

**The present work was submitted to the Faculty of Mathematics, Computer,
and Natural Sciences**

Molybdenum Disulfide based lubricant and its market in Mongolia

Bachelor Thesis

by

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Statutory Declaration

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I hereby affirm in lieu of an oath that I provided the submitted bachelor thesis

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I did not use any sources other than those stated. In case the work is additionally submitted on a data medium, I declare that the written and the electronic form are completely identical. The work was not submitted in the same or similar form to any examination authority.

6/10/2020

Place, Date

Signature

Acknowledgement

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Abstract

The purpose of this study was to determine the current solid and semi-solid lubricant market in Mongolia and to develop a business model canvas of the production of Molybdenum disulfide based solid, and semi-solid lubricant material. The key question was If there is a demand for a solid lubricant, how a Molybdenum disulfide based solid and semi-solid lubricants can successfully enter the market?

We used 3 different research methodologies for this study. In order to determine the current market, firstly we used primary research methods and interviews from 3 different suppliers. The second method is a critical review method for the product development of Molybdenum disulfide based solid and semi-solid lubricants. The extended business model canvas is the last method.

Findings showed that the Mongolian lubricant additive market was estimated high by the coming 5 years forecast. So far, we are using 100% imported lubricants. Additionally, we have several raw material sources, including Erdenet Mining Limited Liability company. Based on these findings, we developed the concept of Molybdenum based powder, grease, and paste production business model canvas and supply-chain design. Future studies should expand this study to Molybdenum disulfide lubricants production project concept development.

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1. Introduction

1.1 The problem statement

According to 2018 statistics, we have about a million vehicles that were registered and all of them are still using 100% imported lubricants(1) which are usually come from Korea, Japan, and Singapore ...etc. In 2019, 218.9 Billion tugrik's amount of 42900 tones of lubricant material was imported due to the rapid growth of the automotive industry(2). The value of the global lubricant market size was estimated at USD 128.51 billion in 2018 and is expected to increase to a Compound Annual Growth rate of 3.6% within the forecast 5 years.

In Mongolia, we have enough demand and growth but there is no local lubricant manufacturer. Furthermore, we don't have comprehensive market research about the lubricant that is available for related academic studies and further research. On the other hand, we need a local manufacturer who can produce compatible lubricants with import products. The most common brands are "Mobil", imported by "Petrovis Oil" LLC in the auto cars sector, and "Total", imported by Mines-Up LLC in mining, heavy mechanism's field in Mongolia. (3)

There is a tendency to understand more about fluid substances rather than a solid or dry when it comes to a lubricant concept. Sometimes fluid lubricants don't meet requirements in friction-reducing but solid lubricants work well in there and also have fewer limitation conditions. (4)

Bulk single-crystalline molybdenum disulfide occurs as a mineral rock in nature and it's available in molybdenum concentrates from Erdenet Mining Corporation. Due to its low-friction properties due to weak van der Waals interactions, thermal stability, flexibility, and robustness, Molybdenum disulfide is extensively used as a solid lubricant. So knowing the existing solid and semi-solid lubricant in Mongolia is fundamental to develop the concept of Molybdenum disulfide- based lubricant production plant, business model.

1.2 The aim of the study

This research study aimed to evaluate the current market of general lubricant and more specifically solid and semi-solid lubricants like Molybdenum disulfide based lubricant material in the industrial sector. The used methodology is the primary research method. Furthermore, studying the characteristics of molybdenum is essential to know the possibilities of producing Molybdenum disulfide based lubricant products, made of minerals and mining products of Mongolia. Molybdenum disulfide property research is fundamental for developing a solid and semi-solid lubricant. There we used a critical

review method. Moreover, that means it's creating an added value in the economy and it is also multi-beneficial for local industrial development.

There are several companies, who import solid lubricants and similar products in the market, including Liqui-Moly, Mines-Up, Wurth, Wagner Asia Equipment, and Petrovis ...etc. We interviewed and observed them in order to conduct market competitors analysis. Moreover, the business model development canvas for Molybdenum disulfide based lubricant is the basic expected outcome and following the business model, the product ideation research, and the general supply chain concept will be determined by extended business model development method, which was developed by Stefan Wiesner.

2. Literature review

2.1 Characteristics of Molybdenum disulfide

Molybdenum disulfide's most common natural form is Molybdenum ore, which reacts not so easily with the influence of acids and oxygen. The mineral molybdenite is a silvery black solid which relatively stable bonding where no need for moisture absorption. Compared to graphite, molybdenum disulfide has a sandwich-like structure which means the transition metal molybdenum atoms layer lies between 2 chalcogen sulfides atoms as shown in figure 1. Weak Van der Waals forces are acting In between 2 layers, so this can be destroyed easily but there is an interacting covalent force, between 2 different atoms of transition metal dichalcogenide complex, consists of Mo and S atoms, is strong. (5)

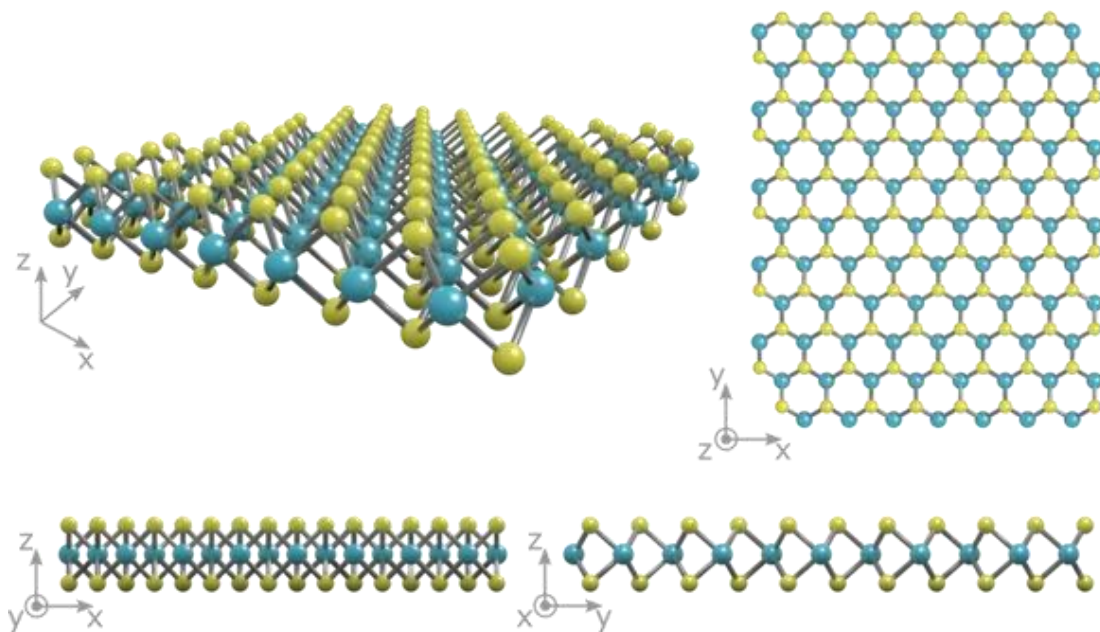


Figure 1: The crystal structure of monolayer Molybdenum disulfide showing a layer of molybdenum atoms (blue) sandwiched between two layers of sulfur atoms (yellow). (6)

Molybdenum disulfide has a lower friction coefficient of 0.3 and a wear coefficient of 0.2 and a high melting point at 2375 °C. Table 1 shows additive materials characteristics such as friction and wears coefficient under different loads and materials and also moly disulfide is in between them. Keeping low friction and low wear under different loads and materials is considered as an advantage for using moly disulfide as a solid lubricant and a lubricant additive. (7)

Test Lubricant Load 200N	Tool Materials 1040 Tool Steel	Tool Materials GM 238 Cast Iron	Tool Materials GM 246 Cast Iron	1040 Tool steel Load 1000 N
--------------------------------	--------------------------------------	---------------------------------------	---------------------------------------	--------------------------------

Dry (unlubricated)	High friction ($\mu=1.5-3$) High Wear ($d \geq 8\mu$)	High friction ($\mu=1.3-3.2$) High Wear ($d \geq 8\mu$)	High friction ($\mu=1.5-3$) High Wear ($d \geq 8\mu$)	High friction ($\mu=1.5-3$) High Wear ($d \geq 8\mu$)
Magnesia	High friction ($\mu=1.6-3.1$) High Wear ($d \geq 8\mu$)	High friction ($\mu=1.2-3$) High Wear ($d \geq 8\mu$)	High friction ($\mu=1.4-3.1$) Moderate Wear ($2 \leq d \leq 6\mu$)	High friction ($\mu=1.5-2.8$) Moderate Wear ($2 \leq d \leq 6\mu$)
Graphites	Low friction ($\mu=0.3-0.7$) Moderate Wear ($2 \leq d \leq 6\mu$)	Low friction ($\mu=0.3-0.6$) Moderate Wear ($2 \leq d \leq 6\mu$)	Low friction ($\mu=0.3-0.8$) Moderate Wear ($2 \leq d \leq 6\mu$)	Low friction ($\mu=0.3-0.8$) Moderate Wear ($2 \leq d \leq 6\mu$)
Boron Nitride	Low friction ($\mu=0.4-1$) Low Wear ($d \geq 2\mu$)	Low friction ($\mu=0.4-0.7$) Low Wear ($d \geq 2\mu$)	Low friction ($\mu=0.4-0.6$) Low Wear ($d \geq 2\mu$)	Low friction ($\mu=0.4-1.1$) Low Wear ($d \geq 2\mu$)
Moly Disulfide	Low friction ($\mu=0.3-0.6$) Low Wear ($d \geq 2\mu$)	Low friction ($\mu=0.3-0.6$) Low Wear ($d \geq 2\mu$)	Low friction ($\mu=0.3-0.7$) Low Wear ($d \geq 2\mu$)	Low friction ($\mu=0.3-1.1$) Low Wear ($d \geq 2\mu$)
Pekite 50 (Mixed 50% BN+50% Magnesia)	Low friction ($\mu=0.3-0.6$) Low Wear ($d \geq 2\mu$)	Low friction ($\mu=0.3-0.6$) Low Wear ($d \geq 2\mu$)	Low friction ($\mu=0.3-0.6$) Low Wear ($d \geq 2\mu$)	Low friction ($\mu=0.2-0.7$) Low Wear ($d \geq 2\mu$)

