A SCENARIO ANALYSIS OF PLATINUM GROUP METALS WITHIN THE TRUCKING INDUSTRY

Master Degree Project in Innovation & Industrial Management

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ABSTRACT

Platinum Group Metals (PGM) are important components within the automotive industry, used for cleaning vehicles toxic gas emissions. An increasing demand of these metals have been observed, and simultaneously, mining organisations have been experiencing declining ore grades in the mines, causing the demand to exceed the supply. This creates an imbalanced market, which strongly impacts the price levels of the metals. The increasing and volatile prices, combined with the posing threat of supply scarcity, makes it essential for Original Equipment Manufacturers (OEMs) in the trucking industry to secure their supply in a sustainable way.

This study aims to investigate the future evolution of the Platinum Group Metals within the trucking industry in a five-year time horizon, and to provide insights which serves to guide OEM's in their responses to manage the future uncertainties. This through using the scenario analysis methodology, which is a forecasting method suitable for areas characterised by high uncertainty. Through the identification and analysis of trends that will drive the future evolution of PGM, and the uncertainties that will shape this evolution, four plausible future scenarios are derived. The study is based on an empirical investigation including both interviews and literature covering this topic. The analysis establishes a continued imbalance between the supply and demand resulting in increasing PGM price levels and a volatility. Moreover, the analysis finds that the most critical uncertainties that will shape the evolution of the PGM within the trucking industry are (1) the relevance of PGM as a result of new technological development and (2) the sustainability focus. By combining the potential outcomes of these two critical uncertainties, four future scenarios are built which are labelled; Sustainability is King, Doing good by Doing Well, In it for the Ride and Money Talks. This study shows that the specific OEM can meet the challenges of each scenario through adapting their level of involvement in the supply chain. This study contributes to an understanding of how the evolution of PGM within the trucking industry will look like in the coming five years, and how the level of involvement in the supply chain can be used to generate a competitive advantage.

KEY WORDS. Trucking industry, Platinum group metals, PGM, Scenario planning, PGM within trucking industry

DEFINITIONS AND ABBREVIATIONS

Automotive industry An overarching term that covers a wide range of companies and organisations involved in the design, development, manufacture, marketing, and selling of motor vehicles. The automotive industry includes different types of motor vehicles and can be decomposed into segments such as the trucking industry and the passenger cars industry.

Trucking industry An industry providing transportation for commercial products including vehicles such as trucks, busses and construction equipment vehicles.

OEM An abbreviation of Original Equipment Manufacturer, which is a company manufacturing goods that are used as components in the products of another company or in its own products.

HDV An abbreviation of Heavy-Duty Vehicle, which includes trucks, buses and coaches. Moreover, freights vehicles of more than 3.5 tonnes or passenger transport vehicles of more than 8 seats such as busses and coaches. Trucks are further segmented into several categories including long-haul, regional delivery, urban delivery and construction.

Scenario analysis A long-term forecasting tool for environment scanning which is suitable when great sources of uncertainty exist and when the environment has or is expected to experience significant change.

Trend A development factor, which is used in the scenario analysis, that have a powerful impact on the topic and have a low to medium uncertainty in outcome.

Uncertainty A development factor, which is used in the scenario analysis, that have a powerful impact on the topic and have a high uncertainty in outcome.

PGM An abbreviation of Platinum Group Metals, which is the six member family group of the rare and precious chemicals, consisting of Platinum, Palladium, Rhodium, Osmium, Iridium and Ruthenium. For the scope of this study, the three platinum group metals being analysed are platinum palladium and rhodium and are the metals which will be referred to by the abbreviation.

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1. INTRODUCTION

This chapter introduces the chosen field of research for this study, namely Platinum Group Metals in the context of the trucking industry. The following chapter is initiated with a description of the background and problem discussion of the topic. As the trucking industry is a part of the automotive industry, a distinction between these on a general level is difficult, and therefore, the automotive industry be the base for the background and problem discussion. The narrowed scope of the trucking industry will be applied in the subsequent sections of purpose and research questions. Lastly, a presentation of the delimitations of the study and a disposition of the thesis is outlined.

1.1 BACKGROUND

The historically imbalanced Platinum Group Metals (hereinafter referred to as PGM) market, characterised by a high demand, supply scarcity and increasing price levels, is of interest for both nations and organisations. Ensuring the supply of the PGM in a sustainable way is essential and understanding the sources of uncertainty surrounding the future evolution of the PGM can potentially support this process. Hence, through further investigating the trends and uncertainties that will shape the evolution of PGM in the coming five years, insights can be provided and used to manage the challenges and opportunities this evolution pose.

Platinum, palladium and rhodium are three metals belonging to the rare precious metals of the family group PGM (Gunn, 2013). The metal of platinum which for many people is strongly associated with expensive pieces of jewellery, have in fact other less glamorous, but important application areas as well. Platinum along with palladium and rhodium have valuable chemical and physical properties such as being resistant to corrosion and weathering as well as being excellent catalysts. Hence, they have been made a critical part of the modern eras advanced chemistry and technology, were the metals are important components within the automotive industry, the electronics industry and for investments, to name a few (Sverdrup & Ragnarsdottir, 2016).

Today, the majority consumer of PGM is the automotive industry which stands for approximately 70 percent of the gross demand (JM, 2019). More specifically, in this application, the metals have special external catalytic properties, making them an irreplaceable part in vehicles exhaust after treatment systems (EATS). This as they are cleaning the toxic gas emissions of carbon monoxide, oxides of nitrogen, hydrocarbons and particulates (Johnson Matthey, n.d.b). The metals therefore play a critical part in the strive of minimising the carbon footprint of vehicles, which today represents a quarter of Europe's total greenhouse emissions. Hence, PGM is vital in order to reach these sustainability goals (European Commission, 2020).

The application of PGM within the automotive industry, where stringent emission legislations continuously increase the amount needed, is one driver for increased PGM demand. Additionally, there is and has been an increasing demand of these metals in all industries. Simultaneously, mining organisations are experiencing declining ore grades in the mines, causing the demand to exceed the supply (Henckens, Ireland, Driessen & Worrell, 2016). This has historically impacted the price levels which follows the market logics, causing the prices to elevate through the roof. This is exemplified by rhodium which over the course of the last years has experienced an increase of 430 percent (JM, 2019). According to Sverdrup & Ragnarsdottir (2016) multiple researchers are expressing concerns about the potential future scarcity and peak of PGM production, generating challenges for the overall market. Further enforcing that scarcity will be evident in the coming decades.

As PGM is essential for minimising the carbon footprint from vehicles, it is critical for achieving environmental sustainability. Due to the scarce nature of the raw materials, huge efforts have been directed towards the development of new and innovative material solutions with the potential to reduce the use of PGMs in various applications, from both academic and industrial research laboratories. However, the potential of substituting the use of PGM is considered to be unlikely (IPA, n.d.b). Moreover, PGM is classified as a critical material by the European Commission (2017), determined through examining and comparing the economic importance of the material and the supply risk. This constrained supply in combination with the growing demand, pose the risk of an imbalanced market, which may hinder both technological development and sustainable development of nations (Lapko & Trusso, 2018). This is making the evolution of PGM important for organisation as well as nations.

1.2 PROBLEM DISCUSSION

As the PGMs are one of the most expensive material-groups used within the automotive industry today, the price evolution is not sustainable in the long term. Moreover, as PGM is essential for the environmental sustainability and that there is no indication that it can be substituted with other materials, (IPA, n.d.b.) the evolution of PGM within the automotive industry is highly relevant for the Original Equipment Manufacturers (hereinafter referred to as OEMs). Moreover, the increasing turbulence within the business environment for all industries, which stems from the complexity of the globalised market, new and emerging markets, increased volatility and faster paced of technological development, calls for an increased need for organisations to engage in activities of foresight in order to scan the environment for opportunities and challenges (Vecchiato, 2015). Further investigation of the buyer and supplier relations in the PGM market can be considered a potential tool for organisations to increase their ability to identify and mitigate the challenges associated with PGM. Hence, these relations should be considered when developing strategies and policies to secure a stable flow of materials (Lapko and Trusso, 2018).

The imbalanced market of PGM with high and volatile prices, in combination with an ever-changing and complex business landscape surrounding the OEMs raises questions regarding how to manage the challenges and opportunities to be successful in the future. The future evolution of PGM is surrounded with sources of uncertainty from both the imbalanced market, the effects of legislative forces, technological development and sustainability focus to name a few. Being a critical material employed in a technology that is ensuring sustainable development, this area is highly relevant for all actors within the industry as well as the society.

For the OEMs purchasing PGM, this imbalanced market with its volatile prices that keeps increasing as a result of the demand exceeding the supply combined with a posing threat of scarcity, securing their supply in a sustainable way is fundamental. Hence, the evolution of the PGM must be connected to the setup of procuring the materials, further examining the level of involvement in the supply chain for the specific OEMs. The questions that OEMs within the automotive industry are asking, is how the development of the PGM will look like and how it will unfold within five years. Moreover, what is the way forward to meet the challenges and uncertainties of the supply?

1.3 PURPOSE AND RESEARCH QUESTIONS

The trucking industry is part of the automotive industry, hence facing similar challenges in regard to the evolution of PGM. However, the automotive industry includes multiple segments, each with different characteristics such as the rate of technological development and different legislations. Therefore, the automotive industry must be decomposed into segments which needs to be analysed independently in order retain insightful knowledge. As this study is carried out in collaboration with a specific OEM operating within the trucking industry, the trucking segment will be analysed in this study. The sources of uncertainty surrounding the future procurement of the PGM contribute to the purpose of this study which is to investigate the PGM evolution within the trucking industry in a five year-horizon. This to provide insights which serves to guide the specific OEM's in their responses to the uncertainties in the business environment relating to their level of involvement in the supply chain. This purpose will be achieved by generating empirical insights of important trends and uncertainties that will affect the specific OEM's procurement of the PGM in the coming five years through the application of a scenario analysis methodology.

Research questions

In order to examine the future evolution of PGM, two research questions will be investigated. Based on the purpose of the study, the following research questions will be answered:

- *What is the future evolution of the Platinum Group Metals within the trucking industry in five years?*

- *Based on the evolution of Platinum Group Metals within the trucking industry, how can the specific Original Equipment Manufacturer manage the future uncertainties in terms of involvement in the supply chain?*

1.4 DELIMITATIONS

In order to establish a focus of the study within the applicable time frame, certain delimitations have been made. As a myriad of factors, internal as well as external, impact and shape the future of the scope of the study, the application of scenario planning method allowed for an investigation of some of the main important interactions and joint impact of these.

The automotive industry is argued to be the main consumer of the Platinum Group Metals, however, as the scope of the study is made in collaboration with an OEM active specifically within the trucking industry, the industry being regarded in this study will solely be the trucking industry. The trucking industry includes companies and organisations providing transportation for commercial products including vehicles such as trucks, busses and construction vehicles.

Moreover, the supply chain of PGM is extensive and complex with multiple actors and activities involved. This study will focus on activities upstream in the supply chain with the standpoint of the OEM perspective and will not investigate chemical or technical aspects of the PGM as an example.

In addition to this, only three of the six PGM are used within the trucking industry, platinum, palladium and rhodium. Due to the scope of the study, these are the three metals that will be regarded.

1.5 DISPOSITION

Following, a short overview of the disposition of the study is outlined, providing a brief review of the body of structure. The structure of the report is organised in a subsequent matter in order to provide a flow of research and to provide a pedagogical understanding. This first chapter of *Introduction* has outlined the background description of the research field and its problems, a motivation for the study and its purpose and research questions was also outlined.

The next chapter, *Theoretical framework* introduces the Scenario planning methodology, its background, frameworks, main challenges and the applied scenario analysis framework constructed by the authors of the study, customised to fit this specific study.

The *Methodology* chapter is divided into five sections which details a thorough description of the chosen research procedure. Additionally, it motivates for the actions taken through the study.

