicamata, El Teniente and El Salvador (CODELCO Historia, 2020; Millan, A., 2006).

Today Chile is the number one copper producer in the world, with more than 5,822 K metric tons of copper a year. This represents the 28.4% of the world copper production, closely followed by Peru with 11.7%. CODELCO is responsible for 1,588 K metric tons a year, which represents alone

7,7% of the world copper production (Sernageomin, 2019).

3.2 CODELCO's organization

CODELCO is one of the biggest copper production companies of Chile (Sernageomin, 2019). The corporation is in control of eight divisions: Radomiro Tomic, Chuquicamata, Ministro Hales, Gabriela Mistral, El Salvador, Andina, Ventanas and El Teniente (CODELCO Historia, 2020).

Figure 7: Map of CODELCO's Divisions in Chile (CODELCO Report, 2018, p. 12).

Figure 7 shows a map of the distribution of the eight divisions of CODELCO across the country. Geographically separated from one another, which naturally represents a challenge for the administration. Nevertheless, CODELCO uses a hierarchical organization to control all its divisions. At the head of the Corporation is the President, which governs the company from Headquarters in Santiago de Chile. Next in line are the Vice President of North Operations, who is responsible for General Managers of the northern mines; Radomiro Tomic, Chuquicamata, Ministro Hales, Gabriela Mistral and el Salvador, and Vice President of Central-South Operations, who is responsible for General Managers of southern mines; Andina, Ventanas and El Teniente. Figure 8 depicts the organization chart of executive level managers (CODELCO Report, 2018).

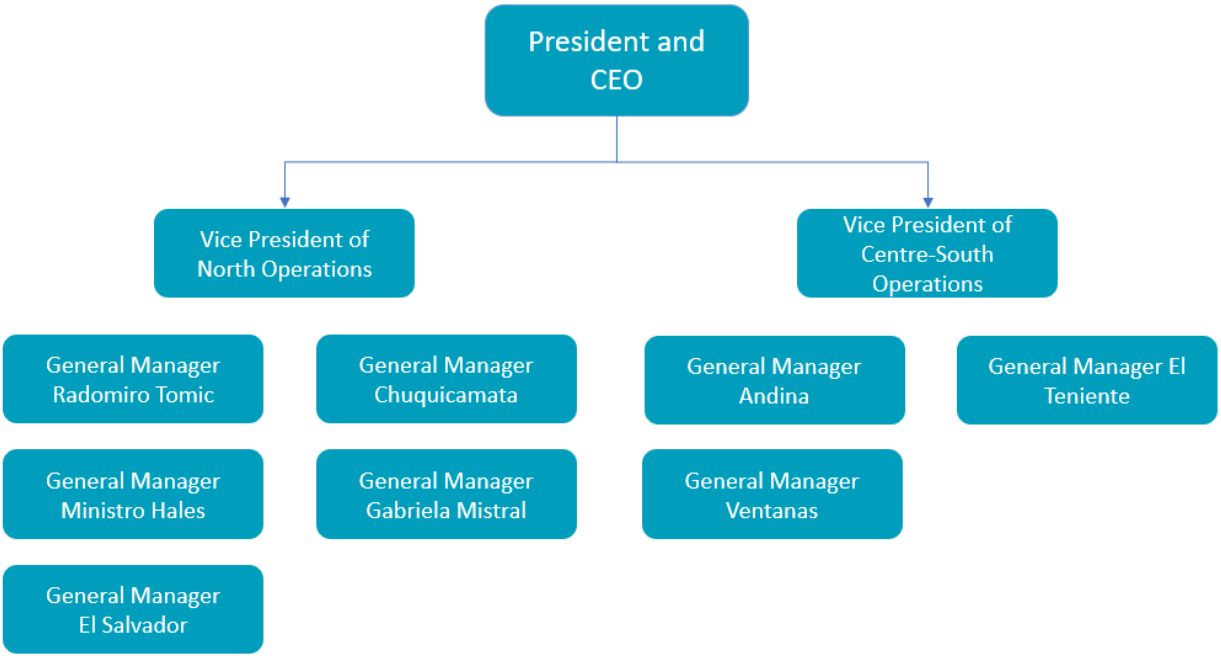

Figure 8: CODELCO's Organization Chart (CODELCO Report, 2018)

Even though the productive areas, known as divisions, are the most relevant in the organizational chart, CODELCO also utilizes transversal services and areas, which serve the different productive divisions, see Figure 9. Run also by a Vice President each, these are: Administration and Finance, Human Resources, Corporate Affairs & Sustainability, Mining Resources and Development, Productivity and Costs, Sales, Legal Counsel, Innovation and Technology Department (CODELCO Report, 2018).

In order to obtain relevant results that would represent all the corporation, it will be necessary to interview workers from both northern and southern divisions. Notwithstanding geographical separation between divisions, interviewing workers from transversal service areas may provide a broader view of all corporation innovation projects. See Figure 9.

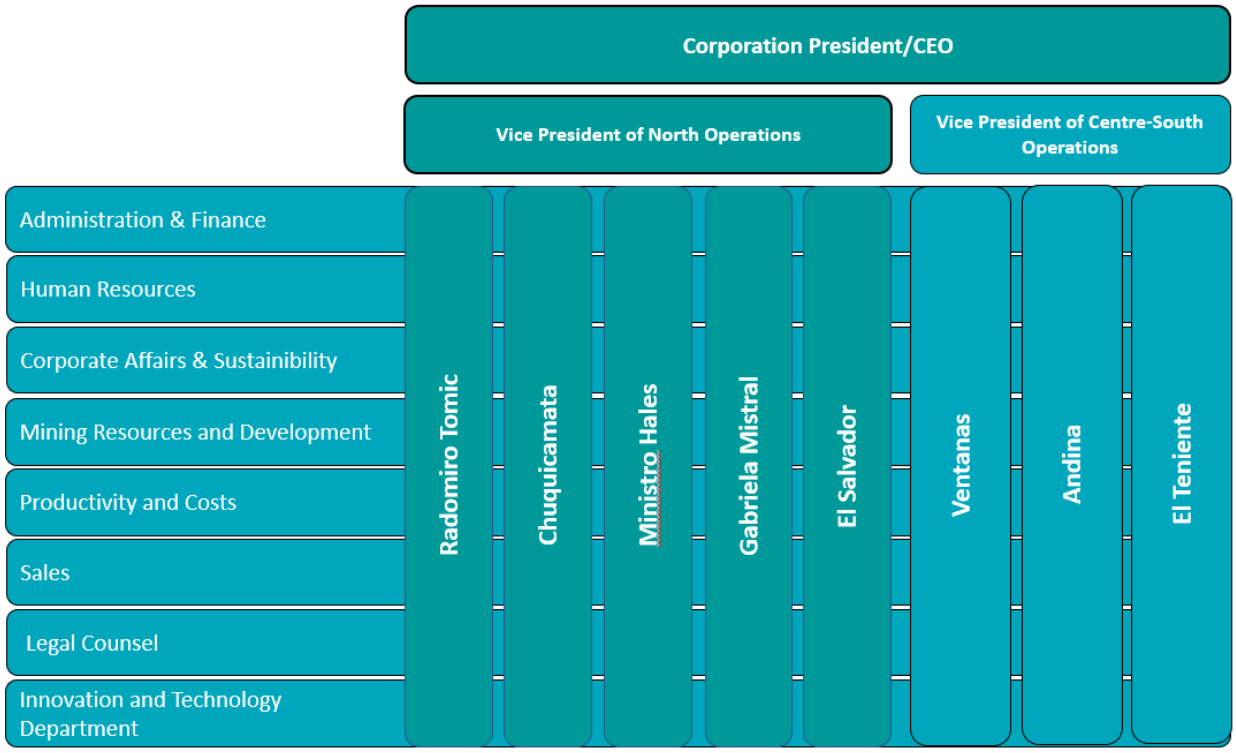

Figure 9: Transversal Areas and Services Chart (CODELCO Report, 2018)

3.3 Industry's Challenges and Innovation

Sebastian Carmona, appointed as general manager of Corporative Innovation Area, describes innovation as an imperative for mining industry, where "it is necessary to improve processes and decrease costs continuously". Under his leadership CODELCO has adopted an aggressive innovation strategy, which is deployed through the Innovation Management Area (Portal Minero, 2018).

Nicolas Rivera, General Manager at El Teniente Division, also highlights the importance of innovation to undertake the challenges of today´s mining industry. The environment for mining industry is constantly changing; as tunnels and open pits get deeper and deeper, the ore grades get lower, thus becoming more expensive the extraction of mineral. In the other hand, due to new environmental legislation, the use of natural resources is either difficult or more expensive. He also emphasizes that the competitivity of CODELCO can only be achieved through an increase of productivity and reduction of costs (Rivera, N. 2018).