Table 1: Different dry lubricants hardness test results (8)

2.2 Using Molybdenum disulfide as a solid lubricant

Fluid lubricants usually operate within a certain range of temperatures, in between -4 F and 212 F. A solid lubricant is a material used as a free-flowing powder or thin solid or dry film which reduces friction and wear of contacting surfaces in relative motion and provides protection from damage with and without any oil medium. Generally, solid lubricants are used in two ways following:

- Mixing with fatty acid and fatty oil
- Applying directly to the sliding surface

An important function of the lubricant is the following:

- Dispersants, emulsifiers
- Viscosity improvers
- Detergents
- Corrosion Inhibitors
- Oxidation inhibitors
- Extreme-pressure additives
- Friction controllers

To operate effectively, lubricants products need materials, chemical additives such as graphite, boron nitride, magnesia and one of those are molybdenum disulfide, as well as a base oil, and can be used as types following:

- Engine oil and hydraulic oil
- Transmission fluids
- General industrial oils
- Gear oils
- Metalworking fluids
- Grease and paste
- Thin film and direct to a sliding surface

The only direct use available for solid lubricant is a thin film and in order to produce this kind of lubricant material, there are few simple processing steps to follow. Basic steps are extracting the Molybdenum ore and then refining the Molybdenum disulfide with a purity of 99%. (8) The flotation is the best way to process relatively pure Molybdenum disulfide after milling function. After the stage, the branch stream for further processing of pure Molybdenum disulfide's lubricant production. Moreover, the mainstream is roasted to separation for alloying and lubricant manufacturing as shown in figure2.

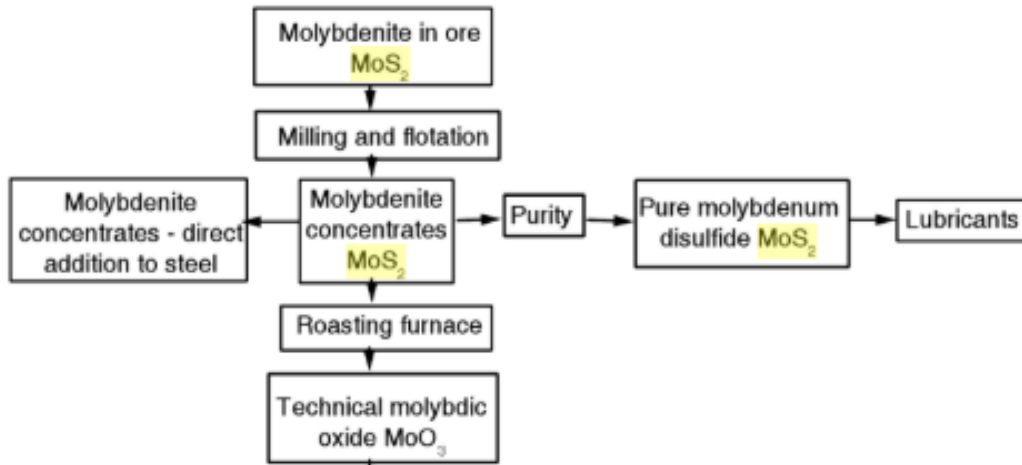


Figure 2: A general production process of Molybdenum concentrate. (9)

Processed Molybdenum disulfide can be used as a dry lubricant in, e.g. greases, dispersions, friction materials, and bonded coatings. With purity of 99.9% and particle sizes of 100nm, 500nm, 1um, 4-5um, 45um, gray to black powder Molybdenum disulfide can be used as a solid lubricant and a thin-film directly in the automobile industry and mechanical.

Even that Molybdenum-sulfur complexes can be used in suspension mixture but more commonly it is used as a solvent in lubricating oils at concentrations of a few percent. Various combinations of additives are used: the most important ones are detergents, dispersants, antiwear, antioxidants, viscosity modifiers, and foam inhibitors. In the following table2, you can see the appropriate content formulation for the corresponding product type with their applications. (8) Depending on the application, Molybdenum's content varies within the product.

Mo Content (%)	Product Type	Uses
1-20	Greases-for manufacturing, mining, and transportation	Ball and roller bearings, spines, chassis, conveyors
20-60	Pastes-mineral or synthetic fluids	Assembly of machinery, splines, gears, universal joints, metal forming
0.5-5	Industrial and Motor Oils or Synthetic fluids	All automotive and industrial gears, reducers, cams
1-20	Water Suspensions	Metalworking and process lubrication, threads, slices, packaging, die casting

Up to 85	Bonded coating-sir or heat-cured, organic, inorganic	Threads, tools, switches, locks, valves, slide, process lubrication, metalworking
1-40	Metalworking compounds, Soaps, Powders	Extrusion, cold forming, wire drawing, deep drawing
10-100	Pure or Mixed Powders	The punch line, stamping, forming, relays, switches, packing
Composites		
1-10	Friction Products, Sintered Cu brakes, Semi-metallic and Non-asbestos pads	
1-30	Plastic, Rubber, and Metal Composites	

Table 2: Molybdenum Disulfide formulation in a lubricant (8)

The special niche of dry lubricant is reducing wear where an inadequate condition of liquid lubricant is existing, such as vacuum space and the bearing surfaces in tribological contact must still be effectively separated and where the lubricant needs to stay in place.

2.3 Possibilities to produce Molybdenum disulfide based lubricant in Mongolia

In 2017, China was the main producer and consumer of Molybdenum disulfide in the world. Moreover, we, Mongolia was within the top 10 Molybdenum disulfide producer country by 2400M tones products, which were produced mostly from Erdenet mining corporation as mentioned. In Mongolia totally around 50 mining licenses registered which contain molybdenum ores. Six of them considered rich with molybdenum ores. Three of them Mongolian are strategical mining sites, Erdenet, Oyu Tolgoi, and Tsagaan Suvraga. Two of them already started mining in figure 3 as we know.

Erdenet Mining Corporation SOE is one of the biggest Ore mining and Ore processing factories in Asia. It started its operation in 1978. Now Erdenet LLC consists of large processing complex with an annual capacity of 26million and annual productions are around 530.0 thousand tons of copper concentrate and 4.5 thousand tons of molybdenum concentrates per year. (10)

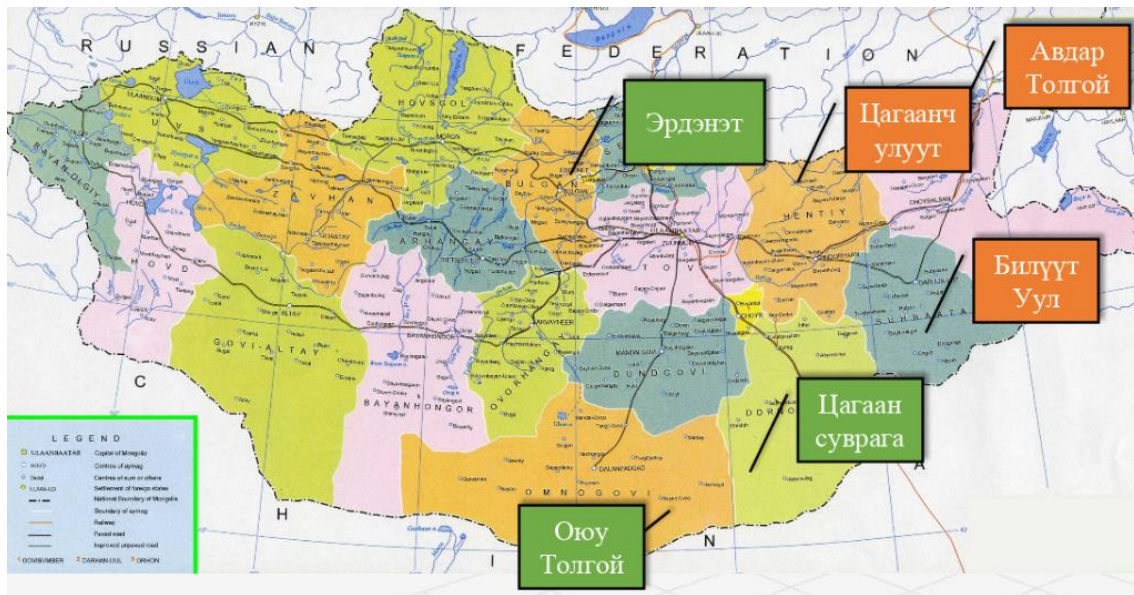


Figure 3: Potential deposits of production raw material(11)

So far, we are using 100% import lubricant product but we have that potential resource to produce a lubricant material that can substitute or share the amount of market share which is fulfilled by an imported product.

2.4 Patent reviews of Molybdenum disulfide based lubricants

Products containing solid lubricants are often utilized in applications when high specific loads are applied to sliding surfaces within the presence of boundary and mixed frictional regimes, at very low hydrodynamically effective speeds, or when the lubricant must perform over a good temperature or under heat conditions in aviation. In nuclear reactor and high vacuum applications, where the rapid aggressive environment is grown and there is a requirement of solid lubricant. For most applications an average particle size of the micronized solids of between 5 and 15 μm is acceptable. Benefits toward the application of dry-film are a clean and environmentally friendly working condition, reduced health risk to the workers about the absence of the vapors and mist since no lubricant spray usage, and elimination of costs with maintaining and operating a liquid lubricant system. Also, since dry-film lubricants are often efficiently distributed, less lubricant is usually needed. Recently the application of solid lubricants is a thin solid film on sliding surfaces and the research is mainly driven in the coating which is adaptive to change of tribological application. Recently these are called “adaptive” or “chameleon” lubricant coatings due to their changeability. As an interesting approach, analysts have as of late coupled strong lubricant layers with shrewd surface designing procedures like micro-texturing or patterning, and in this way accomplished indeed higher levels of

execution and toughness beneath extreme tribologic conditions. For applications including high temperatures, most layered dry lubricants show up ineffectual. Certain lubricious oxides and fluorides could also be wont to combat friction and wear at high temperatures. An expected adaptive solid lubricant film was appeared also to be compelling in accomplishing lubrication at broader temperature ranges. (12)

3. Methodology

As mentioned in the introduction, the research is consists of 2 different expected outcomes, so 2 general methods are discussed below. The first research type is mixed primary research due to the lack of secondary data related to the lubricant market. It includes both quantitative, which focuses on the numerical data collection of the results in statistical analysis and qualitative research, which gives the reasoning for costumer or supplier actions, opinions, wants and needs as shown in figure 4. Moreover, also corresponding methods are given in figure 4 such as surveys, questionnaires, one to one interviews, observations ...etc.