In the *Empirical setting* chapter, an introduction of important information relating to the research topic is outlined. The purpose of this chapter is to introduce and create an initial understanding of the topic which will serve to enhance the understanding of the research field prior to the scenario analysis. The chapter details an overview of the platinum group metals, the automotive industry and the material flow of the PGM.

The fifth chapter, *Empirical investigation,* presents the empirical findings of the study. The findings are structured in accordance with the STEEP-framework and forms the foundation of the scenario analysis which follows.

The consecutive chapter, *Scenario analysis*, incorporates the actual scenario analysis process which has been applied. This chapter is structured according to the four steps of the customised applied scenario analysis and is initiated with the Definition of Scope, Identifying Development Factors, Trend and Uncertainty Analysis and the Scenario Development.

The final chapter, *Conclusion,* outlines a brief summary of the most prominent findings of the study and provides conclusive answers to the research questions outlined in the first chapter. Additionally, suggestions for future research within the topic is highlighted.

In addition to this, a list of the references used in the study and an appendix is attached.

2. THEORETICAL FRAMEWORK

The following chapter outlines the theoretical framework which results in an applied scenario analysis framework used in the study. The chapter is initiated with an introduction of the selection process for the literature, followed by a description of the scenario planning concept. Moreover, a literature review of the most prominent scenario planning frameworks and the main challenges of applying the methodology is outlined. The chapter is concluded by the authors own applied scenario analysis framework based on the literature review with the main challenges in mind. This constitutes the base for this study's methodology.

2.1 SCENARIO PLANNING

To outline the theoretical framework presenting different scenario planning approaches, several databases such as the library of Gothenburg's own search function, Google Scholar, Emerald Insights and others supported the search for the most prominent, relevant and reliable literature. The inclusion criteria for the theoretical framework includes but are not limited to; "Academic articles describing the methodology of scenario planning; Academic articles as the main source of data; Academic articles considered as fundamental to the scenario planning methodology". The exclusion criteria are; "Sources that do not stem from academia; Academic articles that are not peer reviewed; Scenario planning models not recognised within academia; Articles describing case studies of scenario planning". The introduction of the search process aims to provide a high level of transparency.

The theoretical framework aims to find a scenario planning approach that fits this specific study, which is the foundation guiding the empirical investigation, analysis and overall structure. Hence, a thorough description and review of existing approaches is essential to create a deep understanding of the methodology, to successfully develop an approach with steps and tools that are customised to this study, and to avoid potential pitfalls.

2.1.1 WHAT IS SCENARIO PLANNING?

Scenario planning is a strategic planning methodology, where potential future events are studied in order to predict their impact on an organisation. This is carried out to enable proper strategic actions for the business to succeed in the future (Schoemaker, 1995). Scenario planning is a disciplined method to systematically gather, analyse and regard the myriad of factors in the business environment which potentially will shape the corporate future. By capturing the full range of data in rich detail, elements of future trends and uncertainties are reflected upon. From this, scenarios are built through the interactions of the different elements of trends and uncertainties. The scenarios serve as the base for a future strategy which guides the strategic actions of an organisation (Schoemaker, 1995; Schwenker & Wulf 2013; Lindgren and Bandhold, 2003). This type of environmental scanning is efficient to stay up to date with both the direction and the magnitude of emerging changes (Schoemaker, 1995). Moreover, according to Lindgren and Bandhold (2003), there are two key performance drivers for an organisation that is characterised by high uncertainty that can be observed. First, generating a high level of responsiveness, which is the ability to sense and respond to changes. Secondly, to have robust business concepts and strategies, which is the potential for success under different future scenarios. This combination of characteristics can potentially be achieved through using scenario planning.

Using scenarios as a strategy for responding to uncertainties in the external environment originates from the military in the 1950´s. It was most famously adapted and implemented in a business context by organisations such as Royal Dutch Shell, General Electric Company and SRI International in the 1970´s. (Millett, 2003) Moreover, Bishop et. al. (2007) describe that the specific scenario methodology that is widely used as default for scenario planning performed by consultants and organisations is the aforementioned Royal Dutch Shell framework. This

approach was later popularised by first Schwartz (1998) in the *Art of the Long View*, where the Global Business Network Matrix, was introduced as a further development of the Royal Dutch Shell framework, and later by Van der Heijden (1996) in *Scenarios: The Art of Strategic Conversations* (Bishop et al 2007). Schwenker and Wulf (2013) also describe the Royal Dutch Shell and the Global Business Network Matrix as two of the most influential approaches to scenario planning over the last 40 years. Additionally, they describe two scenario planning approaches as important from an academic standpoint, those of Schoemaker (1995) and Van der Heijden (2005). Today there are several different approaches that can be used for scenario planning that differ in detail in regard to what frameworks and techniques that are used. However, many of them sharing similar features, where the more recent framework proposed by Schwenker and Wulf (2013) aims at consolidating the different approaches into an easier applicable framework.

2.1.2 SCENARIO PLANNING FRAMEWORKS

One aspect to consider when using the scenario planning methodology for guiding future strategic actions is the vast amount of different approaches proposed. According to Millett (2003), one of the major challenges of using scenario planning is to resolve the confusion regarding the multiple methods and definitions that exist, to be able to use it as a valuable source of analysis. By analysing a number of well-known, well-cited and influential methodologies of scenario planning, this literature review aims at reducing the complexity through finding similarities and differences to adopt a scenario planning approach which fits this specific study. Four different scenario planning frameworks will be outlined in this section. The selection of these frameworks is based on the literature review, where the framework by Schoemaker (1995) and Schwartz (1998) have been highlighted as important and influential, taking different approaches with their base in academia versus business. Additionally, the framework by Schwenker and Wulf (2013), will be presented as it is well-cited and aims to consolidate the most important approaches from several frameworks. Lastly, the framework proposed by Lindgren and Bandhold (2003) will be outlined as it is a more recent methodology that is well-tried out in several organisations and projects. A compilation of respective authors various steps in short, compared to each other's is found in Appendix A.

2.1.2.1 SCENARIO PLANNING: A TOOL FOR STRATEGIC THINKING SCHOEMAKER (1995)

The original scenario planning process by Schoemaker (1995) is constituted by ten steps, which is argued to work well for corporatewide strategic planning and vision building in an industry which is about to, or has experienced, significant change. These steps will be further outlined.

1. Define the Scope
The first step incorporates setting the scope of the scenario planning and includes defining the time frame and outlining the uncertainties. The scope of scenario planning can relate to the topics such as technology, material, product or markets etc. Furthermore, the adequate time frame is set based on a review of important factors that may have an impact on the topic of the scenario analysis. To set a proper time frame, Schoemaker (1995) suggest looking back a couple of years and identify the respective changes that has occurred. This is followed by expecting similar or exceeding future change to answer questions such as, what knowledge would have been useful and what do you wish that you had known?

2. Identify the Major Stakeholders
Following step is to identify and map the stakeholders that will be impacted, will impact or have an interest in the topic. The stakeholders should be identified from both the external and internal environment, in both current and emerging markets. The mapping not only includes the identification of who the stakeholders are, but also identifies factors such as their current roles within the industry and power positions.

3. Identify Basic Trends
The third step includes an identification of basic trends. These are events that will have a significant impact on the topic and scope of the scenario analysis and exist both in the micro and macro-environment. This spans over economic, technological, legal and the industry

spectra for the specific topic. These trends need to be outlined and include a concretisation of its main impact, in a positive, negative or uncertain way of the specified industry or organisation.

4. Identify Key Uncertainties
The proceeding step includes an identification of events which will take place in the future but were the outcomes are uncertain, (uncertainties) and an analysis of the interconnectedness among these. Similarly, to the previous step, the uncertainties regarded, span the economical, technological, legal and industry field. Next, a mapping of the correlated relationships among the uncertainties and how they impact each other is outlined through a correlation matrix, as visualised in Figure 2.1. If the occurrence of outcome #1 for uncertainty X affect the chances of occurrence of outcome #1 for uncertainty Y, a correlation between the uncertainties is evident. If the chance goes up, there is a positive correlation (+), if the chance is lower, the correlation is negative (-). If the relation is neutral or impossible to determine, no correlation is found, and it is marked with a zero (0).

CORRELATION MATRIX EXAMPLE					
	U1.	U2.	U3.	U4.	U5.
U1.		0	-	-/+	0
U2.			0	0	0
U3.				+	+
U4.					+
U5.					

Figure 2. 1. Correlation matrix (Schoemaker, 1995)

5. Construct Initial Scenario Themes
Once the initial steps in the process are done, the overarching frame of the scenario analysis is set, and the next step is to construct the initial scenario themes. Various approaches to do this are outlined. One approach takes its starting point in dividing the trends and uncertainties based on a positive or a negative impact on the current strategy. Another approach is to cluster elements based on level of continuity, preparedness or turmoil, and a third way to construct the themes is by selecting the top uncertainties and cross them together. However, this should primarily be done if some uncertainties are seen as more important than others.

6. Check for Consistency and Plausibility
The sixth step is to analyse the initial scenario themes for internal inconsistencies and their impact on each other. This is done through one of three outlined consistency tests which regard the outlined trends, the outcome combinations and the stakeholders' reaction. The trends need to be analysed with regard to if there is compatibility within the chosen time frame, if the combination of the scenarios and the outcomes of the uncertainties go together and if the power positions of the major stakeholders' changes throughout the time frame.

7. Develop Learning Scenarios
The proceeding step analyses the initial boundaries of the scenarios with the main objective of the scenario planning, to identify what is strategically relevant. Based on the relevancy factor, possible outcomes and trends identified in the third step are based around these scenarios and are assigned a specific weight or attention to mark their importance. In this step, the initial scenario themes are outlined as learning scenarios which are described as storylines, assigned with appropriate names that strive to capture the essence of the scenario. It is stressed that the title must reflect the story as these are the foundation for guiding the strategic actions.

8. Identify Research Needs
In the following step, the scenarios should to be further developed through engaging in additional research of the various elements incorporated. This step is important as it gives the opportunity to go outside the knowledge already acquired to really scrutinise and find blind spots in the scenarios. This includes researching emerging markets and fields which might impact and side-line the industry.

9. Develop Quantitative Models
In the proceeding step, a re-examination of the scenarios with regards to their internal consistencies should be made. The interactions in the scenarios are assessed whether they should be formalised through quantitative models or not. The quantitative models help attain a plausible balance between the factors making up the uncertainties. The main goal of this step is to make sure that implausible scenarios are not made up and that the consequences of the uncertainties can be quantified.

10. Evolve toward Decision Scenarios
The final step of the process is to evolve decisions based on the scenarios. This is an iterative process where current strategies should be tested, and new ideas should emerge which strategic actions are based upon. This step also includes determining whether the scenarios are good enough, based upon relevance and if they are internally consistent and archetypal.

2.1.2.2 THE ART OF THE LONG VIEW SCHWARTZ (1998)

Schwartz (1998) presents a scenario analysis approach that is based on the most famous scenario planning framework, namely the Royal Dutch Shell framework. Through an eight-step process this framework gives organisations the possibility to develop a strategic vision including uncertain elements.

1. Identify Focal Issue or Decision
In this first step, an inside-out approach is recommended, starting with organisational factors and then moving towards the external environment. The strengths of using this approach when identifying the focal issue that will form the base of the scenarios, is that it allows for a more focused analysis. Hence, contributing to scenarios that are aligned with the specific business or industry of interest. One way of approaching this is to start looking at major strategic decisions in the near future and based on those, factors to look into can become distinctive.

2. Key Forces in the Local Environment
The second step in this methodology aims at identifying and listing forces in the local environment of the focal issue that might influence the success or failure of the business or industry. These key forces can include looking into customers, suppliers, competitors etc. In summary, this analysis includes everything in the local environment that can be of importance when making future decisions.