The actual focus of the corporation lies in the following initiatives (Rivera, 2018):

a) Improve mining offer
b) Automation and machine efficiency
c) Asset management and mining preparation
d) More technology in mining processes
e) Water resources and tailing dams
f) Energy efficiency
g) Digital Transformation

These challenges intrinsic to the mining industry add up to new environmental requirements issued by the Ministry of Environment, and the unstable copper prices. These conditions create pressure upon mining companies that operate in Chilean soil (Betancour and Maldonado, 2013; Memoria, 2016), pushing them to recourse to innovation as a rapid solution for production increase and cost reduction (Rivera, N. 2018; Betancour and Maldonado, 2013; Memoria, 2016).

3.3.1 CODELCO's Innovation Strategy

Sebastian Carmona, leader of Innovation Management, says that his area is working on three innovation fronts: disruptive innovation, in order to address strategic requirements in the long term; such as ore lixiviation process or technologies for deeper extraction in underground mines. The second front, incremental innovation, developed locally by each Division in CODELCO. The objective is to look for short term needs and match them with an existing solution that is deployed within the same company or even from outside. The innovations can be implemented as such or they can be tailored to satisfy the necessity of the company in the short and medium term. Finally, CODELCO focuses in capturing new technologies for automation, robotics, remote controlling, and data processing that will improve the productivity and safety in operation (Portal Minero, 2018).

For all innovation strategy, CODELCO emphasizes the use of Open Innovation as a way for reaching its goals. Innovation is being made alongside service providers, universities, and

government agencies. Among these, the most important are CODELCO Tech, the Corporation's own technological daughter company, Fundación Chile, a public-private innovation agency, and CORFO, government agency (Portal Minero, 2018).

3.3.2 CODELCO Tech

In the year 2016, CODELCO defined an innovation strategy which focused on the development of new technology by engaging third party organizations to bring further value to the corporation. In this effort, CODELCO created the Corporative Innovation Management Unit, leaded by Sebastian Carmona, which is responsible for identification, design, evaluation, planification and execution of innovation opportunities with third party organizations through acquisition, sales or associations within Chilean national territory or abroad (Memoria, 2016; CODELCO Report, 2018).

A direct result of the new strategy was the re-structuration of CODELCO technological subsidiaries: IM2, BioSigma and CODELCO Lab, integrating them all into one and single company called CODELCO Tech, 100% owned by CODELCO Corporation. The new created company benefits from the experiences of the absorbed companies and its primary objective is to create disruptive innovation; breakthrough technologies to address the challenges of the mining industry, such as constantly decreasing ore grades, deeper deposits, mineral impurities, water and energy shortage and high prices (Memoria, 2016). Overall, CODELCO Tech became the orchestrating and champion unit that CODELCO deemed necessary to focus on solving the challenges of an ever-changing environment (CODELCO Tech, 2020).

CODELCO Tech developed its own innovation management system, which strives to systemize innovation process and measure its results in time. In 2016, a broad assessment of implemented innovation projects, and projects in course was performed to define a baseline and prioritize corporation resources to get better results (Memoria 2016). Later, it adopted open innovation as the major approach for acquiring new technology, thus engaging research centres, universities, service providers, startups, just to name a few (CODELCO Tech, 2020).

At the beginning of the year 2020, CODELCO Tech was terminated due to the lack of results

expected by the Corporation. Most of the responsibilities left will be absorbed by CODELCO's Innovation Unit (Cesco, 2020).

3.4 Interview Construction

This thesis is based on empirical research conducted through semi-structured interviews to CODELCO workers. Given that not all workers necessarily participate in innovation processes, only certain profiles qualified for the interview. For instance, five managers and three executives from the following units were interviewed: Innovation Unit, Mining Operation, Mining Resources and Development, and Vicepresidency of Technology, Automation and Projects. People were chosen from these units because of the relevance they represent to the mining firm. Innovation alone oversees proposing innovation projects, but only operational areas, such as Mining Operations, Plant or Mining Resources and Development, decide whether the projects are worth of receiving financing and execution. Operational level workers were left out of the screening plan, due to low relevance to innovation projects.

Interviews were carried out via phone calls between September 2020 and October 2020. The different units and divisions chosen for the interviews ensure the validity of the study. Table 2 shows a summary of the interviewed personnel.

Table 2, Summary of Interviewed Staff.

Company	Level	Area	Division
Codelco	Executive	Vicepresidency of Technology, Automation and Projects	Northen Divisions
Codelco	Executive	Mining Resources and Development	Northen Divisions
Codelco	Executive	Innovation Unit	Northen Divisions
Codelco	Manager	Vicepresidency of Technology, Automation and Projects	All Corporation
Codelco	Manager	Innovation Unit	All Corporation
Codelco	Manager	Mining Operations	Northen Divisions
Codelco	Manager	Vicepresidency of Technology, Automation and Projects	Northen Divisions
Codelco	Manager	Vicepresidency of Technology, Automation and Projects	Northen Divisions
Codelco	Manager	Vicepresidency of Technology, Automation and Projects	Southern Divisions

The objective of the interviews was to understand (1) how CODELCO is implementing Open Innovation methodology in its organization and to assess (2) How CODELCO's Open Innovation

implementation affected projects' results. Embedded in the last question, it was also asked whether CODELCO would persist in its effort to institutionalize Open Innovation.

First, the organization phase is recognized by questions regarding the level of OI penetration in its organizational structure (Zynga et al, 2019). Additional information offered by the interviewees helped to further clarify OI implementation detail.

a) Unfreezing Stage

- CODELCO is using **only** closed innovation and only recently you have heard that OI is a feasible methodology to be used in future innovation projects?
    - Have you or your team being told about OI methodology?
    - Have you or your team being invited or received to OI training?

b) Moving Stage

- CODELCO is experimenting with OI methodology and it is recently running pilots?
    - have you or your team being invited to participate in OI project in the last 24 months?
    - Has CODELCO defined responsible person (scout), or team, to search for external sources of information?
    - Has CODELCO defined a person (gatekeeper) or team in charge of disseminating, integrating, and retaining the externally obtained knowledge?
    - What sources of external innovation/knowledge CODELCO has used in the past 24 months? For example: Alliances, Joint ventures, partnerships, user communities, contests? '

c) Institutionalizing

- CODELCO has developed a commitment to Open Innovation and has made it part of its strategy?
    - Does your team or organization have incentives for incorporation of external knowledge?

- Has your team or organization unit experienced changes in roles and responsibilities for handling OI?
- Does your team or unit have a formal network for exchange of knowledge?

The second research question aims at assessing how CODELCO has succeeded in the implementation of Open Innovation. This is attained by asking about the results of OI projects developed in the last 24 months. The definition of a successful project was taken from Kezner (2019). Finally, it was asked whether CODELCO will persist in its intentions to implement OI as part of innovation strategy:

1) How many Open Innovation projects CODELCO has successfully or partially successfully implemented in the last 24 months?
    - What was CODELCO's external source of innovation Information for the project?
    - Did CODELCO developed the final product or process, or was it an external partner?
    - How did project's results impact CODELCO's business?

2) How many Open Innovation projects CODELCO failed to implement in the last 24 months (complete or partial failure)?
    - What was CODELCO's external source of innovation Information for the project?
    - Did CODELCO developed the final product or process, or was it an external partner?
    - How did project's results impact CODELCO's business?

3) Given the actual OI project experience, will CODELCO persist in its efforts to institutionalize Open Innovation as part of its strategy?

The compilation of questions presented to the interviewees provide with valuable information to understand how CODELCO implements Open Innovation from Lichtenthaler's framework's point of view (Lichtenthaler, 2011), the level of organizational transformation to Open Innovation

strategy (Zynga et al, 2019), and how successful the last 24 months projects have been (Kezner, 2019).

3.5 Interview Results

Previously to exhibiting the questions to the interviewees, four definitions were presented to the participants to unify concepts to obtain answers coherent to the theory. Definitions were provided for Business innovation (Oslo Manual, 2018), Open Innovation (Chesbrough, 2006), innovation project (Oslo Manual, 2018), and successful innovation project (Kerzner, 2019).

Results will be presented separately for each question, after which analysis will be offered complementing with extended answers from the interviewees.

3.5.1 Determining how CODELCO is implementing Open Innovation

- CODELCO is using closed innovation and only recently you have heard that OI is a feasible methodology to be used in future innovation projects?

Table 3: Answers regarding unfreezing-phase in an organization

Have you or your team heard about OI?

yes	no
3	6

Have you or your team participated or been invited to OI training?

yes	no
1	8

Most interviewees were not aware of the meaning of Open Innovation. See table 3. After offering an initial definition at the beginning of the interview, respondents said that they had not heard about the concept within the company. Two workers new the concept beforehand due to personal studies outside the firm. Only one worker had received proper training regarding OI from CODELCO Tech, CODELCO's daughter company. These results indicate that CODELCO may

have not achieved the necessary organizational micro foundations mentioned by Zynga et al (2018). In this context, broad communications structures are required in order to engage the organization in supporting Open Innovation projects. Additionally, CSF groundwork recognizes the importance of communication culture among Critical Success Factors in organizations.