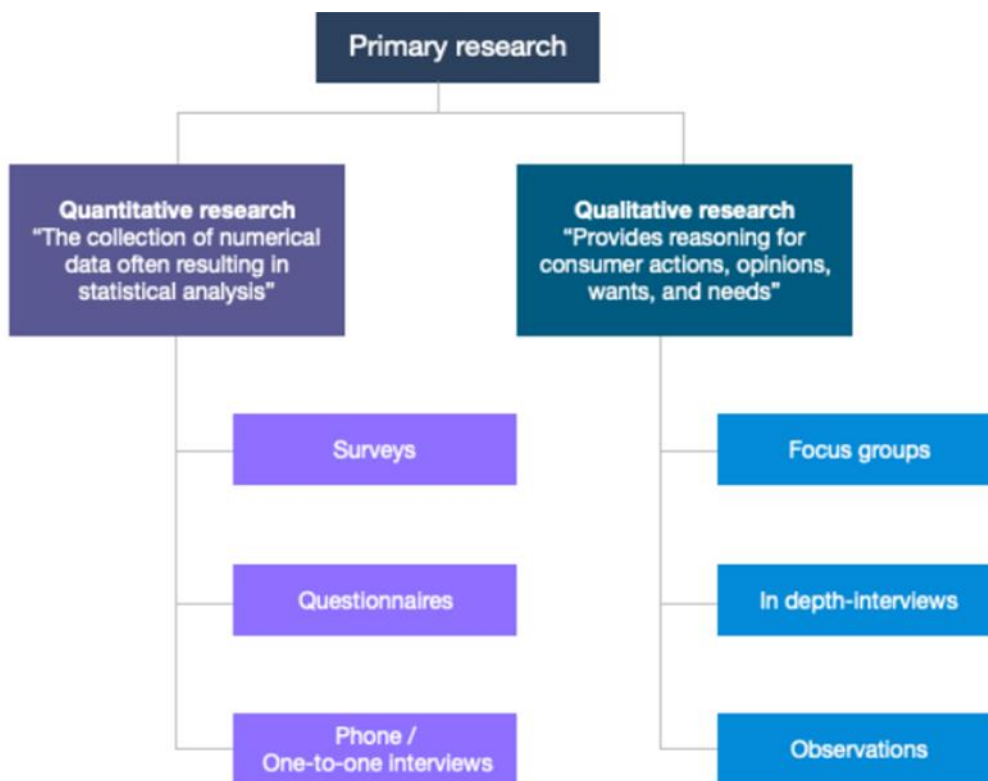


Figure 4: Primary research and method classification (14)

The used methods for the first research are the questionnaire and interview which covers more qualitative and less quantitative data.

The second research is the Molybdenum disulfide based lubricant product development concept and the corresponding method is the critical review method. A critical review doesn't create just a simple summary; it is a complex analysis and evaluation of literature. Steps to writing an effective critical review are reading, analyzing, and writing. (13)

3.1 Molybdenum disulfide based lubricant local Market

3.1.1 Research study scope

The Asia-Pacific region is expected to dominate the market over the forecast period in the global lubricant additive market, which is forecasted by Mordor Intelligence, market intelligence, and advisory firm. Within ASEAN countries including China, India, there is a there are developing countries and they cause the rapid growth pace in the market. China is the largest producer of automotive, with more than 27.8 million vehicles. (14) In India, the sales of automotive vehicles have been increasing over the recent past. This has resulted in an increased active number of automotive vehicles, in turn, leading to rising demand for lubricants, thereby projecting a rapid growth rate for lubricant additives in the Asia-Pacific region rate in figure 5.

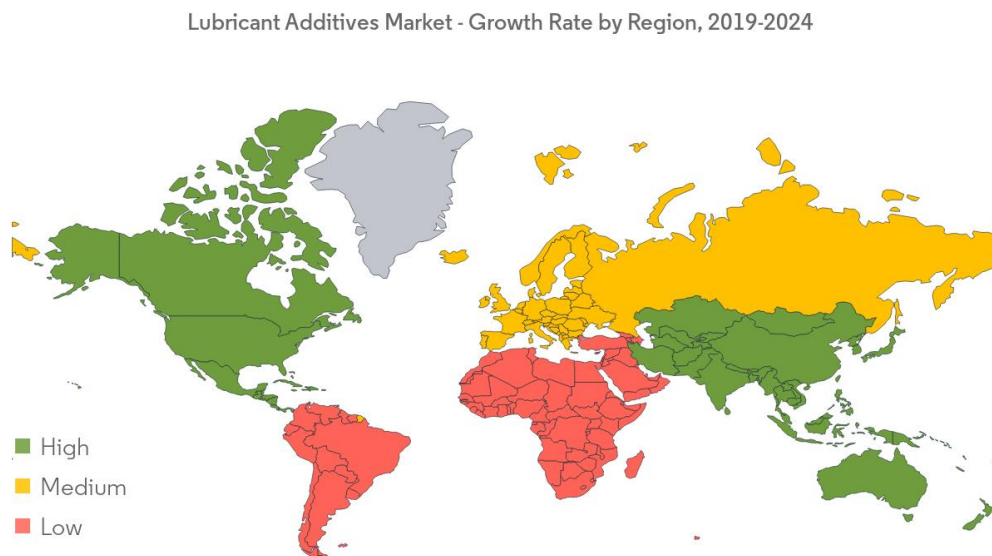


Figure 5: Lubricant additive market growth by region(14)

The core study area is Mongolia and the local automotive and mining industry, where high friction and high temperature are constantly created. If we look at the mining sector, according to the Minerals and Petroleum Authority's 2018 report, the number of mining license owners in Mongolia is about 1,900 and there are more number of types of equipment are used in there, which shows how large the mining sector's market for lubricant is for the local lubricant market.

Refers to an integrated static database, there are 970,880 registered Automotives in 2018. Moreover, from it, the main target customers can be over 240,000, including trucks, and mechanisms, which are used in industry or mining field.

2018' Registered automotive statistics by type and location	
Types of transportation	Statistic
Bus	6501
Truck	211945
Passenger automobile	631436
Special purpose	21468
Mechanism	12561
Trailer	31043
Bicycle	55926
Total	970880

Table 3: 2018 Automotive registration statistics

2018' REGISTERED AUTOMOTIVE STATISTICS BY TYPE AND LOCATION

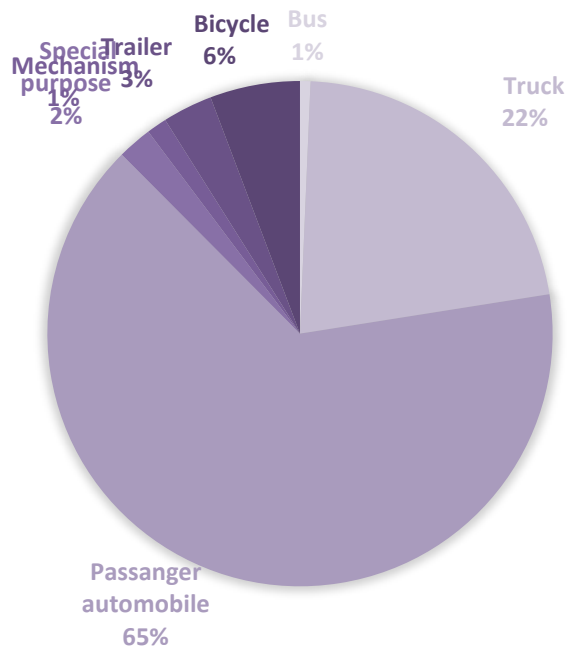


Figure 6: 2018's registered automotive statistics

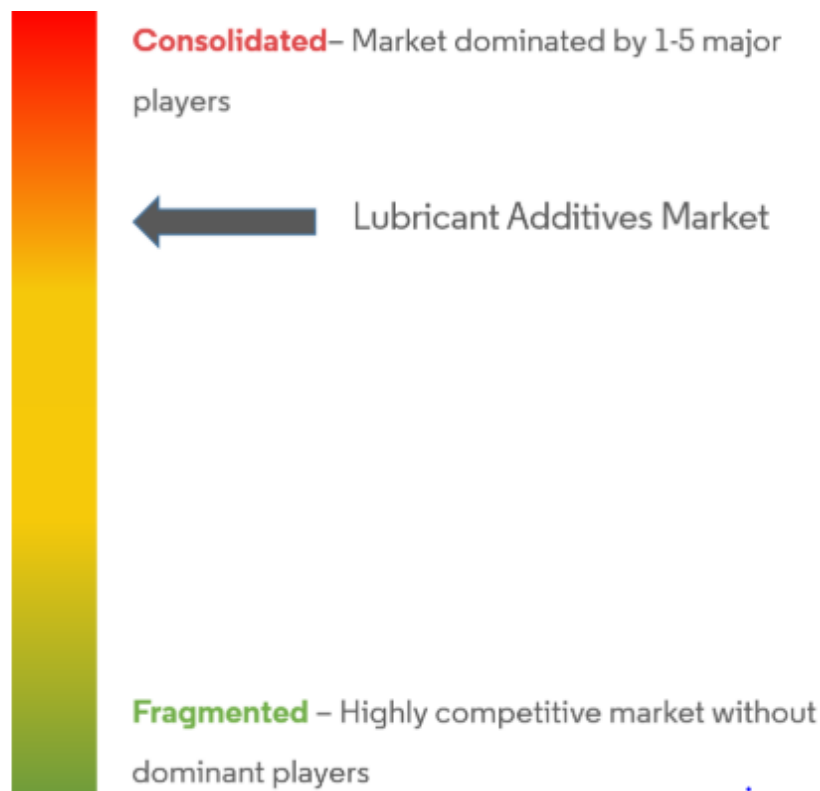


Figure 7: Lubricant additive market concentration (14)

Mongolia corresponds to the high growth rate region hence this market is expected to register a Compound annual growth rate(CAGR) over 3% during 2019-2024, the forecast period generally. Even though the global market concentration within this market is high as illustrated in figure 7, it is partially consolidated and we don't have any local competitors at the manufacturing level in Mongolia. But once there is a demand for lubricants, there are few companies that distribute import products from foreign lubricant manufacturers. So the market analysis's study area is local retailers of similar lubricant products, such as lubricant additive, mineral-based solid, or semi-solid lubricants. There are well-known leader companies, such as "Petrovis LLC", "Mekhlopat", "The Liqui-Moly Mongolia", "The Mines-Up", "Wagner Asia Equipment" and "Wurth" ...etc.