3. Driving Forces
Subsequently, this step includes listing the driving forces in the macro-environment that influence the forces identified in previously step. A checklist including social, economic, political, environmental and technological forces can constitute the base. To obtain a relevant macro-environmental analysis, an addition to the checklist is to uncover the forces behind the micro-factor from previous step. Some forces are considered to be predetermined, such as demographic factors, and some are unpredictable, such as the public opinion. Hence, there is a possibility to paint a picture of what the future might hold in terms of foreseeable and uncertain events. The latter being more difficult since novelty is hard to predict. This step is considered to be very research intense as it creates the base for the whole scenario analysis.

4. Rank by importance and uncertainty
The next step of ranking of the key factors and driving forces is carried out on the basis of two criteria, namely the degree of importance for the success of the focal issue and the degree of uncertainty of these factors and trends. In this step the main objective is to find two or three factors or trends that are the most important and the most uncertain.

5. Selecting Scenario Logic
As a result of the ranking, the two or three most important and uncertain factors that will influence the focal issue will constitute the axes along which the plausible scenarios will differ. The ultimate goal is to create significantly different scenarios that can support decision-makers. The fundamental differences of the scenarios are considered to be the "scenario drivers" and should be limited. These can be presented in different ways, through a matrix with two axes, a volume with three axes or along one axis as a spectrum. Hence, the logic of a scenario will be characterised by the location in the chosen tool set up by the most important scenario drivers. As an example, for the automotive industry, fuel price and protectionism could be considered the most important scenario drives. The scenario logic would be to set each driver to the extreme, such as low fuel prices and high fuel prices, a protectionist environment and an open economy. When combining these two drivers, four different scenarios would emerge.

6. Fleshing out the Scenarios
The most important forces are underpinning and distinguishing the scenarios. However, by returning to the factors and trends from step two and three, the skeletal scenarios are fleshed out in this step. Each key factor or trend should be included in all scenarios. These key factors and trends together with the uncertainties create the narrative of the scenario and the idea of what events that need to happen for this scenario to be plausible is the key focus.

7. Implications
After developing the scenarios in detail, attention is brought back at the focal issue, identified in the first step. The implications of the different scenarios are evaluated and cross-checked with the strategy and or the decision of the organisation.

8. Selection of Leading Indicators and Signposts
Lastly, when the scenarios are fleshed out and the implications have been analysed, there are advantages in also adding some indicators to monitor in the future. By carefully choosing indicators that are linked to, or even extracted from the scenarios, the industry future might become less unpredictable. By extension, this allows companies to make better decisions and to increase their abilities to meet uncertain events.

2.1.2.3 SCENARIO-BASED STRATEGIC PLANNING BY SCHWENKER AND WULF (2013)

Schwenker and Wulf (2013) have through examining several different scenario planning tools, both ones widely used in business, and ones primarily used in academia, concluded a six-step process that is common for all approaches. For each step, the researchers have applied a specific framework either from traditional scenario planning methods or through one that has been developed by the researchers themselves.

1. Definition of scope
The framework used in this step, is the Framing Checklist. It consists of five questions that ensure that all key aspects are covered and includes questions related to the level the analysis in terms of strategy, a definition of the stakeholders included, the level of engagement from top management as well as a definition of what members that will be included in the process. Lastly the time horizon for which the scenario planning will cover. The result of this stage is to have defined and clear process goal.

2. Perception Analysis
The framework used in the second step is a 360° Stakeholder Feedback. The intended goal is to investigate different perspectives, including both internal and external stakeholders, on the future developments. As a first step in using this framework, the researchers suggest sending a questionnaire composed by questions related to the macro environment, to identified stakeholders. Factors considered to be relevant are clustered and a new questionnaire is constructed where the respondents are asked to rate the factors with regards to level of uncertainty and impact on performance. This generates a list of key factors that will influence the industry, which allows the company to identify potential changes and potential blind spots.

3. Trend and Uncertainty Analysis
The goal of the third step is to structure the development factors that have been identified in previous step. The development factors are to be sorted into three categories. To do this, the proposed framework is an Impact and Uncertainty grid, visualised in Figure 2.2. According to the level of uncertainty and the level of potential impact, the developmental factors are mapped in a grid. From this, the important trends and uncertainties used in the scenarios in the next step can be identified. In the upper left corner, factors with a relatively low degree of uncertainty with a large impact in the organisation are found. These factors are considered to be trends. Factors identified to have high levels of uncertainty and a strong potential impact are found in the upper right corner, called critical uncertainties. Two critical uncertainties can be used as stand-alone dimensions for the scenarios, or multiple related critical uncertainties can be clustered into two major critical uncertainties setting the dimensions of the scenarios.

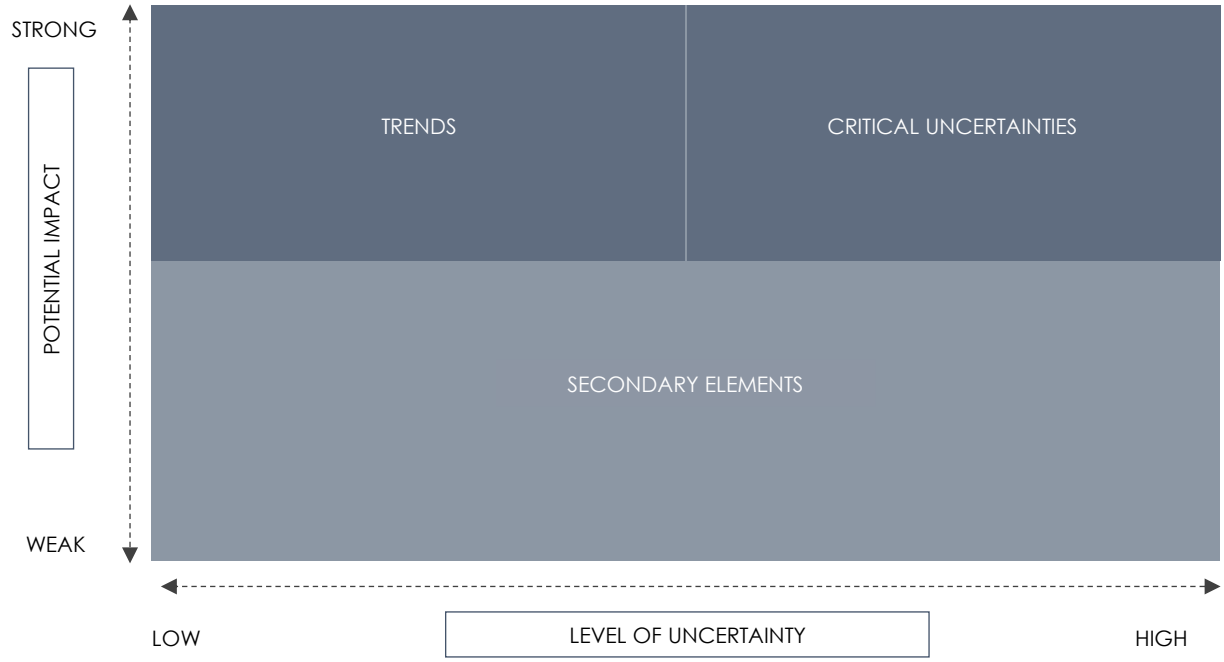


Figure 2. 2. Impact & uncertainty grid (Schwenker & Wulf, 2003)

4. Scenario Building
The results of the trend and uncertainty analysis is used as a base for constructing scenarios, through using a Scenario Matrix**.** When applying this framework, each scenario is built upon two extreme values. These are the boundaries of the scenario matrix, that consists of four quadrants displaying four potential future scenarios. These scenarios are named, and further details can be added through an influence diagram, showing the cause and effect for each scenario based on the uncertainties and trends identified in the previous step. Lastly, a storyline for each scenario is created.

5. Strategy Definition
Based on the four scenarios and the storylines developed, each scenario is describing a potential future outcome with challenges and opportunities for the organisation to meet through strategic actions. The framework proposed by the authors is the Strategy Manual, which starts by investigating each scenario to derive specific strategic recommendations for that scenario. Subsequently, these sets of strategic recommendations are compared and contrasted in order to find similarities and common features. From these, a core strategy can be formed. This strategy can, regardless of external development, be implemented by the organisation to manage the unpredictable future. Additional strategic recommendations and actions that are not common for the scenarios can be implemented, depending on need.

6. Monitoring
This step aims at implementing the strategic recommendations that were developed in the previous step. A Scenario Cockpit is used as a framework to understand developments in the external environment for the company, to find what scenario that is closest to the real world. This is derived from the influence diagram, the fourth step, where each indicator is assigned a maximum range for the value, which is compared to actual values. This shows what scenario is closest to reality, and hence, what strategic activities that the company should implement. Moreover, the Scenario Cockpit can help companies to assess if the scenarios they have developed are valid.

2.1.2.4 THE TAIDA-METHODOLOGY LINDGREN AND BANDHOLD (2003)

TAIDA™ is a well-tried out methodology for scenario planning that has been widely used for projects of different character. It includes five phases, however, important when starting this process is to specify a number of prerequisites beforehand. These include the time horizon of the analysis and the boundaries of the focal question. Additionally, the system that will be analysed needs to be identified, which could for example be the entire organisation, or a specific part. Lastly, the past and present for the organisation and the landscape needs to be defined.

1. Tracking
Changes as well as indications of threats and opportunities are traced at this phase. The purpose of this phase is to find and to describe the changes that can be observed in the external environment that could potentially have an impact on the topic investigated. Tracking is essentially about identifying trends or patterns of change, as well as uncertainties and threats. The authors propose an outside-in approach, starting with driving forces at a macro-level, followed by industry trends and company specific factors. When identifying and verifying the potential trends, there are several methods that can be used, such as the Delphi method and Expert panels. This is especially useful when examining a trend more in depth.

2. Analysing
After identifying the trends, uncertainties, threats and opportunities, this step is to create an understanding of the drivers and impact of these. To gain a deeper understanding of the trend and to evaluate potential interconnections, a Cross-Impact analysis framework, visualised in Figure 2.3, can be carried out. The level of interconnection between the trends spans from 1 to 2 for positive correlation and from -1 to -2 for negative connection. Each trend is systematically put in relation to the other trends, to evaluate if a relationship exists. The values are summarised to determine which trends that are driving others and which trends that are dependent. Consequently, the researchers suggest the construction of scenarios, by starting with the certainties. Moreover, there are often a number of factors that potentially can have a large impact on the topic, that are uncertain. The researchers propose that two of these driving uncertainties should be put on respective axis of a scenario cross. This will generate four different scenarios. From these, a compelling storyline should be created.

CROSS-IMPACT MATRIX EXAMPLE					
	T1.	T2.	T3.	T4.	Summary
T1.		0	2	-1	3
T2.	2		-2	-1	5
T3.	-1	-2		0	3
T4.	0	1	0		1
Summary	3	3	4	2	

Figure 2. 3. Cross-impact analysis (Lindgren & Bandhold, 2003)

3. Imaging
The Imaging-phase is focused on creating visions for the future. The previous steps have contributed to a better understanding of the possible future scenarios and hence, generated a foundation for setting goals and strategic actions. The researchers propose a creation of a BHAG (Big Hairy Audacious Goal), which is a highly focused goal that is tangible and energising, described in a short sentence. This goal sets the frame for a vivid description of the vision that can be used for future strategic actions.

4. Deciding
After carrying out previous phases, this next phase is about summarising and connecting all parts to create a strategy. The strategy is intended to meet the different scenarios that has been created in this process. There are several methods of how to strategise in a complex and changing environment, and the Consequence Tree is one. It is an interlinked system composed of driving forces expressed as the root system, clusters of identified trends as the trunk of the tree and the consequences they will impose illustrated as the branches. This visualisation aims at generating a comprehensive overview of the environment for future strategic actions.

5. Acting
The final phase of Acting is focused on two parts. First, to implement the strategies that were decided upon in the previous phase. This is often carried out through implementation toolsets of various kinds. Second, the authors underline the importance of following up the scenario planning where continuous follow-ups on the process that has been carried out is suggested. Including monitoring of how the external environment changes and further creation of processes for how to continuously monitor the environment and the scenario planning.