Despite the negative answer regarding knowledge of Open Innovation definition, participants were asked to determine whether they had participated in Open Innovation projects based on the definition of OI provided at the beginning of the interviews. Eight out of nine respondents recognized that they had indeed participated in projects that met the requirements of an OI project.

- CODELCO is experimenting with OI methodology and it is recently running pilots?

Table 4: Answers regarding moving phase in an organization

Have you or your team been invited to OI projects in the last 24 months?

yes	no
8	1

Has Codelco defined a person or scout to search for external sources of information?

yes	no
9	0

Has Codelco defined a person or gatekeeper for disseminating, integrating, and retaining external knowledge?

yes	no
7	2

Table 4 shows the answers regarding the *moving* phase in an organization. Contestants were prompted to recognize whether they had been invited or participated in Open Innovation projects even though they had not been told that it was an OI project. Almost all the interviewees indicated that they had participated in OI initiatives, except for one. This shows that, although innovation projects are leaded by Innovation Unit project managers, operational unit workers participate as users or clients to the innovation being produced in these initiatives. Some respondents also shared their opinion concerning the importance of including all the stakeholders from the very beginning of an innovation project if wanted it to be successful. The information provided in this set of

questions only strengthens the importance of horizontal and vertical communication as micro foundation, described by Zynga et al (2018) and CSF framework.

Regarding the existence of a scout and gatekeeper (Zynga et al, 2019), all the interviewees responded that Innovation Unit was in charge of scouting for external knowledge that leaded to innovation. When consulted about a gatekeeper figure, some answers were divergent. This is because Innovation Unit workers considered that, after the termination of CODELCO Tech, their knowledge management systems required further development. Positive answers regarding knowledge about organizational roles indicate that some form of internal communication keeps workers up to date regarding organizational changes and units' roles.

Table 5: Sources of External Knowledge Utilized in CODELCO in last 24 months

What source of external innovation/knowledge CODELCO used last 24 months?

Alliances	Joint Ventures	Partnership	User communities	Hackathon	consultants
5	4	1	1	1	1

All participants had some knowledge regarding the use of external sources of information for innovation except for one, that had not participated in any innovation project in the last 24 months. Contestants were able to name different type of sources such as alliances, and joint ventures, which were used the most in recent innovation projects. Other sources of external information were partnerships with universities, user communities, hackathon, and external consultants. The type of alliances chosen by CODELCO, may be an indicative about the complexity of the problem at hand and the hiddenness of the knowledge required for a solution design (Felin & Zenger, 2013). The results show that, with the given alliances, CODELCO addresses rather medium to highly complex problems, with known sources of information.

- CODELCO has developed a commitment to Open Innovation and has made it part of its strategy?

Regarding the incentive structure for incorporation of external knowledge, some workers in Northern Divisions mentioned the existence of Performance Evaluation System (PES) that by default had an item for innovation, and the incorporation of innovative solutions in projects during the year. Nevertheless, some workers did not perceive this PES item as relevant for the search and incorporation of external knowledge into initiatives, thus answers were divided. Other respondents from center and southern division did not have innovation incentives in their PES. Furthermore, it was pointed out that PES objectives were drafted by Human Resources separately for each division. Overall, workers either do not have incentives or do not consider enough incentive the PES system. See Table 6 for interview results regarding organizational questions and answers. The organizational transformation for OI framework, proposer by Zynga et al (2019), indicates that the establishment of structures, such as incentive structure, is an important micro foundation required for the institutionalization of OI within a firm. The lack of such an important structure may affect negatively the results of OI implementation.

Table 6: Answers regarding Institutionalization of OI in the organization

Does your team or organization have incentives for incorporation of external knowledge?

yes	no
3	6

Has your team or organization unit experienced changes in roles and responsibilities for handling OI?

yes	no
5	4

Does your team or unit have a formal network for exchange of knowledge?

yes	no
4	5

Concerning organizational changes in roles and responsibilities, some workers have experienced recent changes that aim at the implementation of the innovation strategy of the corporation. Particularly, Innovation Unit had had changes after the termination of CODELCO Tech, which triggered the incorporation of new roles and responsibilities regarding scouting and knowledge management. The Vice-presidency of Technology, Automation and Projects (VTAP) had also experienced changes that aim at optimizing internal processes as well as better handling projects; included innovation projects either closed or open. Workers in operational areas did not experienced changes in their organizations, which have remained more or less the same during the past eight years. Extensive organizational changes in some units, and the lack of changes in operational areas, indicates that the firm recognizes Open Innovation as an important tool for obtaining solutions to complex competitiveness problematic, but the adoption of important micro foundations has been overlooked by decision-making executives.

Mixed answers were obtained regarding the existence of formal channels for the exchange of knowledge. It was asserted by executive workers that CODELCO had indeed signed several alliances with universities and other technological companies, and that these were to be as channels for sharing inbound as well as outbound knowledge. Despite the creation of these channels, only executives and Innovation Unit workers had information about these channels. The rest of the workers, including operational units and VTAP, did not know about them, lest made use of them to exchange information. These results are, once again, indicative of overlooking relevant communication and organizational engagement micro foundations mentioned in CSF framework.

3.5.2 Determining how CODELCO's OI implementation affected projects' results

The second objective of this thesis is to determine whether the implementation of Open Innovation has had a positive influence in project results. The definition of a successful project is not straight forward since there is not a unified criterion for project success. Nevertheless, this paper takes the concept developed by Kerzner (2019) regarding successful projects. Additionally, Critical Success Factor framework shall be used to distinguish the existence or lack of particular elements in the management of open innovation projects. The following section shows the results of the second set of questions.

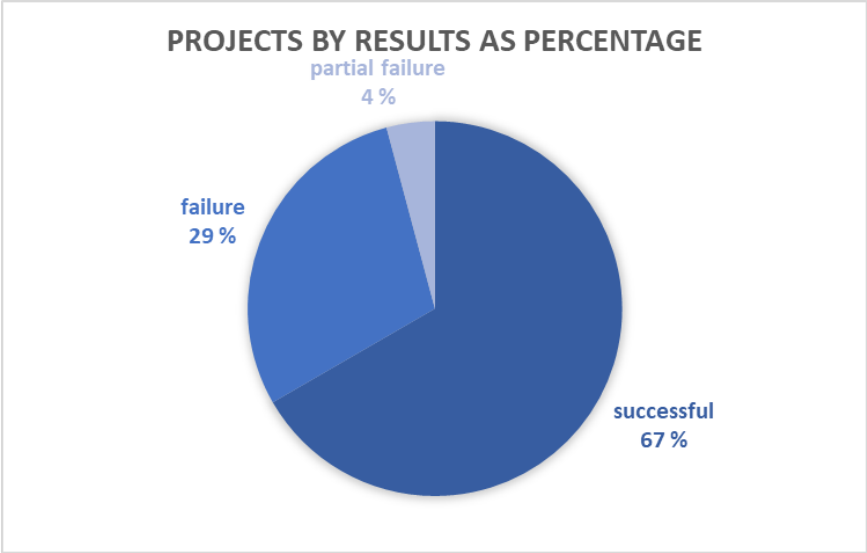

Figure 10: Projects by Results as Percentage

Figure 10 shows graphically the results of all projects informed by respondents during the interviews. These projects were all innovation projects regardless whether they were OI or Closed Innovation projects. Successful projects represent 67% of the pie chart. One third of the executed projects were described as failures. These results do not represent the reality of all projects executed by CODELCO, because interviewees declared during the interview that it was easier for them to remember successful projects.

The first question that was asked from the interviewees collected information on successfully implemented Open Innovation projects. *How many Open Innovation projects CODELCO has successfully or partially successfully implemented in the last 24 months? For each project, describe:*

a) CODELCO's external source of knowledge.
b) Whether CODELCO or the external counterpart implemented the innovation.
c) The project's business impact.