3.1.2 Research study process

As shown in figure 9, research can be made from 2 different perspectives, and in point of time-saving and recent Covid-19 situation, the supply side perspective is more adjustable. Moreover, due to the lack of transparency in Mongolian demographic and economic data, the supply side's primary research is the only left option unconditionally.

Data Collection Matrix

Perspective	Primary research	Secondary research
Supply side	<ul style="list-style-type: none"> ○ Manufacturers ○ Technology distributors and wholesalers 	<ul style="list-style-type: none"> ○ Company reports and publications ○ Government publications ○ Independent investigations ○ Economic and demographic data
Demand side	<ul style="list-style-type: none"> ○ End-user surveys ○ Consumer surveys ○ Mystery shopping 	<ul style="list-style-type: none"> ○ Case studies ○ Reference customers

Figure 8: The data collection matrix used in market research

Hence there is no manufacturer, the following algorithm in figure 9, is applied in this supplier primary data collection process.

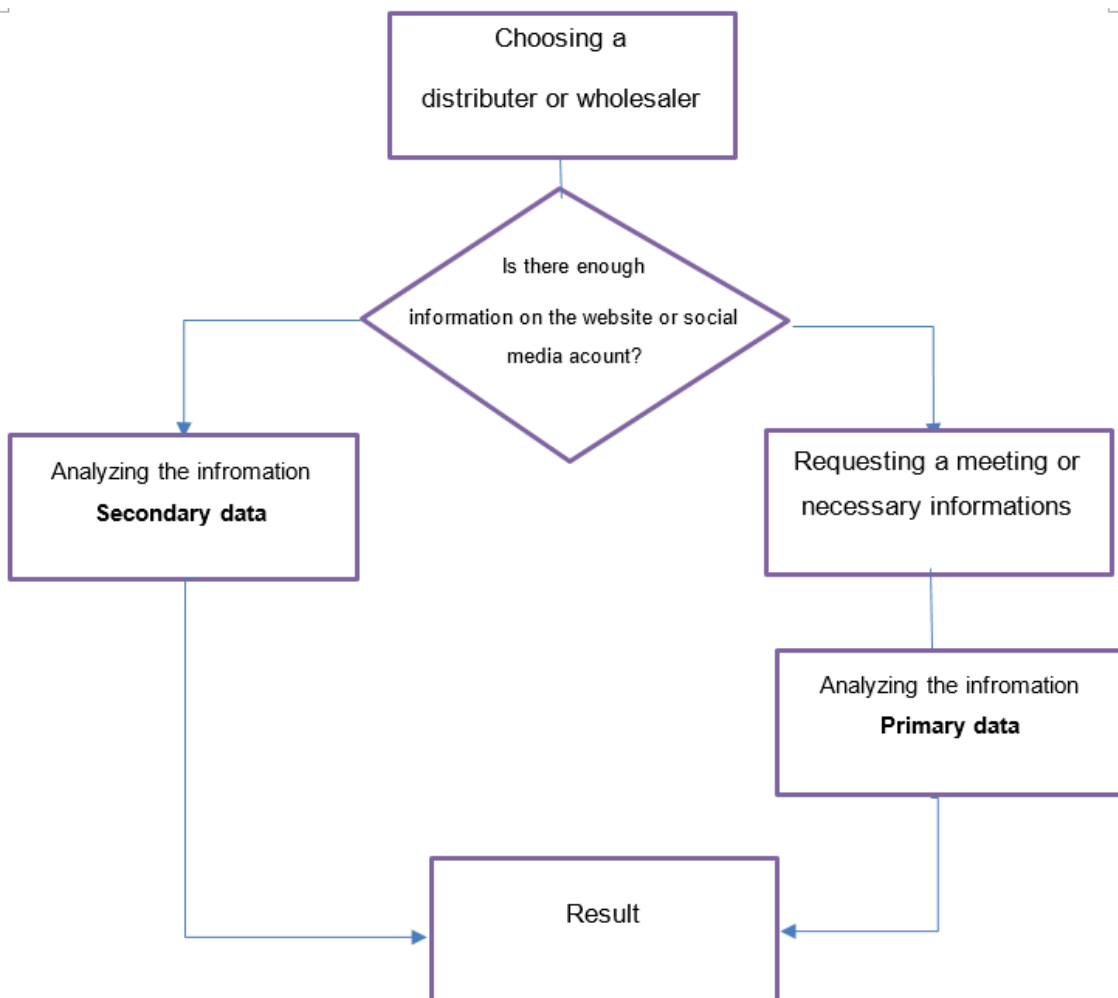


Figure 9: Algorithm of the research process

The general questionnaire includes few open questions and additional information is collected during interviews depending on the interviewer's situation. The questionnaire consists of the basic 4 questions:

- Are your target customers individuals, companies, or a mix of both?
- From which country and company do you import your products?
- How many loyal customers does your company have?
- What is the size of your annual sales?
- What are the advantages buyers look for in your product?

3.1.3 Primary data from interview and questionnaire

The Liqui-Moly



Figure 10: The logo of the Liqui-Moly Co

A worldwide brand, made in Germany, Liqui-Moly is a globally renowned manufacturer of premium quality lubricants, motor oils, additives, vehicle care products, chemical repair tools, service products, glues, and sealants. they provide the right product for any vehicle within the world, quite 4,000 products including lubricants, additives, care products, and chemical repair tools with integrated use guarantee. There are various types of products, such as engine and gear oils, hydraulic oils and, additives group, which deal with cleaning and corrosion protection, for stable lubrication and temperature resistance. Even simple mineral motor oils, which not compared to meeting the wants of today's motors, are up to fifteen additives. They provide vehicle care, repair&service, and adhesives&sealants. Figure 11 shows that their target automotive can be all types, including cars, bikes, commercial vehicles, construction equipment, boats, or garden appliances.



Figure 11: Liqui-Moly's target automotive variety

For personal use reception, in professional workshop applications, or efficient industrial use: their problem-solvers lengthen the service life of motors and aggregates and ensure their excellent performance and proper function for several years to return. They have 2 repair&service centers and a couple of retailing shops in Ulaanbaatar, Mongolia since 2015. They offer full and half synthetic oil-based products and the top trend product is that the Molygen, which controls the friction at the molecular level. The set product includes an engine cleaner, which flushes cleans the dust and dirt particles inside the engine, forms the coating inside the engine, and a gasoline saver. (15)But their Mongolian target market is passenger seat cars.

The Wagner Asia



Figure 12: Wagner Asia Equipment logo

Wagner Asia Equipment LLC's first official dealer was established in 1996 in Mongolia. Their main product is technical equipment but they offer their customers (16) also the lubricant. They sell few lubricants from ExxonMobil and Chemtool Incorporated and their target market is their honest customers who buy types of equipment from them.

Moreover, the underlining product for this research is the grease with Molybdenum disulfide's additive. (17)

The Mines up



Figure 13: Mines Up LLC logo

"Mines up LL" was originated from the 2009's and it has distributed the official world's top brand and products to the Mongolian market for 11 years, under Monnis LLC's execution. It retails lubricant products from the "Total" brand of France in the mining sector.(18) There are a total of 25 sales shops in Ulaanbaatar, Mongolia as shown in figure 14.



Figure 14: "Total" lubricant brand official shops in Mongolia

They supplied 5.5 million tones of lubricant materials to Mongolian big mining companies' heavy types of machinery such as Oyu-Tolgoi, Mongolyn Alt, Khishig-Arvin, Erdenes Tavan Tolgoi, and TEES Mongolia within the last 5 years. They offer 130 products of 17 classifications by now. They can be said 2nd biggest market shareowner in the lubricant market.

3.1.4 Secondary Data

2019's some companies' monthly revenue is shown below in figure 14, calculated by the size of its sale. It is shown that the least sales months are usually in winter, November, December, January, and February.

Moreover, if we look into the sales proportion within only these 4 companies, it is illustrated as the biggest market shareowner is Petrovis LLC and then Mines Up LLC, as illustrated in table 4 and figure 15.