2.1.3 MAIN CHALLENGES OF USING SCENARIO PLANNING

The application of the scenario planning methodology endures some challenges which needs to be regarded in order to succeed. Pitfalls in the application of the scenario planning methodology is an explored area by multiple researchers (Schoemaker, 1998; Lindgren & Bandhold, 2003; Fahey and Randall, 1998). These will be outlined with the primary purpose to ensure that the authors make conscious decisions when formulating their applied scenario analysis framework as well as minimising the risk of pitfalls when applying the framework.

Schoemaker (1998) highlights some main pitfalls prior to the initiation of the scenario planning method. These include lack of top management support and lack of diverse inputs. The researcher outlines the top management of an organisation as vital, since without their support the learnings and actions derived from the scenario planning will not take place at the end of the process. Moreover, a widespread of diverse inputs are essential to go beyond the known organisational boundaries and external inputs such as customers, suppliers and experts should therefore actively be sought. The researchers Lindgren and Bandhold (2003) further highlights a challenge in the preparation phase, which is to not adequately scope the scenario planning, as this may lead to an unclear purpose, ambiguous questions, an inappropriate time horizon or a homogenous perspective of the team. This is confirmed by Shoemaker (1998) whom also highlight the pitfall of setting an inappropriate time frame and scope. Setting the right scope and time frame from the start is a difficult task as organisations exist in a rapidly changing business environment.

Continuing to the next phase of the scenario planning methodology, the researchers Lindgren and Bandhold (2003) outline a challenge associated with the development factors creating the trends and uncertainties. More specifically the challenge of the researchers anchoring the trends inadequately, such as not having actual changes underlying the trends or not having sufficient evidence in the next coming phase of tracking. A thorough analysis of the identified trends should be carried out to minimise this risk. The same researchers further highlight a challenge related to the creation of the scenarios, where finding the right combination of uncertainties and to find scenarios that are precise enough to generate value is described to be a difficult task. This specific challenge is similar to the research by Fahey and Randall (1998) which further elaborates on the lessons needed to master the methodology. These researchers

highlight the lesson of identifying appropriate indicators contributing to the uncertainties and trends. Schoemaker (1998) also confirms this when outlining the pitfall of having uncertainties with internal inconsistencies in the scenarios as he argues that the logic of the scenarios internally must match and not contradict each other. Another pitfall connected to the development of scenarios is to develop too many scenarios as it endures the risk of going overboard and end up with unimportant data. Two to four scenarios are usually sufficient according to Schoemaker (1998).

Finally, several researchers underline specific challenges characterising the final steps of the scenario planning methodology relating to generating strategic actions. Lindgren and Bandhold (2003) highlights the challenge of not communicating and living the vision, not creating a sustainable strategy and not have enough resources allocated to the follow-up of the scenario planning. These concerns are also raised by Schoemaker (1995) in the pitfall of failure to stimulate new strategic options. The objective of developing learning scenarios is to guide the strategic actions to embark on strategic initiatives. The scenarios by themselves are not the end point. This review of pitfalls and challenges when applying the scenario planning framework will be regarded when the authors of this study formulates the applied scenario framework and moreover, when applying the framework in chapter six in order to increase the quality of the scenario analysis.

2.2 APPLIED SCENARIO ANALYSIS FRAMEWORK

With regard to the vast amount of literature describing different methodologies, and approaches towards the scenario planning methodology, a customised scenario planning framework has been developed by the authors to fit this specific study. This is referred to as the applied scenario analysis framework and will be further outlined in detail. An analysis and compilation of above described scenario planning frameworks by the researchers Schoemaker (1995), Schwartz (1996), Schwenker and Wulf (2013) and Lindgren and Bandhold (2003) from the literature review create the foundation of the customised applied framework, which is visualised in Appendix A. Furthermore, through the thorough analysis of the main challenges of applying the scenario planning methodology, the risk of enduring some of the main pitfalls is minimised. The applied scenario analysis framework aims at fulfilling the purpose of the study by answering the two previously stated research questions;

- *What is the future evolution of the Platinum Group Metals within the trucking industry in five years?*

- *Based on the evolution of Platinum Group Metals within the trucking industry, how can the specific Original Equipment Manufacturer manage the future uncertainties in terms of involvement in the supply chain?*

The first research question will primarily be answered through the first part of the scenario analysis with emphasis on the empirical investigation and the identification and analysis of the development factors from the secondary and primary data collection of the study. The second research question will be answered through the final part of the scenario analysis, namely the scenario development, were the storylines are analysed through an organisational lens. This to find the implications each scenario has on the level of involvement in the supply chain.

Figure 2.4 provide an overview of each of the consecutive steps of the scenario analysis used in this specific study, including purpose, data used and final output. Based on the theoretical framework presented, the final step of a scenario planning is usually found to include activities related to the implementation of the strategy. However, with regards to the purpose of this study, these steps have been excluded as the primary objective is to outline the future evolution of the Platinum Group Metals within the trucking industry and how a specific OEM can manage the future uncertainties in terms of involvement in the supply chain.

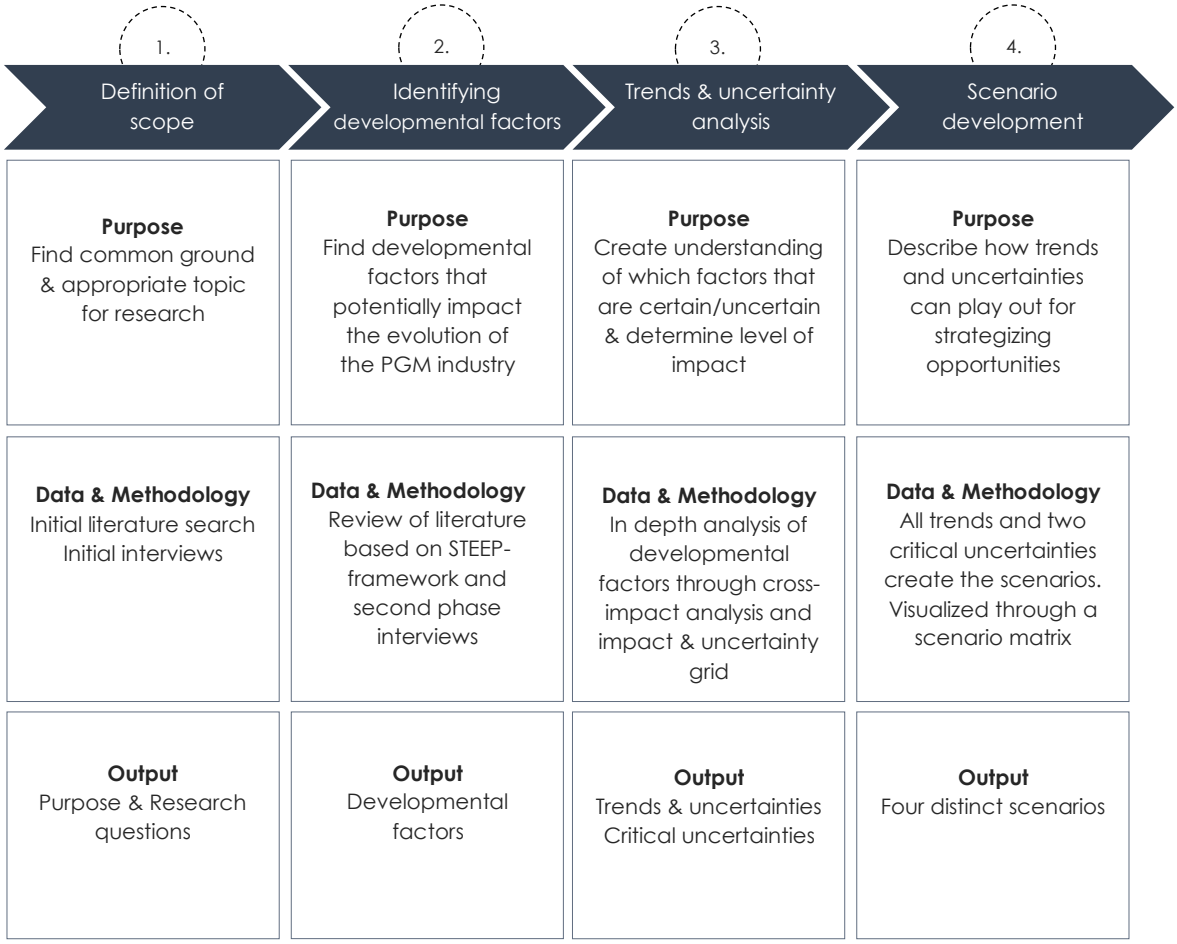


Figure 2. 4. Applied Scenario Analysis framework

Step 1. Definition of Scope

The first step in the applied scenario analysis is to define the scope and goal of the study. All scenario planning approaches included in the theoretical framework have this first step in common, expressed in different ways with only details separating them (Lindgren & Bandhold, 2003; Schoemaker, 1995; Schwartz, 1996; Schwenker & Wulf, 2013). It is essential to create a common ground for the project in order to create scenarios that will be accepted, understood and useful (Schwenker & Wulf, 2013). Moreover, the challenge of setting an appropriate time frame and scope was underlined, by the researchers Lindgren and Bandhold (2013) and Schoemaker (1998) as being of importance. To regard this and to minimise the risk of setting an inappropriate time horizon or a faulty or ambiguous scope, the Framing Checklist by Schwenker and Wulf (2013) is deemed appropriate to use. This as it includes a set of questions closely related to the overarching goal of the study and hence, is beneficial for creating clarity from the start. The Framing Checklist used is visualised in Figure 2.5, and excludes the question related to the Definition of Stakeholders through the 360° stakeholder feedback. This exclusion is based on the lack of availability of a full on 360° within the limited time frame of this study. However, to incorporate the importance of bringing multiple perspectives which is highlighted by Schoemaker (1998), the authors extended the question related to participants to also include stakeholders for this study. The stakeholders for this study was deemed to be the actors within the chosen industry and were further incorporated in the collection of data.

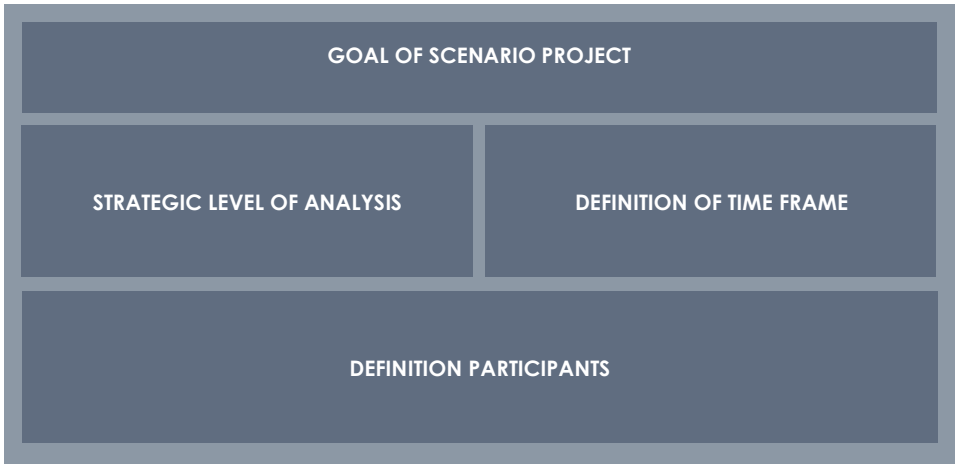


Figure 2. 5. Framing Checklist used in the applied scenario framework

Step 2. Identifying Development Factors

The second step of the applied scenario analysis framework is identifying development factors. This as it is according to both Schoemaker (1995) and Schwenker and Wulf (2013) vital to identify factors which will have an impact on the industry chosen. According to Lindgren and Bandhold (2003) a combination of methodologies can be used, ranging from media scanning to interviews and workshops. This consecutive step is based on the Tracking phase of the authors of Lindgren and Bandhold (2003) who proposes an outside-in approach. Starting to analyse changes in the macro-environment and then shifting to the micro-environment, to retrieve a broad perspective of development factors. The data collection for identifying the development factors will be gathered through primary and secondary data. The analysis will be structured in accordance with the STEEP Framework (Social factors, Technological factors, Economic factors, Environmental factors and Political factors). The purpose of this is to retrieve a widespread collection of data generating a broad view of the topic, spanning over multiple fields. Furthermore, the framework allows for a systematic collection and a selection in the ocean of existing data. This is argued to be essential by both Schoemaker (1995) and Lindgren and Bandhold (2003), to find relevant and important data to create a solid base to the future scenarios.