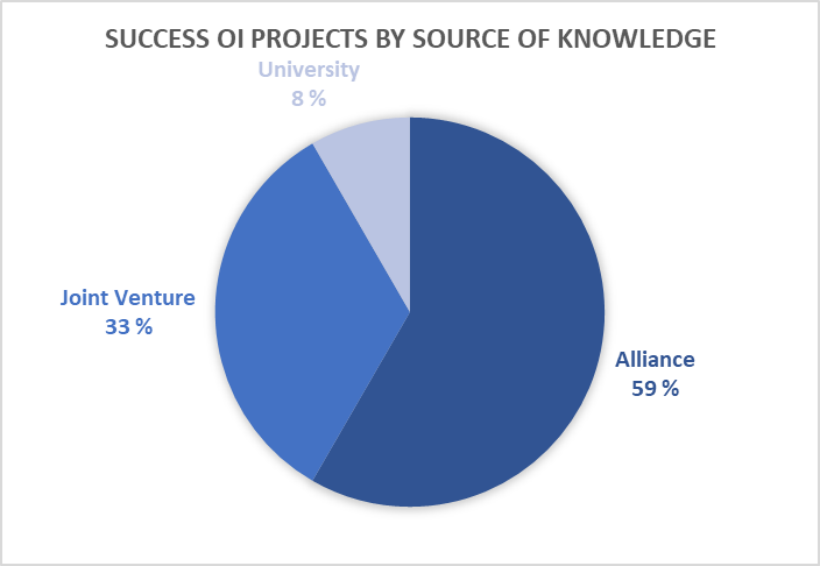

Figure 11: Successful OI Projects by Source of Knowledge

Regarding successful Open Innovation projects executed by CODELCO, Figure 11 shows the distribution of the source of the external knowledge utilized in the projects. Accounting for 59%, interfirm alliances were the most used source of information in OI. The Second most utilized source of knowledge were joint ventures with 33% of the total, and last university networking, represented by 8% in the pie chart. Based on Governance for OI framework, presented by Felin and Zenger (2013), these results may indicate that CODELCO tried to solve medium to high complexity problems with low level of hidden knowledge. See figure 6.

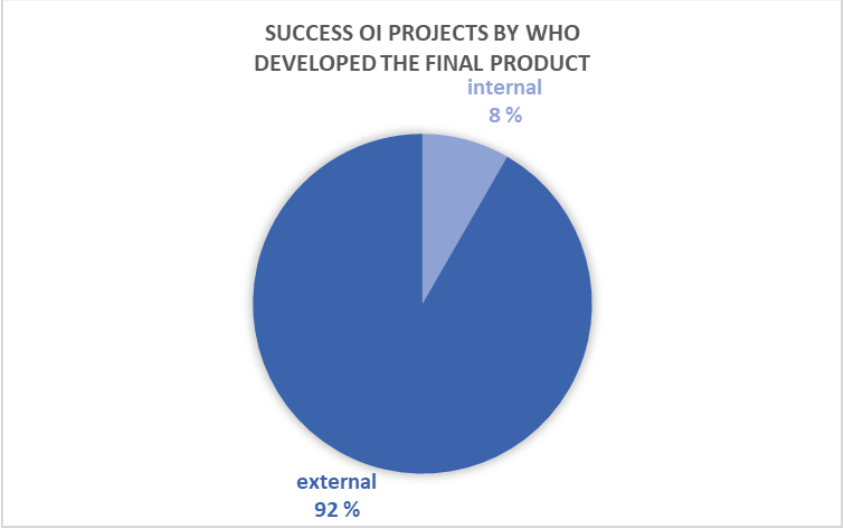

Figure 12: Successful OI Project by Who Implemented the Product

Figure 12 reveals that in 92% of the successfully implemented OI projects an external partner implemented the final solution. Only in 8% of OI projects the final product was developed internally by CODELCO. This configuration may respond to the operational structure of CODELCO. Interview respondents commented that CODELCO has a rather operational structure, and that projects are developed mainly by outsourced companies regardless the innovation level required.

Open Innovation projects that succeeded impacted primarily the productivity of the firm, see figure 13. In second place, OI projects impacted cost saving, and finally operational safety. These results are aligned with the need to preserve competitiveness in the firm. This was mentioned by Nicolas Rivera (Rivera, 2018) in chapter 3.3.

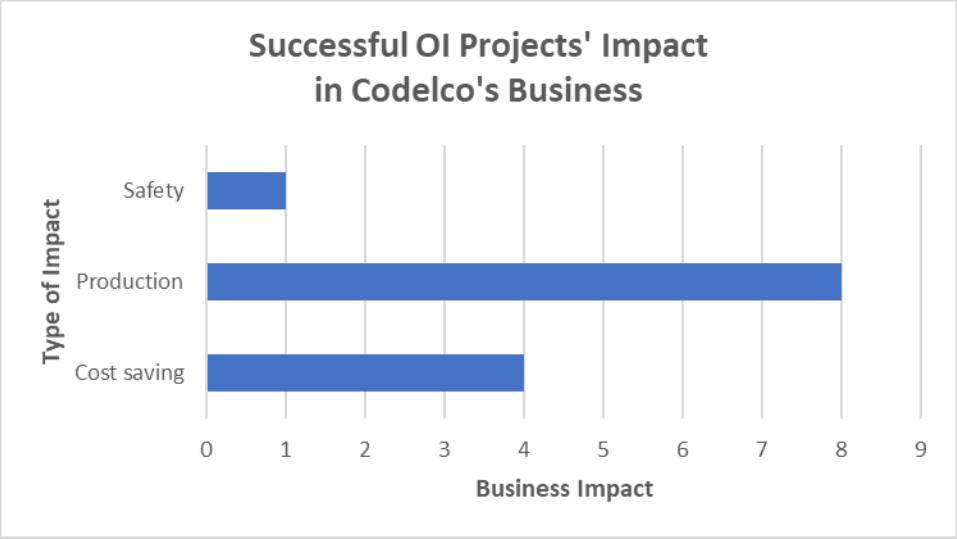

Figure 13: Successful OI Projects' Business Impact

The second question presented to interviewees collected information on failed Open Innovation projects: *How many Open Innovation projects CODELCO has failed or partially failed to implement in the last 24 months? For each project, describe:*

a) CODELCO's external source of knowledge.
b) Whether CODELCO or the external counterpart implemented the innovation.
c) The project's business impact.

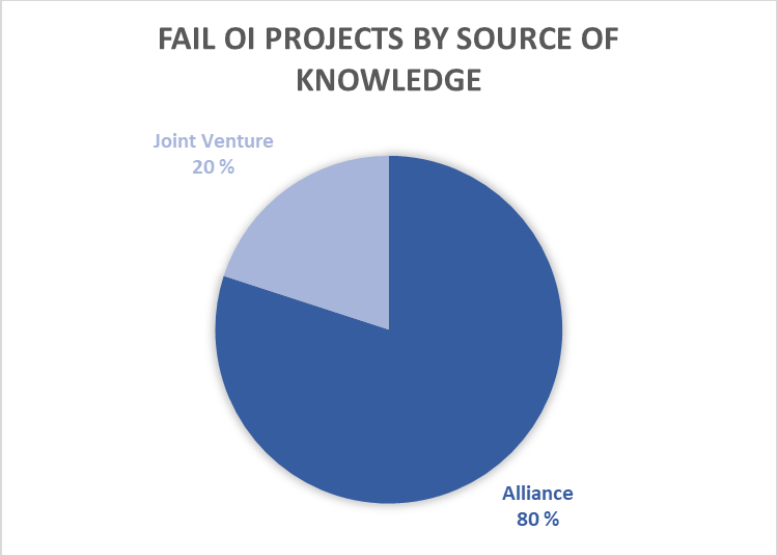

Figure 14: Fail OI Project by Source of Knowledge

The sources of knowledge utilized in fail OI projects are described by figure 14. In 80% of the cases the source of knowledge was an interfirm alliance. Joint Venture accounted for 20% of the cases as external knowledge source in projects. The information provided by data collected does not suggest that any particular external source of information should be better or preferred over another. Furthermore, some respondents indicated that they perceived cultural attitudes as the reason for failure in projects. In some cases, the final operational users did not like the implementation of certain technologies because they did not see a direct benefit or simply because they felt that technology threatened their jobs.

All OI projects that failed or partially failed were implemented or attempted to be implemented by an external partner. See figure 15. These results do not offer additional information whether an internal implementation could have been the reason for failure.