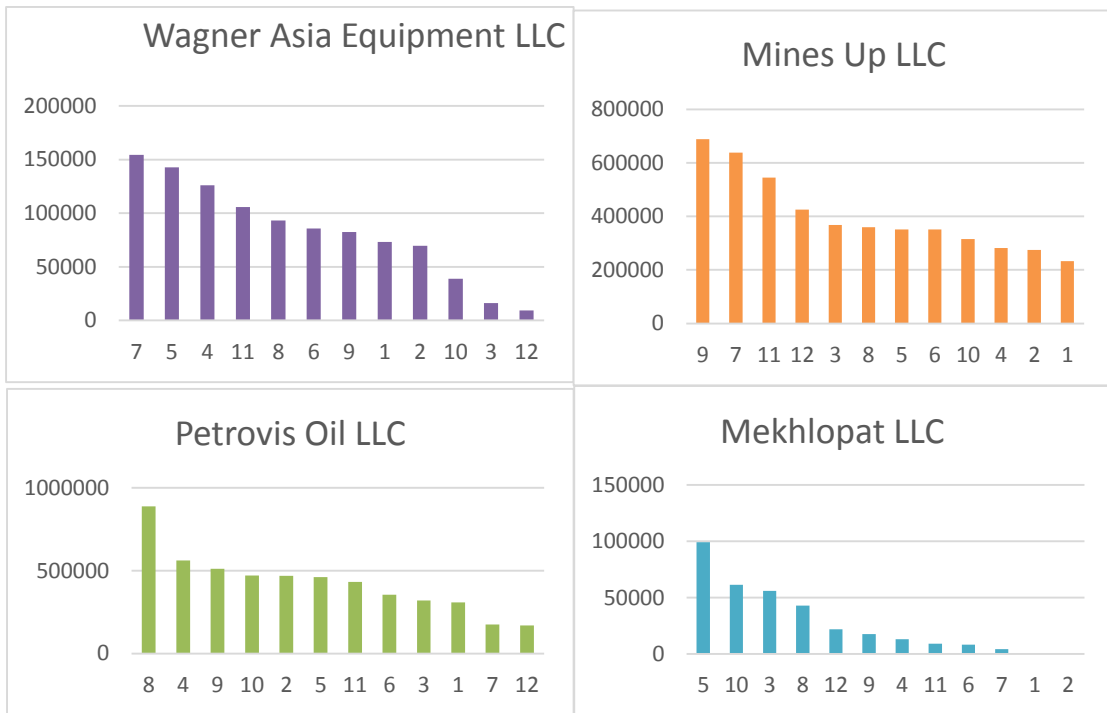


Figure 15: 2019's monthly revenue of different lubricant sellers

	Sales revenue
Mines Up	4,832,585
Petrovis	5,116,038
Mekhlopat	336,522
Wagner Asia	996,800

Table 4: 2019's Sales revenue of 4 distributor companies

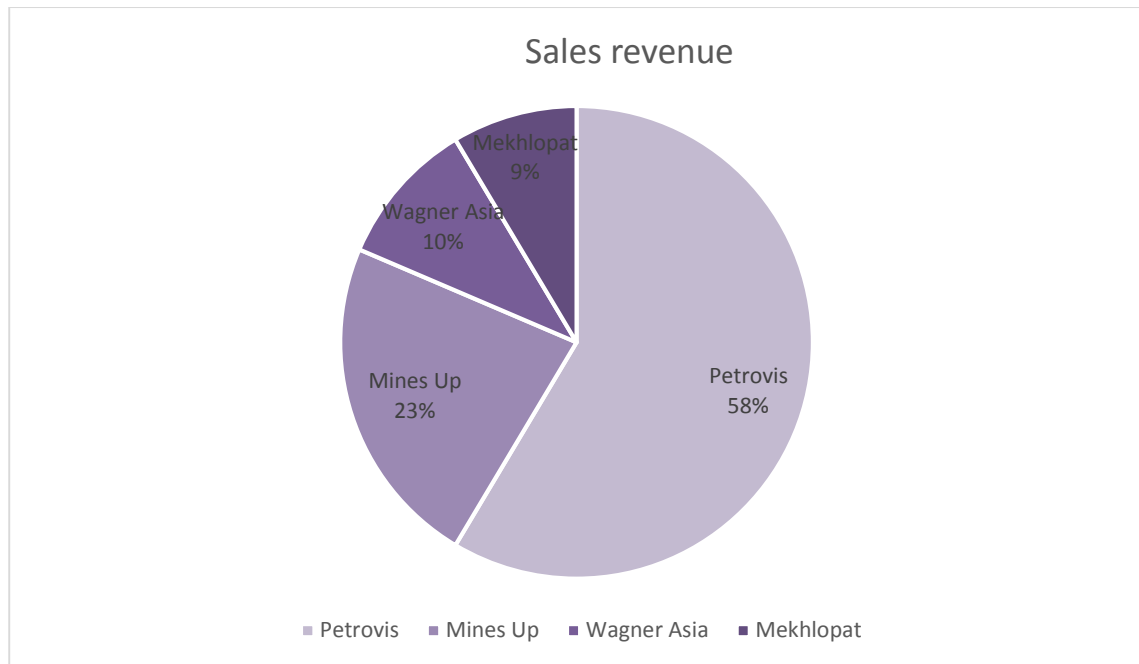


Figure 16: 2019's total lubricant sales proportion by company

3.2 Business Model Canvas development

A Business Model (BM) describes the rationale of how an organization creates, delivers, and captures value. As following the description, The manufacturing industry BMs more focuses on the manufacture or gathering of more or less customized items and create income from their net sales. (19) Manufacturing Business Models are focused on selling physical products in traditional market segments through supplier-buyer relationships. According to Business Model Canva, it can be described with nine building blocks:

- value Proposition
- customer Segments
- channels
- customer Relationship
- key Resources
- key Activities
- key Relationships
- cost Structure
- revenue Streams

The business model methodology can be driven in a clear procedure for the development of a new strategy and BM methodology's roadway is given. Moreover, the methodology is divided into three sequential phases, where the next phase has a high dependency on the previous phase result and a pre-analysis, as visualized in Fig 17.

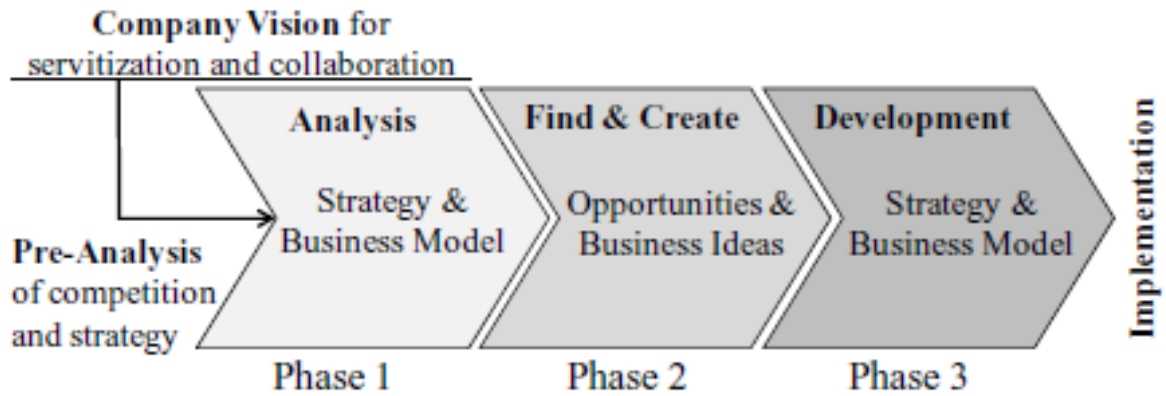


Figure 17: Phases of the Methodology for Business Model Development.

The methodology desires that the fabrication agency creates an imaginative and prescient to provide its merchandise in collaboration with its key partners in an environment of business. In a pre-analysis phase, the existing market competitive, and its strategic ecosystem is mapped. Then in phase one, the current strategy and BM of the company are analyzed. In a 2nd stage, opportunities and consideration for servitization and collaboration are recognized or made. Finally, the ideal strategy and Extended Product BM is created. Implementation of the BM is not part of the methodology and is a task of subsequent change management. Algorithmic stages are shown below in figure 12.

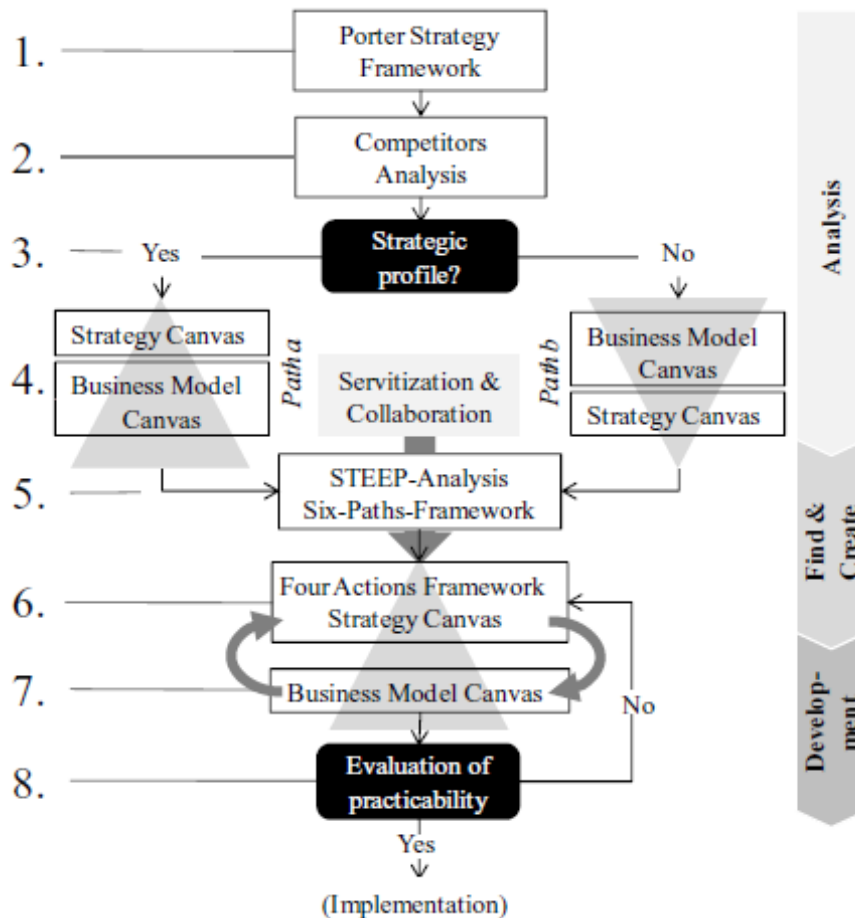


Figure 18: The Steps of the Approach for Business Model Development.

3.2.1 Competitors Analysis

Porter Strategy Framework

Porter's Five Forces analysis is a framework that helps to research the extent of competition within a particular industry. When you are new within the market, it is essential. Refers to this framework, competitors are not the only factor for competition. Rather, the state of competition in an industry depends on five basic forces:

- the threat of new entrants,
- bargaining power of suppliers,
- bargaining power of buyers,
- the threat of substitute products or services, and
- existing industry rivalry.