Step 3. Trend and Uncertainty Analysis

The third step in the applied framework is focused on a thorough analysis of the previously identified developmental factors. All identified factors are subject for analysis in three consecutive steps. This process is carried out to systemically sort, select and understand the factors that will constitute the base for the scenario development. According to Lindgren and Bandhold (2003), does the phase of Analysis allows for distinguishing between trends and uncertainties since these are influencing the focal issue in different ways. Furthermore, the main advantage of this type of analysis is according to Schwenker and Wulf (2013) that it makes it possible to isolate trends and uncertainties and in detail further analyse them. Several approaches to this have been argued by the different researchers and in for this customised applied scenario analysis framework, the analysis is carried out as a combination of Lindgren and Bandhold (2003) phase of Analysis, the third step of Trend and uncertainty analysis in Schwenker and Wulf's (2013) approach and finally a combination of Schoemaker (1995) third and fourth step. The combination of these different approaches for this specific step is chosen by the authors as it creates the foundation for answering both of the research questions. Hence it is vital that this step is thoroughly worked through in an orderly and systematic way. The purpose of this is to increase the quality of the outcome of the scenario analysis. The three levels of analysis and the tools included are further outlined below, starting with identifying impactful development factors and a classification of trends respective uncertainties, followed by the trend- and uncertainty analysis, and finally the impact and uncertainty grid.

Impactful development factors

The first of the three levels of analysis is to examine the identified developmental factors to establish their impact on the focal issue. It is emphasised by the researchers Lindgren and Bandhold (2003) that development factors that are to be considered for the scenarios must fit the scope and goal of the study. Furthermore, the factors need to be both meaningful and be validated to the study. In this customised framework the authors ensure this by establishing three criteria to determine if the development factors are impactful or not. The criteria deemed suitable for this study is visualised in Figure 2.6. The first and second criteria relates to whether the development factor is accurate and meaningful to the study or not. This is examined through observing if the development factor is mentioned in literature and if it is mentioned by experts in the interviews. The third criterion relates to the relevancy to scope and the time frame, which determines if the development factor fit the scope of the study. All of the three criteria need to be fulfilled for a developmental factor to be deemed as impactful. If one or more citations are not fulfilled, the development factor will be disregarded.

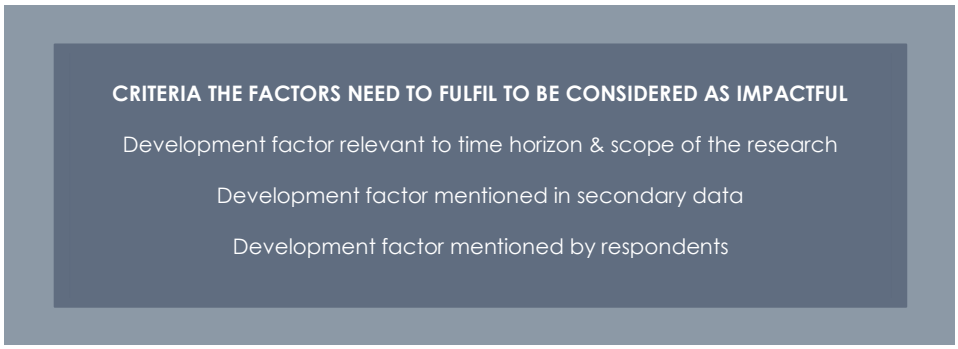


Figure 2. 6. Criteria for a development factors to be consider as impactful

Trend Analysis
The next level of analysis is to determine whether the impactful development factors are to be considered as trends or uncertainties. This distinguishing is vital as the trends and uncertainties have different impact in the focal topic (Lindgren & Bandhold, 2003). "Trends are factors that have a strong impact on the topic and a low to medium uncertainty" (Schwenker and Wulf, 2013, p. 100). Hence, this implies that the future direction of the development factor is fairly certain. To determine this, a criterion relating to certainty of outcome was set. The aspect of certainty of the identified development factors is established by the process of verification through the authors intuition, discussions with the interviewees in the primary data collection and analysis of the primary data. Added to this as a complement to the criteria is further discussion with an expert within the focal topic. The use of multiple tools for this applied scenario planning step allows for a triangularisation of the factors identified in previous step, to validate their importance. This is a conscious choice by the authors to meet the challenges outlined by Lindgren and Bandhold (2003) of anchoring the important trends and uncertainties that have sufficient evidence which will generate value when building the scenarios.

The developmental factors that were deemed to have a certain outcome was further subject to a Cross-Impact Analysis in accordance with the approach by Lindgren and Bandhold (2003). This to identify the interconnectedness of the trends to reveal future patterns which will hold for all of the scenarios. This analysis is deemed appropriate for this study as it ease the strive for validation and internal consistencies in the scenario development. Furthermore, to make sure that the foundation on which the scenarios are constructed is solid and thoroughly analysed. This step was also deemed necessary as the researchers Fahey and Randall (1998) highlights the importance in identifying appropriate indicators contributing to the trends.

Uncertainty Analysis
"Uncertainties are factors that have a powerful impact on the topic and are exposed to high uncertainty" defined by Schwenker and Wulf (2013, p. 100). Moreover, these factors are considered to be most important as they are the most difficult to manage since the development of the factor is unknown (Schwartz, 1996). The identification of uncertainties is

also based on the criterion of Certain outcome. Thus, including developmental factors which outcome could not be determined as having a level of certainty. These uncertainties were subject to a Correlation Analysis in accordance with the fourth step by Schoemaker (1995). A correlation analysis allows the researcher to identify relationships among the uncertainties as well as the critical uncertainties. The tool of correlation analysis is deemed suitable for this study as it in a practical way allows for an assessment of the scenarios consistencies to establish a correct and solid base which will ground the detailing of scenarios in the coming step. This is something that is argued by the researcher Schoemaker (1998) to be of great importance as he argues that the logic of the scenarios internally must match and not contradict each other.

Impact and Uncertainty Grid
The third and final level of analysis in this step of the applied scenario analysis framework is based on Schwenker and Wulf (2013) approach using the tool of Impact and Uncertainty grid. This tool is efficient in terms of further discussing and evaluating the relevant trend and uncertainties through visualisation. Moreover, it supports the visualisation of potential clusters as well as the processes of selecting the two dimensions for the scenario development (Schwenker & Wulf, 2013). Based on the Impact and Uncertainty grid, the two most critical uncertainties are chosen to lay the foundation for the scenario building step by forming two dimensions (Schwenker & Wulf, 2013). This is similar to the approach by Lindgren and Bandhold (2003), claiming that two of the driving uncertainties identified should be highlighted. Through the mapping of trends and uncertainties in the Impact and Uncertainty grid, the visualisation makes, as mentioned, clustering of multiple uncertainties possible. The clustering is according to Schoemaker (1995) a technique for sorting the most critical uncertainties in which will create the two scenario dimensions which will create the starting point of the next step of scenario building. To improve the quality of this process, the impact and uncertainty grid is to be sent to one of the experts of the study.

Step 4. Scenario Development
The final step in the applied framework is scenario development. This is an important phase in order to visualise the future and is also one of the main steps in the scenario planning discipline (Lindgren & Bandhold, 2003). This step in the applied scenario analysis is a combination of the fourth step of Schwenker and Wulf (2013) framework and the fifth step in the approach by Schoemaker (1995). This combination allows for a development of the scenarios based on the previously identified trends and their interconnected relationships along the identified critical uncertainties. The two tools used in this step are outlined below.

Scenario outline
According to Schwenker and Wulf (2013) and Schoemaker (1995), the overarching goal of the scenario building step is to develop four distinctive scenarios. These are derived from the interaction of the critical uncertainties and the identified trends. To develop the scenarios, the Scenario Matrix framework by Schwenker and Wulf (2013) is used, as visualised in Figure 2.7. This framework is chosen as it is an efficient and well-structures tool for development of the four scenarios through its quick and logic way (Schwenker & Wulf, 2013). The two scenario dimensions derived from the uncertainties creates the starting point of the Scenario Matrix as they are placed on the x and y axes of the framework to form the boundaries. This is also following the fifth step in Schwartz approach (1998) to set the scenario logic. The trends are placed into the matrix four quadrants and in relation to the extreme values this creates a variation in the four scenarios based upon the various interactions with each other, creating four initial scenarios. The trends included have been selected based on level of certainty and importance and are therefore included in all of the four scenarios. Four scenarios were deemed appropriate as it minimises the risk of going overboard and end up with too much unimportant data as previously mentioned. According to Schoemaker (1998) are two to four scenarios usually sufficient.

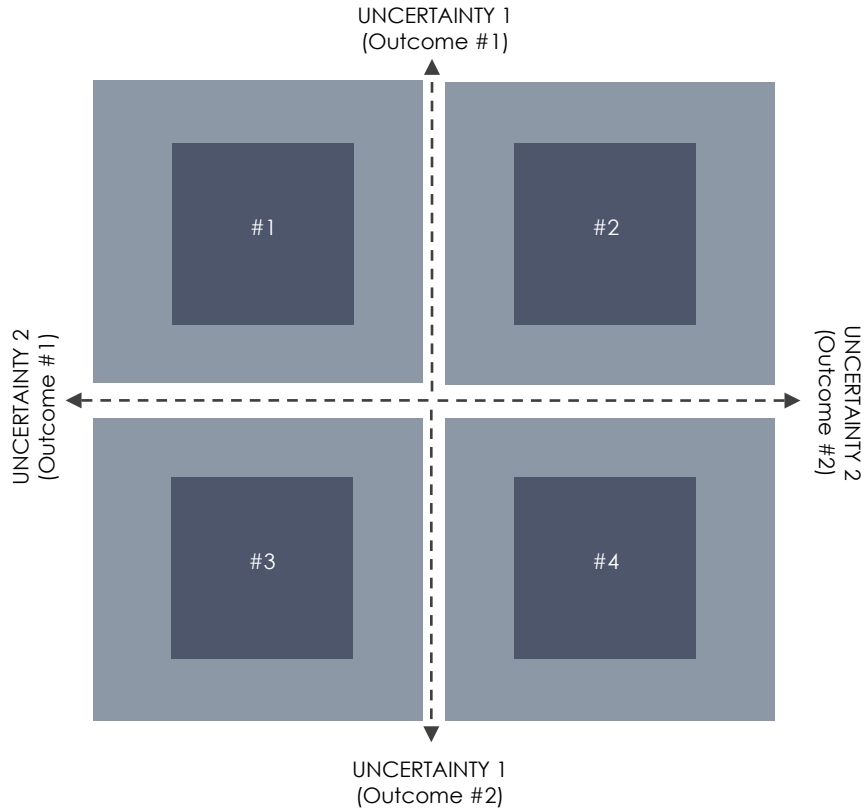


Figure 2. 7. Scenario Matrix

Scenario Storylines

From the initial scenario building a storyline should be created to ensure the variation in the different scenarios. Each scenario is a narrative and vivid description of possible future path. (Lindgren & Bandhold, 2003). Hence, this consecutive step includes the creation of scenario storylines which follows the fourth step of Schwenker and Wulf (2013) approach. Each of the four scenarios are evolved through fleshing out and adding details by the creation of compelling storylines which more thoroughly describes each of them. This is followed by naming the scenarios with names that properly create an instant understanding of the direction of the scenarios, which also goes hand in hand with the storylines.