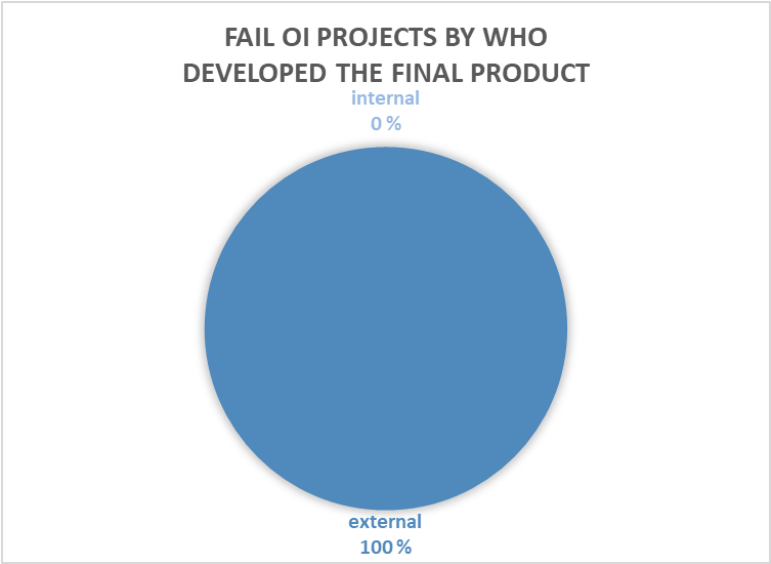

Figure 15: Fail OI Projects by who Developed the Final Product

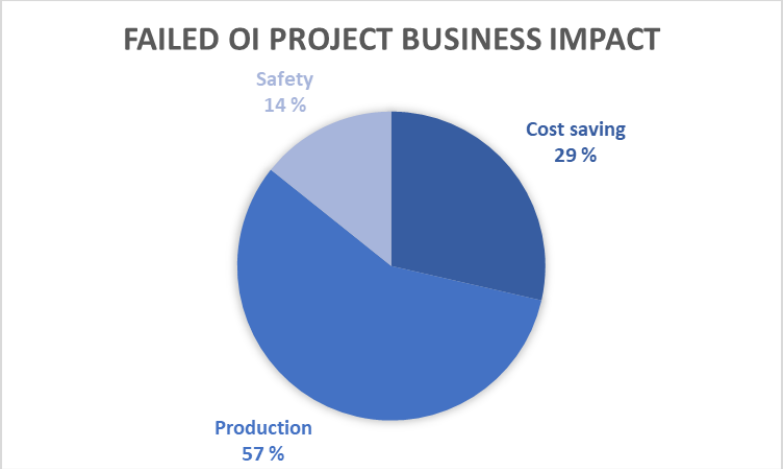

Figure 16: Fail OI Project by Business Impact

Classified by the business impact, figure 16 shows the business objective of failed OI projects. In first place, production was the main driver with 57%. In second place was cost saving with 29%, and last was operational safety with 14%. Unfortunately for CODELCO, these projects were not implemented successfully. A partial failure, mentioned among these OI projects, was particularly important because it generated knowledge and experience that was later utilized for the implementation of future projects.

Provided information regarding OI project management reveal that CODELCO has only recently implemented a knowledge management system, that serves the purpose of organizing and retaining the information generated during project execution. The lack of information concerning previously implemented projects has resulted in fruitless multiple attempts to implement similar project without organizational learning. One respondent indicates that, this deficiency has been detected and efforts are being made to resolve this problem.

In the interviews, it was mentioned a project that was held successful by a manager and a complete failure by an executive. It is the Integrated Operation Centre (IOC) implemented by Division Ministro Hales. This was a pioneering remote integrated centre of operations that concentrated the whole mining operations from load and hauling to the smelter and roasting plant. It was the first project in the world that remote controlled Ministro Hales' whole mine operations. Designed and implemented by a Joint Venture between CODELCO and Honeywell called Kairos Mining, this project began in October 2015, and was located 1535 km from the physical mine (Mineria Chilena, 2016). Despite its acclaimed beginnings, the Integrated Operation Centre was dismantled on the year 2019, when CODELCO's executives noted that the initiative did not generate the expected value to the business. One interviewed manager held this project a complete success since it technically worked owed to a huge effort from the operation level workers. On the other hand, executives declared the project a failure after calculating the costs versus the benefits. Notwithstanding the failure from Division Ministro Hales' Integrated Operation Centre, the generated information was valuable to the corporation's following projects: Integrated Centre of Operations for Division El Teniente, and Integrated Centre of Operations for Division Chuquicamata (CODELCO, 2016; CODELCO 2019).

The last question of the interview inquired respondents to tell if CODELCO will persists in its efforts to institutionalize the use of Open Innovation as part of its innovation strategy. Figure 17 shows the results of the collected data.

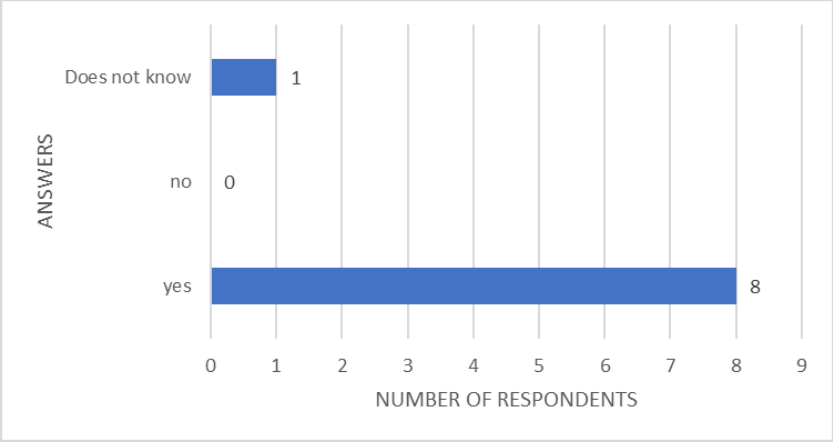

Figure 17: Will CODELCO institutionalize OI?

The empirical results show that eight out of nine respondents indicated that CODELCO will persist in its efforts to utilize Open Innovation methodology in innovation project management. One of the workers declared ignorance on CODELCO's plans concerning this question. The overall positive attitude towards OI may be a reflection of CODELCO's executives' positive experience with innovation projects.

4 DISCUSSION

The first part of the discussion addresses how CODELCO is implementing Open Innovation methodology in its organization. The scope of the research question is broad and rather descriptive in nature. In order to narrow down the extent of the discussion and purposely answer the first question, the following topics will be discussed:

a) OI process framework
b) Organization readiness for OI

The second part of the discussion will immerse into the characterization of how CODELCO's OI implementation has affected the results of innovation projects. Whether CODELCO has achieved overall success in the implementation of OI shall be discussed openly. It can be difficult to determine global organizational success in OI implementation, nevertheless a conclusion shall be attempted based on successful project definitions. The following topics will be discussed

a) CSFs elements in projects
b) Governance framework for OI
c) Successful definition for OI

4.1 First Question: How CODELCO is implementing OI Methodology?

The results of the semi-structured interview show that CODELCO is using Open Innovation as part of its innovation strategy. Respondents recognized participation in OI projects, also admitted the existence of organizational unit in charge of scouting and management of externally obtained knowledge, as well as organizational changes in roles and responsibilities to better address innovation in the firm.

Now the analysis of the first set of questions concerning knowledge of OI concept, participation in OI training, and knowledge on formal external channels for knowledge exchange, clearly indicate that CODELCO has overlooked the importance of extensive communication across the

organization. Regarding knowledge about open innovation, only workers from innovation unit knew the concept. Other exceptions were observed, but knowledge was obtained from personal studies. In the case of external formal communication channels, these were known by executives and innovation unit workers. The rest of interviewees did not recognize formal external communication channels. It was mentioned by some contestants that they had resorted to informal channels to obtain information on technologies and innovation knowledge. This lack of knowledge and communication regarding the objectives of OI may cripple the building of organizational capacities for managing OI processes described by Lichtenthaler (2011). At the user level, not knowing the purpose of OI projects nor the objectives of corporative innovation strategy have affected the attitudes of some workers towards the implantation of innovative solutions in processes. The latter is discussed more extensively in project analysis in chapter 4.2. Another deficiency was observed in the incentive structure deployed by the firm. OI elements were incorporated in the Performance Evaluation System in northern divisions, but only few workers recognized this structure as relevant for their daily routines. Southern divisions did not have the same OI elements present in their PES system, leaving incentive structures completely out of workers' routines.

Lichtenthaler's (2011) OI process framework is utilized to describe CODELCO's OI strategy implementation. See figure 18. According to the data collected, exploration is the main channel for obtaining innovation information for the organization. This task is executed principally by Innovation Unit, which has implemented an "Innovation Vigilance" concept for seeking and incorporating external knowledge. At the organization level is observed a medium absorptive capacity. It would be interesting to see how this capability could improve if all the organization were to be engaged in the acquisition of external knowledge by implementing the correct incentive structures. At a project level, interview results show that buy-in is the main form for setting up innovation projects. It was also observed that some projects were developed with internal sources of information provided by operational users, which leaded the definition and implementation of a solution. Most of interviewees displayed a rather positive attitude towards buying-in external knowledge. This may be due to constant participation if projects with external counterparts.

Knowledge retention appeared to the weakest of the Open Innovation processes according to the data collected in the interviews. Respondents indicated that knowledge retention was a rather new function within the organization, and that only recently external information and projects' results were integrated to a knowledge management system.