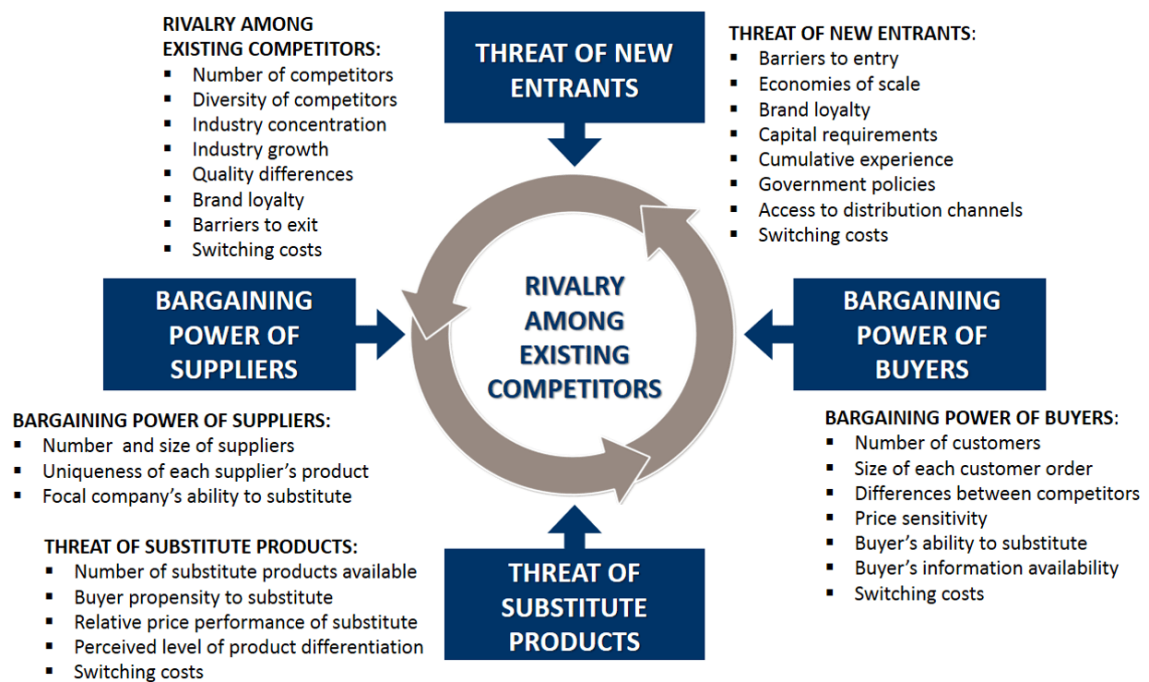


Figure 19: Porter's 5 force analysis framework

Competitors analysis

This sort of investigation isn't fair enough for first-time trade proprietors, either. A competitive examination can be a living archive that's continually advancing as your company develops and develops over time. A competitive examination is the market examination of your competitors and how your trade compares. By assessing the qualities and shortcomings of your competition, it'll be able to define how to donate your company an advantage. The competitive investigation makes a difference in commerce decide potential focal points and obstructions inside a target market advertise around an item or benefit and for the most part makes a difference brands screen how coordinate and backhanded competitors are executing strategies like promoting a product or a service, estimating prices, and conveyance. (20) By revealing the existing market competitors' advantages and disadvantages, the framework for determining the competitive advantage of the business model is developed. It is usually recommended to be analyzed in the frame of 10 companies but in the case of this study, it covered 4 companies due to the time and quarantine limitations.

3.2.2 Find and Create a competitive advantage

STEEP analysis

STEEP is an acronym that stands for social, technological, economic, environmental, and political. It is additionally determined with similar analysis, like PEST, PESTEL,

PESTLE, STEPJE, STEP, STEEPLED, and LEPEST. A strategic technique to outline and survey the conditions of distinctive variables and their results inside a company or framework. (21) One way to a better way to get it what's changing is to break down the different patterns by types. One such bunch of categories is alluded to as STEEP, or social, technological, economic, ecological, and political trends (22) as shown in figure 18.

Social	Technological	Economical	Ecological	Political
-demographic change -change of people behavior and lifestyle	-innovations -product development trends	-overall economic growth -interest -income -market -competitor	Ecological impacts of products and/or services, both physically and biologically	Political changes involving -laws -regulations and policies -development goals -incentives or policy burdens

Figure 20: STEEP Analysis framework (23)

Six Paths Framework

Blue ocean strategists provide a tool to create new market space: the six paths framework (Kim and Maubourge, 2009). Instead of competing within a given market space, firms and product developers are encouraged to compete across them. The six paths refer to the six boundaries that constrain competition. They are:

1. alternatives within industries;
2. strategic groups of customers;
3. buyers (as distinct from purchasers, deciders, and users);
4. scope of product and services (including complements);
5. function-emotional orientation (the balance between functionality and emotional connection)
6. time (the logical extension of a trend).

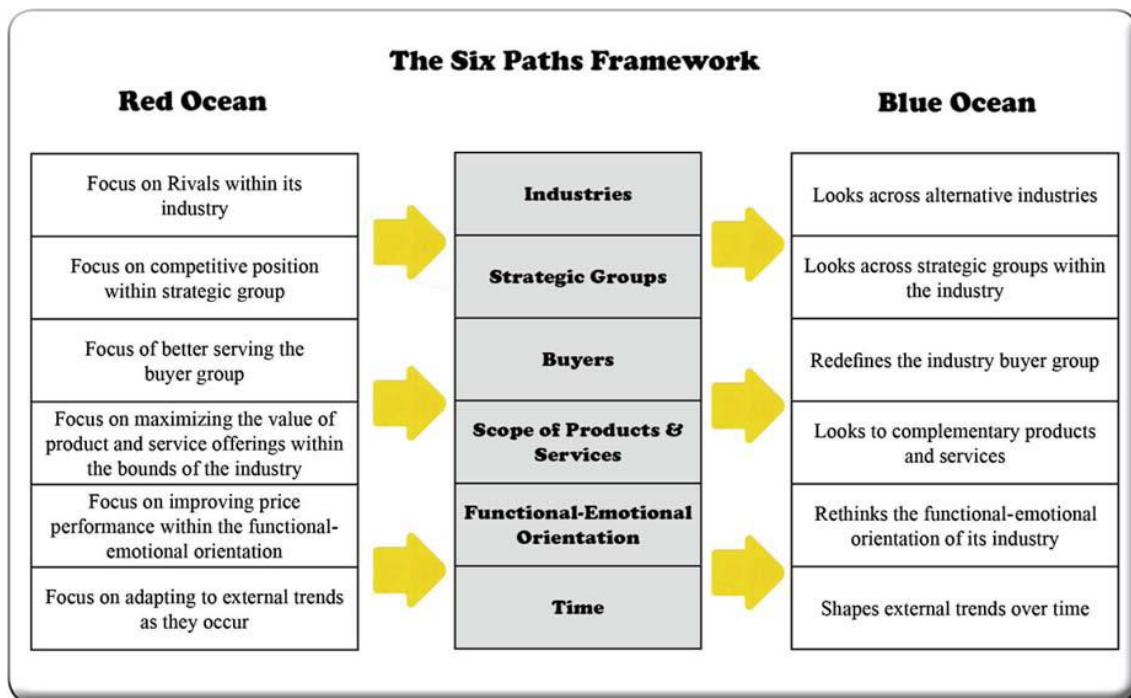


Figure 21: 6 Paths Framework (24)

Figure 19 depicts the paths. Together, they present marketers with six distinct opportunities to develop new offerings and escape to uncluttered markets. Each one allows new product developers to create a value innovation that will satisfy customers and be insulated from competitions.

The Four Actions Framework

Applying a blue ocean strategy to new product development. The first tool, the strategy canvas, would help with ordinary new product development since it focuses on product attributes, the competition, and consumer preferences. However, using the strategy canvas alone will not provide an uncluttered market space. Firms that remain within their original industry boundaries may gain a temporary competitive advantage from their insights. Inevitably, competitors will initiate changes and erase the advantage.

- Which of the factors that the industry takes for granted should be eliminated?
- Which factors should be reduced well below the industry standard?
- Which factors should be optimized and go above the industry benchmark?

- Which factors should be created that the industry has never offered?

Eliminate

- Which of the factors that the industry takes for granted should be eliminated?

Reduce

- Which factors should be reduced well below the industry's standard?

Raise

- Which factors should be raised well above the industry's standard?

Create

- Which factor should be created that the industry has never offered?

Figure 22: 4 Factors framework

3.3.3 Development

<p>KEY PARTNERS</p> <ul style="list-style-type: none"> - University - Microprocessor's company - Cloud computing service provider - Current partners 	<p>KEY ACTIVITIES</p> <ul style="list-style-type: none"> - Development of IoT hardware - Development of embedded software, app and cloud - Software maintenance - Product distribution in points of sales or online - Product assembling, testing and packaging 	<p>VALUE PROPOSITION</p> <p>B2C market</p> <ul style="list-style-type: none"> - Managing home access by third parties - No cost to generate extra keys - Managing remote keys - Increasing home's safety (e.g.: built-in alarms) 	<p>CUSTOMER RELATIONSHIPS</p> <ul style="list-style-type: none"> - Product website/blog/chat - Social networks - Product app - Phone - Business trade fairs 	<p>CUSTOMER SEGMENTS</p> <p>B2C market</p> <p>Domestic users familiar with IT and resident in big cities</p> <p>B2B market</p> <p>Corporate users, mainly hotels and real state agencies</p>
<p>10th – IT INFRASTRUCTURE</p> <ul style="list-style-type: none"> - 3G/4G networks - Wi-fi connection - NFC - Android and IoT platform - Cloud: SaaS - MQTT protocol 	<p>KEY RESOURCES</p> <ul style="list-style-type: none"> - SW/HW development teams - Consulting services for patents and marketing - Financial resources 	<p>B2B market</p> <ul style="list-style-type: none"> - Managing corporate access by third parties - Managing remote keys to clients anytime, anywhere - No cost to generate extra keys - Increasing corporate safety 	<p>CHANNELS</p> <ul style="list-style-type: none"> - Marketplaces - Partners' channels 	
<p>COST STRUCTURE</p> <ul style="list-style-type: none"> - Labor - Cloud services (monthly fee) - Freight, storage, distribution - Advertising 		<p>REVENUE STREAMS</p> <ul style="list-style-type: none"> - Fee from additional services, such as extra keys or detailed information - Equipment rental - OEM sales 		

Figure 23: Business model canvas framework and examples (19)

Figure 23 shows the example framework of the business model canvas and their parameters, that can be applied in our study. Within the study area lubricant additive market is not new but it's not so well-known in the automotive field and the product is surely brand new, so from the Ansoff matrix in figure 24, it is considered to Product Development or Market Development, and determined as new to same or same to new wisdom.