3. METHODOLOGY

The following chapter outlines the methodology of the conducted research were actions and decisions throughout the study are described and motivated. This chapter is initiated with an overview of the structure of the methodology and the connections between the sections, visualised in figure 3.1. As visualised, the chosen research strategy and research design of the study will be outlined. Followed by the methodology for data collection and the process of analysing the data. As the scenario planning analysis is the foundation of the entire study, this research design has guided most of the decisions

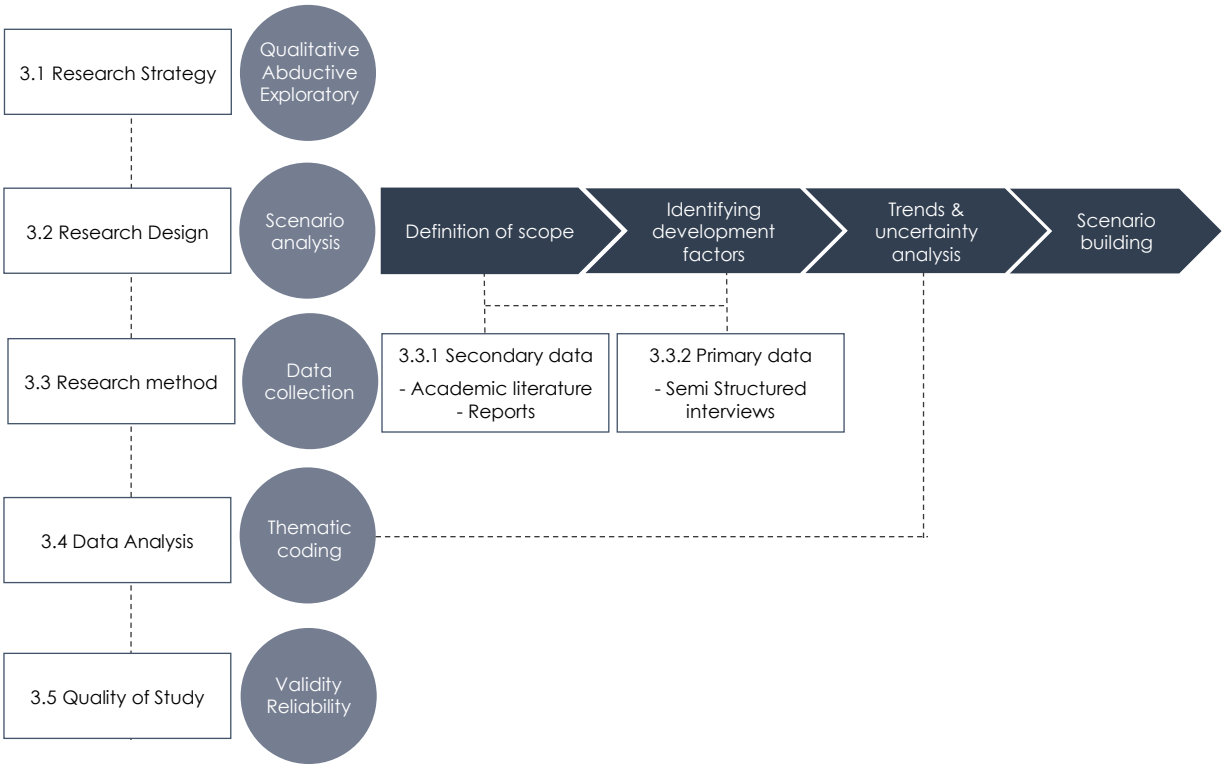


Figure 3. 1. Overview of the methodology for this study

3.1. RESEARCH STRATEGY

A qualitative research strategy accompanied by an exploratory approach was deemed suitable for the research being conducted in this study. Arguments supporting these choices are mainly the fact that the field of research is relatively unexplored, resulting in a limited data availability. Additionally, the fact that available data rests mostly on knowledge and outputs from the private sector further supports a fit with the qualitative strategy. Moreover, with regards to the unexplored field, this lack of pre-existing knowledge generates sources of uncertainty, which allows theory to emerge throughout the process of the study. Hence, the theory approach was therefore chosen to be of the abductive matter, were the authors through an iterative approach seeked to both test and build theory. This was also deemed appropriate with regards to the two phases conducted in this study, were the abductive approach allows for an iterative move between the approaches in the two different phases (Eriksson & Kovalainen, 2015). The strength of the abductive approach is that it allows for a back and-forth-engagement between the academic literature and the social world (Bryman & Bell,

2018). In addition to this, it was argued to be out of value when exploring this research topic for above reasoning.

The qualitative research strategy, and more specifically the qualitative interviews provided the opportunity for an in-depth analysis of the research field as well as an opportunity for thorough exploration. This approach allowed the authors to grasp the respondents point of view and opened up for further exploration of novel and new information. The abductive and exploratory approach guided the research design, which was chosen to be a scenario planning analysis, as outlined in the next section. (Bryman & Bell, 2018)

3.2 RESEARCH DESIGN

The research design guiding the methodology of the study was chosen not to follow one of the archetypal designs mentioned by Bryman and Bell (2018). Instead, the research design guiding the execution of the research method and analysis of the gathered data was based on a scenario planning analysis. This choice was deemed appropriate as it allowed for an intensive, deep and detailed analysis of the particular field of research, which then formed a solid base for the analysis. Moreover, with regards to the sources of uncertainties and the large amounts of available data within the chosen scope and time frame of the study, the scenario planning analysis design allowed for a systematic and orderly analysis of the uncertainties and a simplification of the sorting and prioritisation of the data in multiple steps. However, it is important to highlight that an intense research within a narrow field may risk being at the expense of a lower level of generalisability of the results of the study. This, as a trade-off between a deeper and more detailed analysis of the narrow field, and a briefer analysis with higher generalisability is evident. With this in mind, the authors made the conscious decision to grasp the opportunity to engage in a more detailed and in-depth study of the topic, and in this way answer the research questions to fulfil the scope of the study. This design further supported an effective collection of the qualitative data, where primary data was combined with secondary data in a back-and forth engagement (Bryman & Bell, 2018). Moreover, this design also allowed for a thorough analysis of the data, which will be elaborated in below sections.

On the contrary, the sole application of scenario analysis design as scientific method endures certain limitations to the results of the study which have been regarded. Scenario planning is one type of design for conducting this type of research. Other methods for environment scanning include forecasting or a quantitative approach. The researchers Mietzner and Reger (2005) outlines that for scenario planning to be valuable, deep understanding and knowledge of the topic is necessary. This as the design holds different element of intuition of the authors to endure insightful results. This has been regarded both by the authors indulging in two phases of the study which will be outlined further below and also that the study has been in collaboration with a partner firm. Moreover, certain steps of the scenario analysis have been made in collaboration with an industry expert and supervisor of the collaboration firm which provided deep insights and knowledge. Finally, it is important to emphasize that the scenario analysis design is a scientific method of conducting the research, but the scenario analysis process is a practioner-driven approach (Mietzner & Reger, 2005).

The results of this study can be considered to be more practical rather than purely scientific. With this in mind, the flexibility and opportunity it provides for adjustments in the scientific method, the opportunity of creating several plausible futures and with regards to the corporate collaboration made the authors deem the scenario planning design appropriate. The approach of the scenario planning analysis design is based on the applied scenario analysis framework which was outlined in previous section 2.2 (applied scenario analysis framework). However, the motivations for, and execution of each step from a methodology standpoint and the actual outcome will be outlined below. The steps of the applied scenario analysis framework are visualised in Figure 3.2.

Figure 3. 2. An overview of the Applied Scenario Analysis framework

The aim of the first step, definition of the scope in the scenario analysis was to form a solid and common ground for the study. The definition of the scope was based on the Framing Checklist framework. This step was carried out after the initial phase of data collection, when the authors had obtained knowledge of the topic and its present challenges, this to obtain a solid ground for the study. Moreover, the study's purpose and the research questions were defined. This step resulted in the following.

The goal of the scenario analysis was established to generate plausible future scenarios of the Platinum Group Metals evolution for the trucking industry in five years and also to generate insights in how the specific OEM can manage the future uncertainties with a focus on their level of involvement in the supply chain.

The strategic level of analysis was deemed to be at industry level. This was determined with regards to the overarching purpose of the research which aims at describing potential future scenarios for the Platinum Group Metals evolution for the entire trucking industry. However, as the second research question of this study is targeting the specific OEM, the implications of the different scenarios will be outlined from the perspective of the specific OEM.

Participants of the Scenario Analysis was deemed to be the participants of the Scenario Analysis process. The stakeholder perspective was excluded in the applied scenario analysis. However, with regard to the importance of including the right areas of expertise to generate a study with an appropriate level of credibility (Schwenker and Wulf, 2013), the authors combined the questions related to stakeholders and participants to outline the actors needed for the data collection, as well as to create an understanding of the industry structure. The stakeholders for this study was primarily decided to regard the actors in the trucking industry using PGM, which became the participants in the study.

A five-year time horizon for the scope of the scenario analysis was established, motivated by the consideration that five years was short enough to generate probable scenarios, and long enough for critical external changes to take place.

The second step of the scenario analysis, identification of developmental factors, was conducted through the data collection of this study, combining secondary data and primary data. A thematic analysis supported the identification and knowledge generation of the development factors relevant for the scope. The main tool used to select and structure the development factors, presented in chapter 5 (empirical investigation), was the STEEP-framework, which concerned the factors of Social, Technological, Economic, Environmental and Political perspectives. This choice of factors was motivated by the opportunity to include wide spanning areas which could have an impact on the industry, and to have a clear structure for the data collection and analysis. Additionally, the iterative approach of the study allowed for a flexibility where the authors could move back-and-forth between secondary and primary data collection when new topics were brought up in the literature or from the interviews. Moreover, it allowed the authors to compare the identified factors with secondary data, to benchmark the respondent's assumptions with external perceptions, to ground the developmental factors. The empirical investigation resulted in 13 development factors.

In the third step, the Trend and Uncertainty analysis, the authors made a thorough analysis of the identified development factors. This analysis was conducted in three consecutive levels of analysis. The first level of analysis determined the identified development factors impact on the focal topic. Three criteria of (1) Relevancy to scope and time frame, (2) Mentioned in literature and (3) Mentioned by experts determined the development factors impactful. Through this, 11

development factors were deemed as impactful, and qualified for further analysis in the next level of analysis. This was the categorisation and further analysis of the development factors into trends or uncertainties, were the level of certainty of the development factors outcome was guiding the sorting. The criterion of certainty was established for this step. Six development factors were deemed as trends and five were deemed as uncertainties. These were further analysed of the interconnectedness among the trends and correlation among the uncertainties respectively. The trends interconnectedness was analysed in a cross-impact analysis. For the uncertainties the framework of correlation matrix was used to identify the correlation. The final level of analysis was the uncertainty grid, which allowed for an evaluation of the trend and uncertainties through visualisation. Moreover, it supported the visualisation of potential clusters as well as the processes of selecting the two dimensions for the scenario development. The two uncertainties of new technological development and environmental sustainability was selected by the authors in collaboration with an expert within the field, based upon the impact they oppose on the industry. The two critical uncertainties created the two scenario dimensions of "Relevance of PGM as a result of new technological development" and "Sustainability focus of PGM" which will build the skeleton of the scenarios.

In the final step of the applied scenario analysis framework the scenario matrix framework was used to visualise the coalition between the selected trends and uncertainties. The four quadrants in the framework with the respective interactions of the scenario dimensions and trends were given a narrative and a name. This was carried out in collaboration with one of the expert interviewees within the field to properly set the direction of understanding. The four scenarios developed were Scenario #1 Sustainability is King, Scenario #2 Doing Good by Doing Well, Scenario #3 In it for the Ride and Scenario #4 Money Talks.