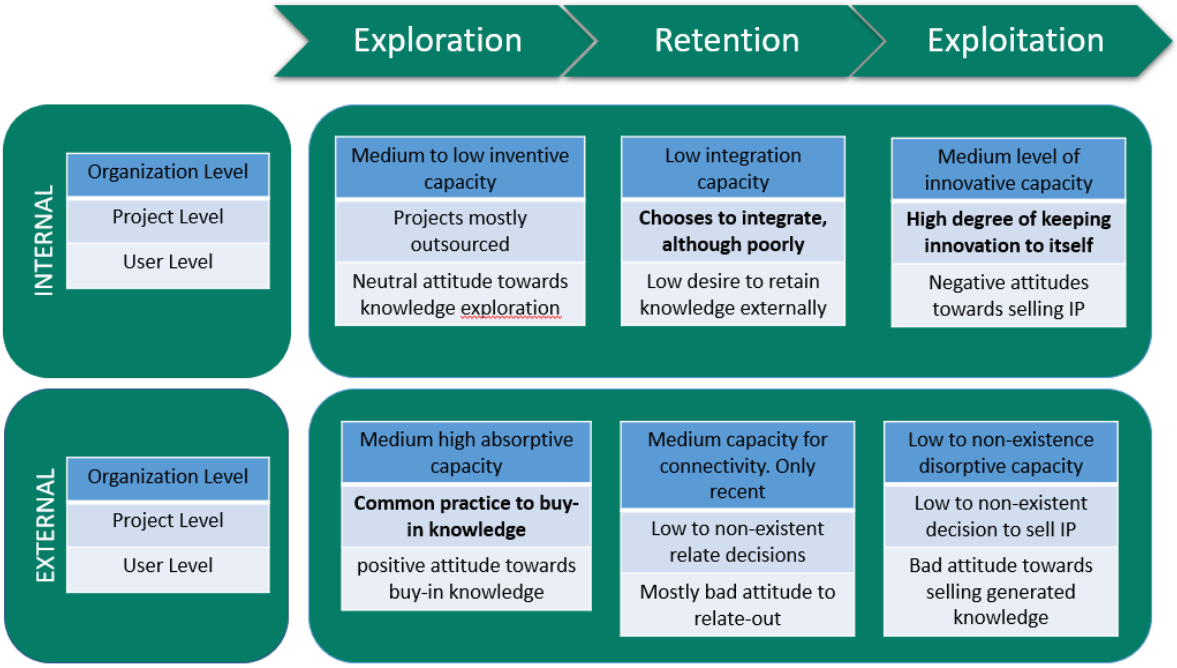

Figure 18: CODELCO's OI Process Framework from Interviews

Regarding exploitation process, CODELCO exploits external knowledge internally. Information was provided that CODELCO Tech, CODELCO's innovation daughter company, was created for the purpose of externally exploiting the innovations generated within CODELCO. After three years of operation, this initiative was terminated due to the lack of results. CODELCO's innovative capacity is being developed and supported by external alliances. At a project level, it has been observed a keep-in decision for innovation created within firm boundaries.

Open Innovation process framework describes CODELCO's implementation of OI from a process point of view. The answers provided in the interview also serve for determining the organizational level or readiness for Open Innovation. The information collected shows that CODELCO has made concrete efforts as well as investments in the development of an innovation strategy that embraces

Open Innovation as the core methodology for guiding the initiatives and efforts of the corporation. At first, network capabilities have been built through alliances and joint ventures with other companies, and universities that allow CODELCO to access external knowledge for solution design. Absorptive capacity has been built based on scouting and gatekeepers from Innovation Unit. Although the implementation of a major, transversal-across-units absorptive capacity has not been so far possible, the existence of a minor capacity has been enough to materialize OI projects.

The termination of CODELCO Tech has triggered the incorporation of an internal knowledge management system for organizing external innovation and executed projects' knowledge into a large database that can serve future information requirements. The implementation of incentive structures mentioned in the interviews is also an indicative of organizational routines for the institutionalization of OI. Some weaknesses were observed in the establishment of some capabilities, particularly the lack of incentives in PES system of southern divisions' workers. Top-down innovation leadership has not yet been able to effectively communicate the OI objective to all corporation units, thus affecting the cross-unit OI acceptance and collaboration in pos of a common goal.

Summarizing, CODELCO can be said to be at "institutionalizing"-level of organizational transformation for Open Innovation (see Figure 19), disregarding some weaknesses observed in the semi-structured interviews performed (Zynga et al, 2019). These deficiencies reflect the either conscious or unconscious inability to implement the necessary micro foundations or capabilities for organizational alignment and communications required for a successful implementation of Open Innovation.

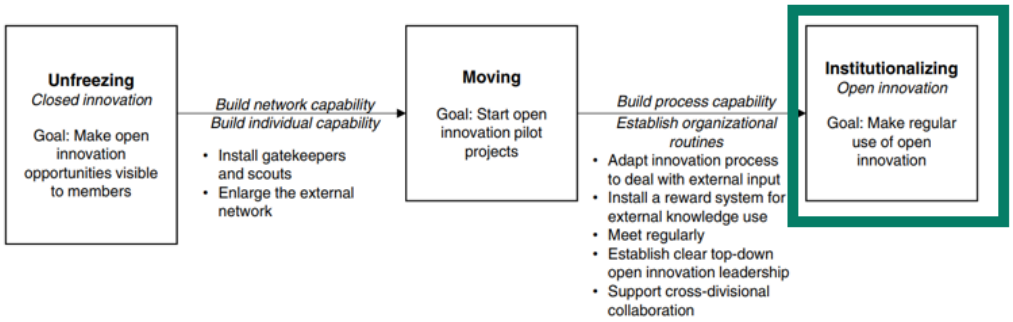

Figure 19: CODELCO at Institutionalizing Stage (Zynga et al, 2019, p. 23)

4.2 Second Question: How CODELCO's Open Innovation implementation affected projects' results

The second part of the interview provided information concerning successful and failed Open Innovation projects. Most of projects, successful and failed, had an external source of information, and were implemented by external counterparts. For reference see figure 11 and figure 14. Only a few projects were closed innovation in nature, and these had operational areas' users as source of knowledge and information, see figure 20. From the interviews it could not be determined if operational areas' users designed the solutions themselves or they obtained the information externally via informal communication channels. Nevertheless, the prevalent form of external source of knowledge were alliances, and the second most important was a Joint Venture between CODELCO and Honeywell.

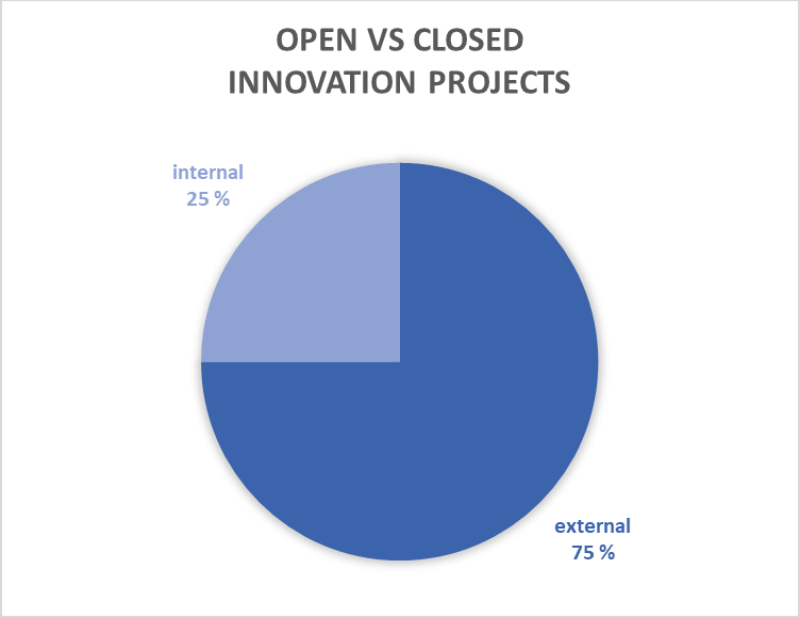

Figure 20: Open vs Closed Innovation Projects

In the case of failed projects, cultural negative attitudes towards innovation was the number one reason for failure. Collected data showed that when innovative solutions were imposed to operational users without their approval or participation, they would simply reject the innovations regarding them as useless for their job. In other cases, operational workers would feel that their jobs were threatened by new technology, thus rejecting offered solutions. Interestingly one of the

projects was evaluated as successful by a mine operation manager because it required high level of commitment and the whole operational team was involved from the very beginning. Then again, the same project was classified as partial failure by a higher rank executive, who pointed out that the results were not achieved in terms of costs and production. These results show that some of the CSF mentioned in the theory failed to be aligned in these projects. For instance, team cohesion, communication, and common goals differ between operational and manager level versus executive level workers of the firm.

Critical Success Factor framework explains to a large extent project failure observed in interviews. Mentioned by both Silje et al (2019) and Subtil et al (2018), (f) “Culture” and (3) “organization management and teams” items justify the failure of the projects that did not achieve company expected value. Some of these projects were also rejected due to cultural attitudes, lack of communication and different goals between operators, managers, and executives.

Regarding the type of project governance chosen by CODELCO, alliances and joint venture were preferred in most projects. This choice characterizes medium complex problems with known source of knowledge for a solution design. The utilization of knowledge holder self-discovery technic was not mentioned during the interviews. This may be an indicative about the type of problem and level of innovation sought by CODELCO. It is more probable that a highly complex problem implies a rather disruptive innovation, and the knowledge required to solve it may be hidden. Speculation may lead the reader to think that the projects identified during the interviews aimed at incremental innovation due to the type of governance choice. Unfortunately, the data collected does not provide enough information to corroborate this conjecture.