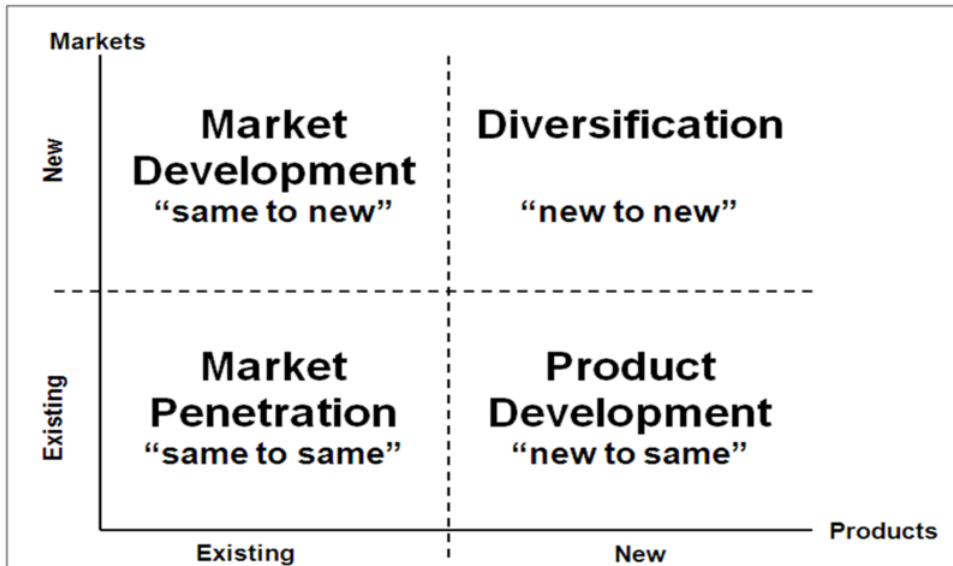


Figure 24: Market Penetration Strategy

4. Result

4.1 Mongolian solid and semi-solid lubricant market evaluation

We can see the increasing line of Mining license 2013-2018 in figure 25, and also mining equipment increase from table 5. Mongolia corresponds to the high growth rate region hence this market is expected to register a Compound annual growth rate(CAGR) over 3% during 2019-2024, the forecast period. (14)

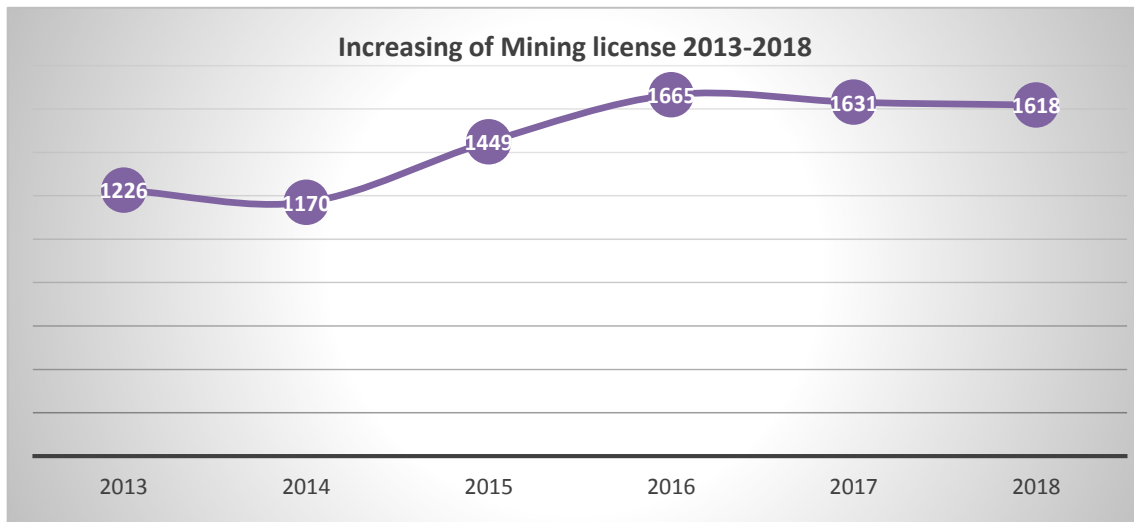


Figure 25: Increasing of Mining license 2013-2018

Lubricant materials	Tonnage	Cost thousand USD
2018	21147	48949
2019	23153	49239

	Equipment number
2016	9,155
2017	8,296
2018	16,722

Table 5: Registered mining equipment numbers from 2016-2018 and 2018-2019's lubricant import

And we can see the simple increasing correlation between lubricant material import size is increasing following the growth of mining license and equipment number from table 5. And you can see the detailed table from Annex 1.

Moreover, within this growing market, we have that few companies which distribute global lubricant brands. As a result of a competitors analysis of Mines Up, Wagner Asia and Liqui-Moly, the following framework is illustrated in figure 26:

target group		Mongolian lubricant market competitors		
		competitors		
		Mines Up	Wagner Asia	Liqui-Moly
strengths	Wide variety of products	Few variety of products	Few variety of products	
	Well-known within the heavy industry and also the eautomotive sectors	Well-known within the mining sectors' market	Good product development strategy	
	One of the top 5 lubricant salers in MGL and globally	One of the top 5 lubricant manufacturers in the world	One of the top 5 lubricant manufacturers in the world	
weaknesses		No offers for passanger cars	No offers for heavy machineries	
		No diversification strategy	Young	
			Not so well-known within the market	

Total brand
Exxon mobil
Liaui-Molv

Figure 26: Competitors analysis framework

From this analysis, Mines Up LLC has no weakness comparing to Wagner Asia and Liqui-Moly because it is the second market shareowner of the lubricant market in Mongolia, right after Petrovis Oil LLC. Those companies are suggested by supervisors and also customers and they are also one of the few Molybdenum disulfide based grease and spray product wholesalers.

4.2 New product patent research result

As a result of critical research of Molybdenum disulfide based product ideation, 3 general products that are common and less complex to be manufactured, products are summarized.

Molybdenum disulfide powder, direct use as thin lamellar film surface

Besides its basic substance application in lubricating materials, it can be used directly on the steel-steel sliding mutual surface, where high temperature and vacuum is created. The application range is quite wide because starting from household usage to industrial application of aerospace, agriculture, automotive, and coating. For example in from bicycle chain lube to on the surface of the screw chaser of a giant bolt, there is massive friction is created and due to the friction, it is also excessing the heat as an energy loss. (25) Additionally, it can be a mixed type of powder with WS₂.

The following requirements need to be filled indirect use of Molybdenum disulfide:

- 99.9% purity
- Content can be varied depending on the application but varies within 10-100% as stated in table 2
- The particle size of max: 100nm
min: 45um
in between: 500nm, 1um, 4-5um ...etc (25)

About the packaging, it can be an iron drum, a plastic drum, and a moisture-proof plastic bag. From the economic side, a plastic bag is optional but it has negative effects on the environment, so a plastic drum is used commonly.

Molybdenum disulfide based grease and paste

The difference between grease and paste are thickener and formation content. (26) Solid contents of grease and paste are the following:

- 1-20% dispersed solid
- 20-60% dispersed solid

Grease is a multi-phase industrial material, where the base oil is caught inside the thickener by a combination of Van der Waals and capillary strengths. Inside a bearing, grease acts as a store discharging lubricant into the sliding contact zone. Mechanical degradation is watched, reflected by the alter of oil consistency, oil drain, clear consistency, etc. during the bearing operation. This is why the loss of solid lubricant content occurs. (27) The most common application of grease is using in roller bearing and low-speed gear systems lubrication.

Greasing intervals can vary depending on the usage, the environment, and the conditions. The capacity of any specific grease to be taken care of by grease pumps grease containers and other components in a robotized framework depend on the

lubricant thickness. The thickener defines the type of grease type. Base oil comprises the largest component of grease, representing 80 % to 97 % by weight. The choice of base fluid can be mineral oil, synthetic oil, or any other fluid which provides lubricating properties.

The requirements which grease is required to satisfy generally consist of

- (i) extreme pressure (EP) resistance,
- (ii) reduced friction,
- (iii) high wear resistance,
- (iv) high thermal stability,
- (v) very good rust-proofing performance
- (vi) very good fluidity, and
- (vii) its consistency does not vary significantly even with repeated stirring.

Table 6 illustrates the advantages and disadvantages of a grease application.

Advantages	Disadvantages
<p>-Grease has a better stop-start performance.</p> <p>-When the framework closes down, the oil channels absent in the case of oil grease, whereas oil remains within the component.</p> <p>-The chance of contamination items such as food and pharmaceutical sort items is diminished with the utilize of grease due to its resistance to stream into the products.</p> <p>-Grease diminishes trickling, splattering, and spillage and decreases noise.</p> <p>-Grease decreases dripping, splattering, and leakage and reduces noise. With the use of grease, the machinery tends to need less power.</p>	<p>-Grease reduces cooling and heating transfer.</p> <p>-In the case of oil lubrication, the flow of oil removes heat from the point of a generation where it can be removed or dissipated.</p> <p>-Grease tends to hold heat in place.</p> <p>-Grease has poorer storage ability.</p> <p>-Alteration of properties due to too long storage separation of base oil and thickener.</p> <p>-Limitation of reaching on all places in need of lubrication in the case of grease lubrication</p> <p>-Application is limited by use at a higher speed.</p>

Table 6: Advantages and disadvantages of grease lubrication (28)

About the packaging, it can be an iron drum, a plastic drum, and a squeeze tube. But squeeze tube is more common on a paste packaging than grease.

The paste is a cohesive lubricant made of solid lubricant additive material and base oil and it is similar to grease except for its solid content and viscosity. Pastes are usually used in the assembly of machinery, splines, gears, universal joints, and metal forming in order to prevent corrosion, slip and adhesion wear. There are 4 main types, such as lubricating and assembly, high temperature, conductive, and screw. The advantage of paste inherent excellent lubricity and great anti-corrosion characteristic.