3.3 RESEARCH METHOD

The data collection process was based on both primary data- and secondary data collection. The primary data was gathered through qualitative interviews performed in two phases, an initial phase and a second phase. All secondary data for the study was gathered through reviewing literature. This process was carried out in parallel with both phases of primary data collection to ensure that the exploratory approach was applied and to broaden and deepen the empirical investigation. This approach was consistent with the abductive research strategy, where the researchers considered it to be valuable to move back-and-forth between interviews and literature to capture multiple aspects of the topic.

As the research design for this study was a scenario analysis, the primary and secondary data was the foundation of the second step "*Identifying development factors*". In accordance with the research design described in the applied scenario analysis framework, the main tool used to identify and structure the data was through the STEEP-framework. This further guided the primary data collection and the secondary data collection.

3.3.1 SECONDARY DATA

The research design used for this study was, as mentioned, a scenario analysis, looking into a rather unexplored research field. Hence, the need for secondary data for the study was considered to be dual. First, due to the exploratory nature of this study, the secondary data was used to guide and steer the primary data collection. This as the findings in literature supported and extended the understanding of the research field. Consequently, this contributed to finding an appropriate scope for the study and added value in the knowledge exchange during the interviews conducted in both phases. Second, the data obtained from the literature was used to support the analysis of the PGM evolution in which the development factors were grounded, to help answer the research questions (Saunders, Lewis & Thornhill 2009). Hence, the secondary data gathered for this study also outlined the characteristics of the overall PGM market, PGM in the trucking industry and the developmental factors influencing the evolution of PGM in the trucking industry.

To simplify the process of gathering secondary data and to provide a high level of transparency to enhance external reliability, predetermined steps were guiding the process of

reviewing literature. By developing and following these steps throughout the whole study, a systematic gathering and evaluation of the secondary data was carried out. The review was conducted in following consecutive stages;

Defining the review objectives: A central component of the review of literature, was to define objectives. The goals for the scenario analysis are included in the first step of the applied scenario analysis framework, as outlined in section 3.2 (research design) and the alignment of the review objective and the scenario analysis objectives was important to ensure that the composed literature was consequent with the purpose of the study. This was carried out before initiating the search process.

Operationalising the review: To further simplify the process of gathering and selecting relevant literature and to provide both a high level of transparency and quality, a set of inclusion and exclusion criteria were formulated, as visualised in Figure 3.3. As there is no easy way to verify that secondary data is of high quality (Saunders, et. al., 2009), these criteria ensure that the secondary data sources included in this study have been carefully evaluated and chosen. The criteria include different factors setting the frame for the literature review.

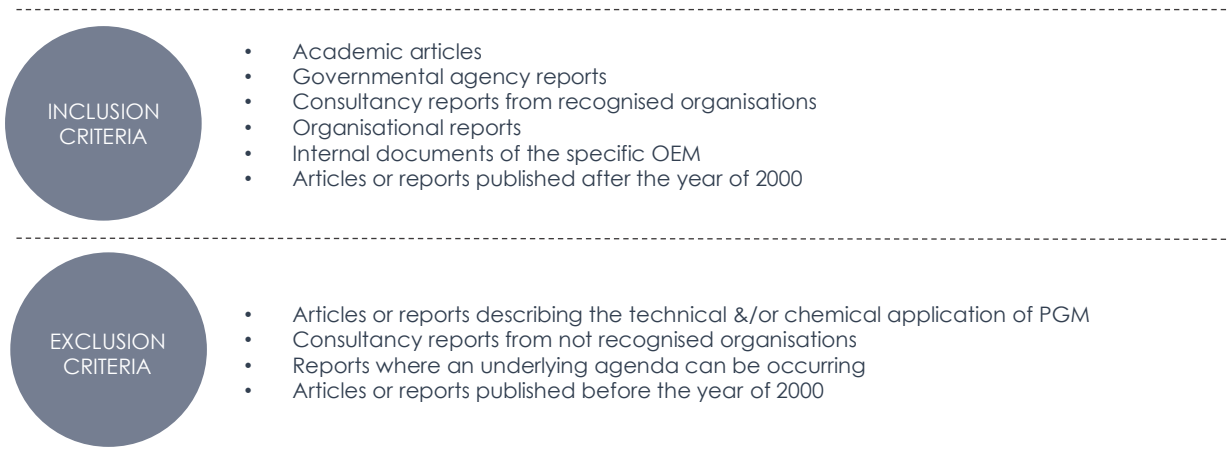


Figure 3. 3. Inclusion and exclusion criteria for secondary data gathering

Finding and selecting articles: When finding and selecting the literature used as secondary data, several databases such as the library of Gothenburg's own search function, Google Scholar, Emerald Insights, and others were used. These were deemed suitable based on their field of focus, the range and quality of content. Additionally, with regards to the unexplored nature of the scope, literature stemming from other platforms was deemed important to fulfil the purpose of the study. Hence, the literature search was extended to include reputable consultancy web pages such as McKinsey and Bain & Co, governmental agencies such as European Commission and International Monetary Fund and other organisations, such as large OEMs and PGM fabricators. To target literature that could provide value and support the purpose of the study, an iterative approach was applied, and the search was carried out in parallel with the primary data collection, adapting the search terms and key words to the specific area of interest. For example, initial search terms included keywords such as "Platinum, Palladium, Rhodium in combination with market evolution, application areas, development, price, demand, supply, etc". Further targeted searches included keywords such as "Mining of PGM, Social sustainability of PGM, Recycling process of PGM, Covid-19, Fuel cell electric vehicles". The authors found that the secondary data used for the literature review was primarily based on reports from different organisations and consultancy reports.

3.3.2 PRIMARY DATA

The method for collecting primary data for this study was based on semi-structured, qualitative interviews with different actors related to PGM. This to obtain valuable data for the purpose of

the research. In total, eight experts were interviewed during ten different occasions. The selection of the respondents will be discussed in detail in section 3.3.2.1 (selection of respondents). The interviews were performed in two steps, through an initial phase and a second phase, were one expert was only interviewed in the initial phase, two actors were interviewed in both phases and five actors were only interviewed in the second phase, see Table 1 for an overview. All interviews conducted were semi-structured, to different extent.

The initial phase interviews aimed at exploring the research topic and obtaining as much insights and knowledge as possible to set the scope of the study and to identify the areas where additional data was need. Thus, the character of the semi-structured interviews supported the exploratory approach with open ended questions (Saunders, et. al., 2009). No interview guide was used, but rather predetermined topics related to PGM and a request of the interviewees to elaborate further and provide their perspectives. For this initial phase, three respondents considered to have broad insights and expertise knowledge of PGM within the trucking industry were included. No limit was set for how many respondents that should be included in the initial phase of data collection, instead the authors applied the exploratory approach where the nature and quality of the findings from this phase constituted the limit. The information obtained from these interviews with the three different respondents was deemed to fulfil the purpose of this phase, generating increased knowledge and understanding of the scope and research field. Moreover, generating broad insights regarding what potential external development factors that could be further examined for the research. Hence, these interviews grounded the base for further research and supported the efforts of the gathering of additional primary data and secondary data.

This was deemed important for the second phase of interviews where the combination of primary data collection from the initial phase of interviews and secondary data from literature guided further exploration of the topic. An interview guide was used during the semi-structured interviews. Moreover, the second phase interviews further aimed to cover all areas of the STEEP-framework, which will be further outlined in section 3.3.2.1 (selection of respondents). This approach allowed for in-depth and focused interviews in this phase, with interviewees chosen due to their competence in the areas of interest for the study. Thus, providing additional perspectives and deeper knowledge for several areas. In the second phase seven respondents were interviewed. Additionally, these second interviews provided opportunities for the authors to once again return to the literature, if topics, insights or perspectives were added.

3.3.2.1 SELECTION OF RESPONDENTS

The exploratory research strategy made the selection process of respondents in both the initial and second phase of the interviews central for fulfilling the purpose of the study. The competence and knowledge of all respondents were key for gathering valuable insights upon which the scenario analysis was based. Hence, the respondents were selected based on their connection to- and knowledge of the different topics explored, such as the PGM market, the sustainability aspect, purchasing competence, raw material competence and technological knowhow. All interview respondents, their expertise area, and details regarding the interview is visualised in Table 1.

It was deemed essential that the respondents in the initial phase could provide a general and broad perspective on the topic, setting an appropriate frame for the study and guiding the authors in further investigations. Thus, starting with the supervisor for the study at the specific OEM, and further adding respondents considered to have a broad insights and expertise knowledge of PGM in the trucking market until the purpose of the initial phase was deemed fulfilled. A purposive sampling using the supervisor at the specific OEM to target actors with this expertise was considered to be valuable for the study. This as purposive sampling is strategic to find respondents who could contribute to answering the research questions (Bryman & Bell, 2018). This sampling strategy was deemed appropriate due to the large network of the supervisor, having access to respondents with the appropriate knowledge. Moreover, as the authors in the initial phase had limited knowledge of the research field, the guidance from the supervisor at the specific OEM was of importance. In total three respondents represented this phase of primary data collection.

For the second phase it was essential to find respondents with the specific competences and expertise needed to extend the knowledge in certain areas targeted in the initial phase and through the secondary data collection. Moreover, as the research design follows the scenario planning approach and the data collection is guided by the STEEP-framework this was also an important aspect to consider, this to obtain a broad perspective and to not overlook any area that could provide value for the study. Hence, finding respondents with insights and expertise in all areas of the STEEP-framework was guiding the selection of respondents. Similar to the initial phase, was the selection of respondents primarily established through a purposive sampling. This as the sampling was strategic to find respondents that could best help answering the research questions (Bryman & Bell, 2018). Hence the respondents were primarily identified in collaboration with the supervisor of the specific OEM. However, some respondents suggested other valuable contacts within their network, adding an element of snowball sampling. Which is described as the process where contact is established with new respondents through earlier identified respondents (Bryman & Bell, 2018). This additional sampling strategy was also deemed appropriate due to the large network of the supervisor and the other respondents, as well as the rather narrow time frame of this study. The disadvantage of primarily using the network of the supervisor was considered to endure the risk of similar perspectives among respondents potentially working in the same organisation. However, as the selection seeked to find respondents with expertise knowledge in different areas this contradicts this notion. Furthermore, the selection of respondents included actors outside of the specific OEM as well, to nuance the research and to gain additional perspectives and insights.

However, uncontrollable events in the external environment, namely the Covid-19 pandemic, influenced the outcome in regard to the participation rate of the study. Selecting respondents that could provide insights and expertise in all areas of the STEEP-framework, having knowledge of PGM in the trucking industry related to social factors, technological factors, economic factors, environmental factors or political factors was the initial approach in the selection process. In the identification processes, carried out with the supervisor at the OEM, respondents that could contribute to each of these aspects were mapped and approached, with the objective of including at least one expert in each area to generate a thorough and solid base for the empirical investigation. Both including actors within the specific OEM and actors from other organisations. For most areas, multiple respondents were included. Some of the respondents selected through the purposive sampling was considered to have knowledge and expertise insights in areas spanning over several factors and some more niched knowledge and expertise related to one of the areas of the STEEP-framework. However, as mentioned, due to the Covid-19 pandemic all planned interviews could not be carried out which affected the overall participation rate for this study. All areas were affected to different extent and some areas of interest, more specifically the area of technology, was deeply affected by this. However, as some respondents was considered to have knowledge and expertise insights in areas spanning over several fields, the primary data collection process still covers all factors in the STEEP-framework more or less. Additionally, secondary data for all factors have been included to capture the development factors with an extended focus towards the areas most affected. In total seven respondents represented the second phase of secondary data collection.