The empirical findings point out that CODELCO has a clear conviction that innovation is the way to maintain competitiveness and performance. It has also experimented for some years with Open Innovation methodology as part of its innovation strategy. The lack of positive results in external exploitation has not proved to be a stumbling stone for the execution of internal exploitation of external knowledge. The management of OI projects has produced expected business value, despite the weaknesses of the implementation. Notwithstanding factors, such as the deficient incentive structure, the lack of team management and reduced communication between areas and

management levels, OI project have been executed successfully according to the results presented in figure 21. The latter shows a positive rate between successful vs failed OI projects. However, the rate obtained from data collected may not be conclusive since interview respondents indicated that they were biased to remember easier successful projects rather than failed ones. Another strong argument to declare success for OI implementation in CODELCO relates to figure 17, where 88% of the respondents declared that CODELCO will continue to institutionalize the use of OI as part of its innovation strategy.

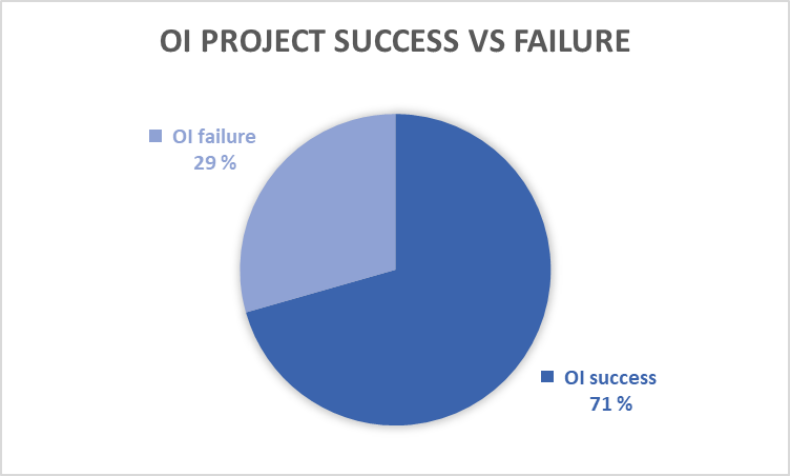

Figure 21: OI Project success vs Failure

4.3 Limitations and Future Research

The first limitation to this case study is the generalization of the results obtained. The fact that this is a single-case study work does not automatically imply that it is not generalizable to other firms or contexts (Yin, 2018). Notwithstanding, this case study does not offer generalization possibilities due to CODELCO's financial context and managerial structure. This firm is the larger mining company in Chile, comprising eight divisions across the country, also it is the only state-owned mining company. This implies considerable managerial differences between CODELCO and other private equity mining companies. While CODELCO is leaded by political interests, other mining companies are solely managed by economic interests, which makes hard to generalize CODELCO's OI implementation to other mining firms. Conducting a multiple-case study with

other Chilean mining companies would allow the collection of relevant information to strengthen and complement the results regarding implementation of OI in mining companies. A similar study was conducted in Norway for metal forming industry by Silje et al (2019). This study focused on Success Factors for the implementation of Open Innovation in aluminum structures manufacturing companies. Based on the multiple-case study of 11 firms, the results were generalized for metal industry in Norway.

As presented in chapter 1.4 reliability in data collection is ensured by choosing respondents considering the following aspects:

d) Divisional and geographical representativity
e) Participation in innovation projects
f) Relevant management responsibility

However, the reliability in data collection may be constrained by the fact that respondents do not have participation in all innovation projects, thus providing information regarding OI projects they were related to. Likewise, respondents themselves declared that they were biased to remember easier successful OI projects rather than failed ones.

The validity of the study is attained by using explanation building technique, presented in chapter 1.4. This is a type of pattern matching that seeks to explain the case study from the data collected. The following iteration is executed if necessary:

- An initial proposition is presented
- The data collected from the interview is compared to the initial proposition
- Modification of the initial statement
- Comparing other details of the case
- Iterate this process if necessary

In the internal analysis, critical Success Factors offered an important insight and explanation regarding the failure of OI projects in CODELCO. Further development of a CSF extended framework could offer important managerial information to executives of mining companies to

implement robust OI methodology in firms. Further research should concentrate in the generation of a scaled level presence of CSF in the implementation of OI in projects. Also, external context variables affecting the firm should be taken into consideration such as type of financing, executive decision drivers, size of the firm, etc.

5 CONCLUSION

This thesis was designed to research the level of implementation of Open Innovation in CODELCO copper mining company, as well as to find out whether CODELCO had succeeded or failed in its attempts to use OI as a tool for project management. Understanding of the state of OI innovation implementation in CODELCO is of paramount importance for Chilean industry since this firm is one of the most important companies for the country. It is relevant to the Chilean economy not only because it generated an average of 11,3% of GDP between 2009 and 2019, but also because it has shaped the rest of the industry revolving around it. Thus, successfully implemented Open Innovation methodology in CODELCO would encourage the adoption of this paradigm by other companies.

In order to guide the thesis, two research questions were formulated at the beginning of the study: (1) How is CODELCO implementing Open Innovation methodology? and (2) How CODELCO's Open Innovation implementation affected projects' results. The first question is broad in scope; thus, a proposition was provided to narrow down the research:

Proposition: CODELCO identifies the necessity for innovation to maintain competitiveness, however it has not been able to implement a successful innovation strategy, let alone Open Innovation. Innovation comes as ready-to-use packages provided by external sources, with little to non-existent development participation of CODELCO.

The theoretical approach for the research corresponds to a single-case study. Multiple-case study was purposely avoided due time and resource constraints. The case study followed a structured comprising 1) definitions of the research questions, 2) research proposition, 3) unit of analysis, 4) logical link between data and the proposition, 5) interpreting criteria of the findings. Data was collected from various sources such as televised interviews, CODELCO´s official webpages, company yearly statements, newspapers, and mainly through semi-structured interviews with CODELCO workers.

A theory base was first developed to show that Open Innovation can accelerate the implementation of innovation at low level of investments. The methodology implicit in Open Innovation was described for the reader. Lichtenthaler (2011) presented a valuable framework that explains the processes of OI from an external and internal point of view. This theory describes that innovation knowledge can be utilized within the walls of the firm, or it could be licensed to external entities for external implementation. Either way, firms benefit directly or indirectly by the generation of innovation knowledge.

Organizational transformation for OI framework delves into the organizational level of adoption of Open Innovation, as well as the necessary micro foundations that firms need to develop in order to attain a determined level of readiness for OI utilization. At first the firm is in an "unfreezing" level, where closed innovation paradigm guides research and development. To move from the first level to a level designated as "moving", the firm must first build network and individuals capabilities that will allow early adoptions of OI. The third level is called "institutionalization", which is attained by generating the appropriate processes and structures to support the continual use of Open Innovation in project implementation. Organizational micro foundations focus on organizational factors in general, but do not explain project factors for success.

Critical Success Factors framework aims at providing a set of elements that firms ought to observe in their projects in order to success. A 22 element CSF framework is presented as a comprehensive guide for success. The theory does not specify which elements should be present, or to which extent these are required, to achieve success. However, the lack of CSFs could be an indicative of future project failure. CSFs are relevant for a proper implementation of successful OI projects, but an appropriate definition of project success or failure is required. Kerzner (2019) provided a definition for project success based on the business value obtained. When a project achieves business value within time, resource, and scope constraints, it is a complete project success. A partial success implies that the business value was obtained, even though some constraints are not observed. When the project does not achieve business value, but some learning is attained, it is called a partial failure. A complete failure entails no business value and no learning during project execution.

Governance choice theory was introduced to shed light upon the firm's project external networking decisions. According to this theory, the type of knowledge source chosen for a particular project is driven by the complexity of the problem at hand and the hiddenness of the knowledge required for solution design.

Following the development of theory base, the empirical research was undertaken. Nine CODELCO managers and executives were interviewed by phone. Face-to-face meetings were discarded due to Covid19 restrictions. The data collected responded the research questions presented at the beginning of the thesis:

a) How CODELCO is implementing OI methodology

Since the year 2016 CODELCO, CODELCO has devoted resources and time to implement an innovation strategy that is based upon OI methodology. The firm has been able to move from a "freezing" to a "institutionalizing" organizational level for Open Innovation. Micro foundations have been developed through the creation of an Innovation Unit within the firm. This unit is responsible for scouting for external knowledge and gatekeeping it, that is to retain, integrate and disseminate the information across the different areas of the firm. External knowledge screening processes have been implemented as well as structures for utilization of Open Innovation. Incentives have been partially adopted in personnel Performance Evaluation Systems. Outbound OI initiatives were abandoned due to the lack of results. Interviewees revealed that the lack of clear legal framework and distrust between counterparts undermined agreement.

b) How CODELCO's Open Innovation implementation affected projects' results

Open Innovation methodology had a positive impact in projects. Approximately 75% of the innovation project were implemented using external knowledge, and about 71% of OI project achieved success. OI project failure was explained by missing CSF that were not observed in projects. The most important CSF neglected was related to top-down communication problems, the lack of common goals in teamwork, and cultural negative attitudes towards new processes or technology. Data collected pointed out that CODELCO will continue to utilize Open Innovation

methodology for innovation projects, this accounts for the institutionalization of OI in the firm.