Detergents

Recording to Anticipated to Record Healthy Demand in the Automotive Industry, detergent is primarily used in automotive lubricants, the demand for which is increasing at a rapid pace across the world, primarily in Asia-Pacific. Therefore, detergents are likely to witness significant demand from the automotive industry, during the forecast period. Within this study, detergents are not researched enough within the timeframe.

4.3 The solid and semi-solid lubricant manufacturing business development

Business Model Canvas for this research study

The Business Model is developed based on the superior vision of servitization and collaboration based on the market evaluation research and the competitors' analysis, as shown in figure 27.






<p><i>Key Partners</i> </p> <ul style="list-style-type: none"> • Erdenet Mining LLC • Retailers • Wholesalers • Base oil supplier 	<p><i>Key Activities</i> </p> <ul style="list-style-type: none"> • Refining Mo concentration • Manufacturing Lubricant 	<p><i>Value Proposition</i> </p> <ul style="list-style-type: none"> • GPD increase • Workplace increase • Industrial development • Increase both import and export • Substitution of import product 	<p><i>Customer Relationships</i> </p> <p>Can have a partner of base oil supplier and instead of it supply additive to them</p>	<p><i>Customer Segments</i> </p> <ul style="list-style-type: none"> • Mining equipments • Automotives • Where high friction and temperature is created
<p><i>Cost Structure</i></p> <ul style="list-style-type: none"> • Capital expenditure • Operation Expenditure 	<p><i>Revenue Streams</i></p> <ul style="list-style-type: none"> • Sales 			

Figure 27: The Molybdenum disulfide based lubricant manufacturing business model canvas

Following Porter's 5 force analysis, we have an only available supplier, Erdenet Mining LLC, and the potential supplier can be Oyu-Tolgoi mining LLC, Aduun-Chuluu ...etc. That means the bargaining power of the supplier is high. The bargaining power of buyers is medium because buyers can be direct customers or wholesalers, retailers...etc. Furthermore, there is also a potential barter partner who supplies base oil to us, and instead of it, we can supply additive to them. And the threat of substitutes is higher, hence some many potential wholesalers and retailers can import similar products. But the threat of entrants is quite low. The variables need to be focused, are political and economical factors for further development

Following the option and drivers, determined in the business model canvas, the first ideation of the supply chain is designed. In nowadays, the only potential supplier of raw material is Erdenet mining LLC as we know. So the preferable location would be near to the supplier and it would allow also energy and water sources without construction if 2 parties assign. But when the other potential suppliers start to process Molybdenum concentration, we would use roadway transportation. Moreover, the core value maker is our refining plant, the heart of our value chain. Furthermore, distributing ways can be optional due to the final customer as illustrated in figure 28.

Those concepts are illustrated in figure 8 generally.

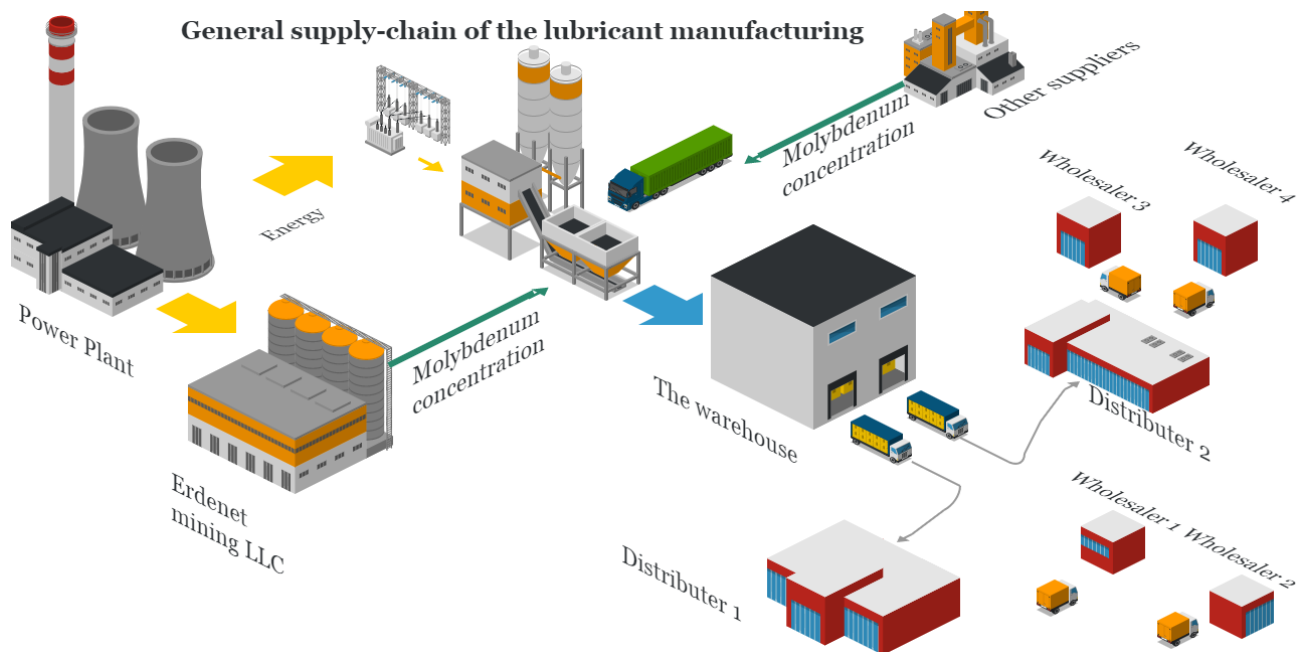


Figure 28: General Supply chain idealization

5. Conclusion

We have studied market research of the Mongolian lubrication market and the primary research method was the most suitable because there is no available comprehensive market research and available database to analyze. So we collected our primary data from the market supplier side using interviews and questionnaires. We got more qualitative data from interviews with “Mines-Up” LLC and Wagner Asia Equipment and web and social media observations were made on Liqui-Moly and Würth, hence they refused the interview. Also, we had lubricant materials monthly imports and imported country of 2018 and 2019 data from Mongolian Customs General Administration’s metadata website. 2018’s total import of lubrication material was valued 48,949 USD and 2019’ was 49,239 USD and one of the increasing factors is the constantly increasing number of mining licenses, automotive, and equipment. The existing market is fairly concentrated at the supplier level but there is no competitor at the manufacturing level.

Moreover, we determined the suppliers’ competitive analysis of the lubricant market using the interview and observation data result. According to data, Petrovis Oil LLC is the biggest supplier in the automotive lubricant market and Mines-Up LLC is the most shareowner of the industrial lubricant market in Mongolia. Hence there is no manufacturer, that is the biggest advantage for us and our market penetration strategy was evaluated as “Market Development” from the Ansoff matrix. And Porter’s 5 forces have evaluated as high at the bargaining power of suppliers and threat of substitutes. The bargaining power of buyers and the threat of new entrants are lower than the medium.

We discussed the possible products to be manufactured are Molybdenum disulfide 100% solid lubricant powder, the paste, and grease due to less production complexity and high demand from the critical research. The production of paste and grease requires base oil and thickener and these raw materials need to be imported. In that production case, the target customers are mining companies and the heavy industrial sector, and further study of Molybdenum disulfide based detergent is recommended about the product development strategy.

The extended business model developed by Stefan Wiesner was easily accessible to our study and the applied methods and frameworks within the approach were understood quickly after a short introduction. Furthermore, the results of a new business strategy and the business model, further insights resulted from the adaptation of the methodology. The approach used in our study showed the interrelationships of market research and business modeling.

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7. Appendix

Appendix 1: The 2018 and 2019's imported lubricants by country

Lubricating oils, other oils	Tonnage/ton/	Cost//USD/
	21,147,486.06	48,949.8
Australia	2,008.6	23.0
United States of America	399,897.0	2,126.0
United Arab Emirates	141,147.2	324.6
Belgium	98,039.2	501.9
Republic of Korea	8,160,246.4	19,622.0
China	1,029,389.8	2,664.4
Denmark	.1	0.0
Spain	2,282.3	5.9
Italy	76,524.1	277.4
United Kingdom	131,285.6	302.6
Canada	5,360.3	40.1
Lithuania	1,223,033.2	1,551.3
Malaysia	13,393.3	54.7
Netherlands	23,989.6	67.9
Russian Federation	4,391,122.2	4,849.4
Republic of South Africa	133,108.0	320.1
Swaziland	3.0	0.1
Singapore	3,305,012.0	9,297.2
Thailand	61,221.4	175.9
Turkey	79,334.0	214.2
Hungary	20.0	0.0
Finland	331.6	9.2
France	250,943.6	1,311.8
Federal Republic of Germany	1,144,127.7	3,627.1
Czech republic	13.8	0.8
Sweden	2,228.8	9.3
Switzerland	7,212.6	60.1
Japan	466,210.6	1,512.5

The 2019's imported lubricants by country

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Czech republic	13.8	0.8
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Sweden	2,228.8	9.3
Switzerland	7,212.6	60.1
Japan	466,210.6	1,512.5

Commodity description	First 12 months	
	Kg Quantity	USD Amount
Lubricating oils, other oils	23,153,085.54	49,239.3
Australia	1,270.3	11.8
Austria	332.2	16.6
United States of America	497,164.9	2,028.7
United Arab Emirates	25,002.6	68.0
Belgium	20,619.4	66.5
Republic of Korea	8,232,688.9	18,229.2
China	1,019,437.1	2,534.7
Egypt	2,221.4	9.9
Indonesia	7,637.6	18.6
Italy	49,647.2	143.5
United Kingdom	142,344.9	375.5

Canada	2,690.6	39.9
Lithuania	1,632,685.2	2,115.0
Malaysia	8,100.0	49.2
Mexico	43.6	0.7
Netherlands	21.8	0.2
Russian Federation	5,778,835.4	6,176.8
Singapore	4,036,159.7	11,812.2
Slovakia	2.8	0.3
Thailand	58,332.3	183.5
Finland	93.1	8.6
France	44,208.7	316.3
Federal Republic of Germany	989,544.0	3,029.1
Hong kong	1,920.0	4.4
Czech republic	45.0	0.2
Sweden	3,077.3	17.1
Switzerland	689.4	8.9
India	360.0	1.7
Japan	597,910.3	1,972.1