After responding the two research questions, the initial proposition presented in this thesis must be discarded. A new proposition is then presented to the reader:

CODELCO acknowledges innovation as the main tool for maintaining competitiveness. The firm has been able to implement its innovation strategy based on Open Innovation, and it is institutionalizing it due to the positive results obtained.

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APPENDICES

APPENDIX 1 - OPEN INNOVATION QUALITATIVE QUESTIONNAIRE

Name _____ Date: _____

Company: _____ Position: _____

The following concepts are first defined to help the interviewee to answer the questions:

Business Innovation (Oslo Manual, 2018): *is a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm.*

Open Innovation (Chesbrough, H., 2003): *is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively.*

Innovation Project (Oslo Manual, 2018): *unique process consisting of a set of co-ordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including constraints of time, cost and resources.*

Innovation Project Success (Kerzner, H., 2019):

Complete Success*: Business value is achieved within all the constraint of time, cost, and scope.*

Partial Success*: Business value is obtained but not all the constraints are met.*

Partial Failure*: Only some intellectual property or knowledge is generated for later use.*

Complete Failure*: Constraints not met, and no business value created during the project management process.*

1) How CODELCO, Chilean state-owned copper mining company, is implementing Open Innovation methodology?

In order to answer this question, the following set of sub-questions is presented to the respondent:

How would you characterize CODELCO's organizational level for Open Innovation?

a. CODELCO is using **only** closed innovation and only recently you have heard that OI is a feasible methodology to be used in future innovation projects?
    i. Have you or your team being told about Open Innovation methodology?
    ii. Have you or your team been trained or invited to OI training?

b. CODELCO is **experimenting** with OI methodology and it is just recently running pilots?
    i. Have you or your team been invited to participate in an Open Innovation project in the last 24 months?
    ii. Has CODELCO defined a person (scout) or a team to search for external sources of knowledge?
    iii. Has CODELCO defined a person (gatekeeper) or a team responsible for disseminating, integrating, and retaining the externally obtained knowledge?
    iv. What sources of external innovation/knowledge CODELCO has used in the past 24 months? For example: alliances, Joint ventures, partnerships, user communities, contests, hackathons, etc.

c. CODELCO has developed a **commitment** to Open Innovation and has made it part of its strategy?
    i. Does your team or organizational unit have incentives for incorporation of external knowledge for innovation? What kind of incentives?
    ii. Has your team or organizational unit experienced changes in roles and responsibilities to better handle open innovation challenges?

iii. Does your team or unit have a formal network or community for exchange of information and innovation knowledge?

2) How CODELCO's OI implementation has affected the results of innovation projects? (Kerzner, H., 2019; Lichtenthaler, U. 2011; Felin & Zenger, 2013; Zynga et al, 2019)?
   a. How many Open Innovation projects CODELCO has **successfully or partially successfully** implemented in the last 24 months? For each project, describe:
      i. CODELCO's external source of knowledge.
      ii. Whether CODELCO or the external counterpart implemented the innovation.
      iii. The project's business impact.
   b. How many Open Innovation projects CODELCO **failed or partially failed** to implement?
      i. CODELCO's external source of knowledge.
      ii. Whether CODELCO or the external counterpart implemented the innovation.
      iii. The project's business impact.

   c. Given the actual Open Innovation project experience, will CODELCO persist in its efforts to institutionalize Open Innovation as part of its innovation strategy?
      i. Do you know about plans for organizational changes?
      ii. Do you know about development of formal external network or alliances for acquiring external innovation knowledge?
      iii. Do you know about future incentive development for OI within CODELCO?

APPENDIX 2 – ENCUESTA CUALITATIVA DE INNOVACIÓN ABIERTA

Nombre _____ Fecha: _____

Institución o empresa: _____ Cargo: _____

Se definen los siguientes conceptos para ayudar al entrevistado a responder las preguntas del cuestionario:

Innovación de negocio (Oslo Manual, 2018): Es un producto o un proceso de negocio mejorado (o la mezcla de ambos), el cual difiere claramente de lo anterior, y que ha podido ser llevado al mercado.

Innovación Abierta (Chesbrough, H., 2003a): Es el uso deliberado de conocimiento interno y externo con el objetivo de acelerar los procesos de innovación de la organización y expandir los mercados para el uso externo de dicha innovación respectivamente.

Proyecto de innovación (Oslo Manual, 2018): Es el proceso que consiste en actividades coordinadas y controladas con fechas de inicio y termino definidas, que tienen como objetivo generar una innovación dentro de plazos, presupuestos y recursos definidos.

Proyecto de Innovación Exitoso (Kerzner, H., 2019):

Éxito Total: Se logra un valor para el negocio dentro de las restricciones de tiempo, costo y alcance.

Éxito Parcial: Se logra valor para el negocio, aunque no se cumpla con todas las restricciones de tiempo, costo o alcance.

Falla Parcial: Se logra generar solo propiedad intelectual o conocimiento durante la ejecución del proyecto.

Falla Total: No se logra concretar el proyecto dentro de las restricciones, ni tampoco se genera conocimiento útil para la empresa.

1) ¿Cómo CODELCO, empresa del Estado Chileno, está implementando Innovación Abierta dentro del negocio?

Primero se debe establecer la fase o nivel de desarrollo organizacional de CODELCO relacionado con la metodología de Innovación Abierta (Zynga et al, 2019).

¿Cómo caracterizarías el nivel organizacional de Innovación Abierta para CODELCO?

a) CODELCO está utilizando solo la metodología de innovación cerrada (interna) y solo recientemente han oído de la metodología de Innovación Abierta como una alternativa viable para futuros proyectos?
    i. ¿Tú o tu equipo de trabajo han oído hablar de Innovación Abierta como metodología de innovación?
    ii. ¿Tú o tu equipo de trabajo han sido capacitados o invitados a capacitarse sobre temas de Innovación Abierta?

b) CODELCO está experimentando con metodología de Innovación Abierta y ha participado en proyectos piloto?
    i. ¿Tú o tu equipo de trabajo han sido invitados a participar en algún proyecto piloto de Innovación Abierta en los últimos 24 meses?
    ii. ¿CODELCO ha definido a un responsable o “scout” para la búsqueda de fuentes de información externa de conocimiento?
    iii. ¿CODELCO ha definido a una persona (gatekeeper) o algún equipo de trabajo para diseminar, integrar y retener la información de innovación obtenida de fuentes externas?
    iv. ¿Qué fuentes externas de innovación o conocimiento CODELCO ha utilizado en los últimos 24 meses? Por ejemplo: alianzas, joint ventures, proveedores estratégicos, comunidades de usuarios o concursos de innovación.

c) ¿CODELCO ha desarrollado un compromiso con la metodología de innovación abierta como parte de su estrategia de innovación?

i. ¿Tú o tu unidad organizacional tienen incentivos incorporados para la búsqueda y utilización de fuentes externas de conocimiento para la innovación? ¿Qué tipo de incentivos?

ii. ¿Dentro de tu equipo u organización han experimentado cambios en roles y/o responsabilidades para gestionar los desafíos de la Innovación Abierta?

iii. ¿Tu equipo o unidad de negocio posee redes externas formales o comunidades para el intercambio de información o conocimiento de innovación?

2) ¿Cómo la implementación de innovación abierta ha afectado los resultados de los proyectos de innovación? (Kerzner, H., 2019; Lichtenthaler, U. 2011; Felin & Zenger, 2013; Zynga et al, 2019)

a) ¿Cuántos proyectos de Innovación Abierta CODELCO ha implementado exitosamente o con éxito parcial en los últimos 24 meses? Para cada proyecto, mencionar lo siguiente:

i. Fuente de información de innovación externada utilizada.

ii. Si CODELCO o la contraparte externa implementó la innovación.

iii. Los impactos de los resultados del proyecto en el negocio.

b) ¿Cuántos proyectos de Innovación Abierta fallaron o parcialmente fallaron en su implementación? Para cada proyecto, puedes mencionar lo siguiente:

i. Fuente de información de innovación externada utilizada.

ii. Si CODELCO o la contraparte externa implementó la innovación.

iii. Los impactos de los resultados del proyecto en el negocio.

c) Dada la experiencia actual en proyectos de innovación abierta, ¿CODELCO va a persistir en su esfuerzo por institucionalizar el uso de Innovación Abierta como parte de su estrategia de innovación?

i. ¿Tienes información acerca de futuros planes de cambio organizacionales para este fin?
ii. ¿Sabes de futuros planes de desarrollo de alianzas o redes externas para adquirir innovación?
iii. ¿Sabes de futuros desarrollos de estructura de incentivo para innovación abierta en CODELCO?