Table 3. 1. Summary of interview respondents and interview process

COMPETENCE AREA	REFERRED TO AS	PHASE OF RESEARCH	DATE & DURATION	CHARACTER
PGM Market expertise	Interviewee A	Initial phase Second phase	06-01-2020 30 min 18-02-2020 60 min	Skype Face-to-face Gothenburg
PGM Procurement expertise	Interviewee B	Initial phase Second phase	16-12-2020 30 min 20-03-2020 30 min	Skype Skype
PGM Raw material expertise	Interviewee C	Initial phase	20-02-2020 60 min	Face-to-face Gothenburg
Procurement expertise	Interviewee D	Second phase	09-03-2020 30 min	Face-to-face Gothenburg
PGM Raw material expertise	Interviewee E	Second phase	10-03-2020 60 min	Skype Gothenburg
Sustainability expertise	Interviewee F	Second phase	11-03-2020 60 min	Face-to-face Gothenburg
PGM Market expertise	Interviewee G	Second phase	03-03-2020 90 min	Face-to-face Gothenburg
PGM Market expertise	Interviewee H	Second phase	26-03-2020 80 min	Skype Gothenburg

3.3.2.2 INTERVIEW GUIDE

The semi-structured interviews performed in the second phase of the study, were based on an interview guide with predetermined, but relatively open questions. This in order to steer the interview in the desired direction (Saunders, et. al., 2009; Bryman & Bell, 2018).

As a part of the interview process, the interview guide was used to structure the order of the questions being asked as well as to guide the interview and ensure that all topics of interest were included and answered. This as the interview guide is considered as an important tool to enable desired flexibility while keeping an appropriate level of structure for the data to be comparable (Bryman & Bell, 2018). For the purpose of these interviews, identifying development factors impacting the PGM evolution for the trucking industry, it was important to balance the structure and flexibility to obtain focused and insightful information. As the data collection in the second phase interviews were deemed to cover different areas of expertise, based on the STEEP-framework, the comparability of the answers was not a priority when creating the interview guide. Instead, the flexibility was valued because of the exploratory nature of this research.

When developing the interview guide for the second phase interviews, insights from the first phase interviews were combined with findings from secondary data to serve as the base. From these findings the authors obtained an understanding of which areas that required further research as well as which areas that had not yet been explored. Hence, questions in an open-ended format were formulated to cover all of these areas and a predetermined sequence were set. This in order to access their individual perspective and insights and to allow the respondents to reply freely. The semi-structured format allows for predetermined topics to be covered and additionally focus on the order of questions asked. Moreover, semi-structured interviews allowed for a relatively high degree of flexibility where respondents can speak freely and elaborate on topics of their choice, which is not possible if conducting a structured interview (Bryman & Bell, 2018). Selecting a semi-structured format for the interviews was considered appropriate with regards to the exploratory nature of the study, where the future of the metals is considered uncertain, which created a possibility for new information to be discussed. Additionally, since the study aimed at examining the future scenarios to guide future recommendations for PGM, a certain degree of structure in order to collect information and

insights that could fulfil the purpose of the study was needed. The interviews were of qualitative character which was deemed appropriate to answer research questions and thereby fulfil the purpose of the research. This, due to the in-depth analysis and several dimensions that can be covered from such data collection (Bryman & Bell, 2018).

The same interview guide, displayed in Appendix B, has been used for all interviews. However, it has been adapted and customised for the different areas of expertise by solely including relevant questions and excluding questions outside of the scope of that specific interview. By using the same interview guide, the authors could display a high level of transparency, since it had been disclosed. Moreover, this approach allowed for a timely and effective way of operationalising the interview process.

The interview guide included a short description of the topic and intentions of the research as well as a short presentation of the interview procedure. This was read to each respondent prior to the interview. This part of the interview guide was considered important to ensure that the respondent felt included and had a sense of understanding of the overall research. By ensuring this, more focused and precise answers was retrieved. The first interview questions were of a more general character and concerned the interviewee. This was followed by in-depth questions of the PGM and their area of expertise. Lastly, the possibility for follow up questions and in-depth discussion of additional topics that were brought up during the interview concluded the interview guide.

3.3.2.3 INTERVIEW PROCESS

Starting the interview process, the first step was the initial contact with the potential respondents. All respondents that had been identified as relevant for the data collection were primarily contacted by email. This initial contact was either initiated directly by the authors or indirectly by the supervisor of the specific OEM. The different approaches were dependent on the respondents, where actors within the specific OEM were considered as easy to approach and having a high interest in participating, and actors from other organisations were considered to be more dependent on the network and status of the person initiating contact. This can further be explained by the different levels of commitment to the study from the perspective of the respondents, where internal actors are major stakeholders with a high degree of involvement and the external actors have a lower degree of direct involvement.

All potential respondents contacted directly by the authors followed a predetermined email template, introducing the authors, the topic and purpose of the research and in what way the respondents could contribute to the thesis. This email was also sent to the potential respondents contacted by the supervisor of the specific OEM. However, it was sent at a later stage, after the initial contact was already initiated. The template has been attached in Appendix C. Furthermore, all respondents were contacted approximately one week before the scheduled interview date, where an overview of the topics included in the interview guides were sent out. This in order to give the respondents an opportunity to prepare for the interview. However, the reason for sending an overview, and not sending the complete list of questions, was to ensure that the respondents answers were not in any way framed. This was considered to be important since the objective of the primary data collection aims to capture the respondents' own perspectives, knowledge and insights of the topic.

When conducting the interviews, face to face, was the preferred format. This because meeting in person is considered to both generate a higher personal engagement from the respondent and also to increase the understanding and interpretation of the conversation. Moreover, face to face interaction allows for a more nuanced conversation. (Bryman & Bell, 2018). However, as interviews is a time-consuming process for both the respondents and the authors (Saunders, Lewis and Thornhill, 2009), other communication tools such as video-calls was used if preferred by the respondents. However, despite the preferred format, a low number of face to face interviews were conducted. This was mainly due to geographical distance, time and resource limitations from the respondents' side and the Covid-19 pandemic, limiting physical meetings. Through using additional communication tools, this allowed the researchers to speed up the data collection process (Saunders, et. al., 2009).

All interviews were recorded after granted consent by the respondent, to avoid the risk of information loss. Moreover, the recording facilitated the transcription process, data analysis and also allowed the authors to validate statements made by respondents. In addition, taking notes of important insights and knowledge during the interviews facilitate follow up questions and to refer back to specific interesting topics during the interviews.

The interview guide described in previous section was used during the second phase interview, setting the frame of the interview and guiding the questions. For the first phase interviews the interviews were guided by pre-determined topics. Following all interviews, the recording was used for the transcription process and the interviews were transcribed in full. This was deemed important as it enabled the data analysis process. The process of transcribing the interviews was initiated and conducted in parallel with the ongoing interviews. Which allowed the authors to profoundly comprehend the information obtained during the interviews to potentially further explore topics in consequent interviews. After conducting and transcribing all interviews, a summary of the interview was sent to the respondent for control, i.e. a respondent validation was carried out. By doing so the risk that the author's subjective views and perspective along with interpretation of the interview could mislead the data decreases. Moreover, by enabling the respondents to control the data and confirm that it was correctly interpreted, is increasing the authenticity and credibility of the data (Bryman and Bell, 2018).

3.4 DATA ANALYSIS

The analysis of data in this study followed a process of first preparing the gathered data and then conducting a thematic analysis. The initial step in this process was the breakdown of raw data. The transcription process was essential to support this as it transforms the data into a manageable form and prepare it for further analysis (Bryman & Bell, 2018). As previously discussed, all interviews were fully transcribed, and this process ensured that no data was excluded from the analysis. This enabled a comprehensive analysis, essential for the exploratory nature of the study. Additional advantages of fully transcribing the interviews was that it ensured an unbiased approach by the authors. Moreover, both authors transcribed the interviews first separately, to ensure a consistent interpretation to increase the internal validity of the study. To generate a high degree of objectivity in the study, all data was included and analysed. Thus, minimising a biased selection of which data that could be considered as important or not. Following the breakdown of raw data through the transcription process, the thematic analysis was used as the main analysis tool. The thematic analysis tool is often used for qualitative data (Bryman & Bell, 2018), which correspond to the nature of the data collected for this study. Qualitative data such as interviews, may be more complicated to analyse compared to quantitative data. This is due to the lower degree of structure compared to quantitative studies (Bryman & Bell 2018). However, the methodology of thematic analysis provided a structured and uncomplicated way of operationalising the analysis of qualitative data, which was considered as one of the major advantages. The potential challenges of thematic analysis relate to objectivity and accuracy. As the data is analysed, coded and categorised into themes by the researches, this constitutes a risk of subjectivity and a risk of losing important insights. To manage this challenge, the authors used both secondary data and primary data for the empirical investigation, in an iterative approach. Thus, returning to interview transcriptions for further analysis if needed.

Regarding the practical application of thematic analysis for this study, predetermined- and emerging themes was applied. This as the data analysis was carried out in two steps. A thematic analysis can be carried out in different ways depending on how the data is coded. Either through predetermined codes, formed by for example the theoretical framework, or through emerging codes, which means that the patterns emerge from the data. As the STEEP-framework aimed at structuring the data collection and ensured that a broad perspective was applied, the first step of the data analysis was to code the data according to the framework. Thus, sorting and categorising all data into social, technological, economic, environmental or political factors. The second step of the data analysis was to find emerging patterns within the predetermined themes, this to identify development factors. Since the study is of exploratory character with an iterative approach, this step of the analysis aimed at capturing all valuable information and insights to provide building blocks for the scenario analysis and ultimately fulfilling the purpose of the study. With this in mind, the second step of the data analysis also

included data not coherent with any of the predetermined themes. Thus, finding additional themes not part of the STEEP-framework and managing the challenge of subjectivity and accuracy. As an example of such, the theme of level of involvement in the supply chain emerged from the interviews. See Appendix D for an example of how the thematic analysis has been carried out. This process was deemed suitable as it allowed the authors to incorporate both the deductive and inductive approach in the process of data analysis as is one of the advantages with the abductive research strategy.

3.5 RESEARCH QUALITY

To ensure a sufficient quality level of the research in this study, the entire research process was evaluated through the two concepts of validity and reliability. Both of which was deemed suitable with regards to the qualitative strategy and the chosen scenario planning design. Combined, both concepts ensure transparency and insights in the study which is based on a certain level of objectivity. (Bryman & Bell, 2018) To ensure the quality of the study, the measures taken to retrieve validity and reliability will be further discussed in below sections.

3.5.1 VALIDITY & RELIABILITY

Research validity refers to the quality of the conclusions of the research and was enhanced through measures ensuring both internal and external validity. Internal validity to ensure a proper match between the observations and the emergence of the theoretical ideas (Bryman & Bell, 2018), which in this study is the match between the empirical findings and the results of the scenario building. External validity refers to the generalisability of the case study to the mass, however, as generalisability is not the primary purpose of the study, less emphasis is put on this. Internal validity was enhanced through the presence and participation of both authors during all of the parts of the conducted study. Both authors were present during all interviews, transcribed all of the interviews separately and subsequently collaboratively analysed the data. The transcriptions of the interviews were also emailed to the interviewees for validation. Additionally, consistency of the findings was ensured through the data collection methods. The external reliability was not emphasised in this study as the authors deemed it more suitable to engage in a more in-depth analysis within this narrow and specific research field, in order to not only scratch the surface. Hence, the external validity was secondary since purpose of the study is to generate insights for the specific actor and not generalise the results to the mass.

Research reliability refers to the degree of which the study can be replicated with similar obtained results (Bryman & Bell, 2018). The qualitative research strategy is in itself brings less structure to the study which had the follow effects that the authors of this study had to take on a strategy to ensure a certain degree of structure in the flexible approach. This was made with the aim of increasing the level of replicability, referred to as external reliability. This in combination to establishing an inter-observer consistency so that both of the authors conducting the study agree upon the observations and theoretical emergence. The internal reliability was enhanced through the study by having a detailed and clearly presented methodology. Moreover, the authors have seeked to describe for the rationale behind the decisions taken. The second aspect of reliability was external reliability, which was enhanced through the measures taken to provide a certain level of structure in the conducted study. Analysis material and the interview guide is presented in full in the appendix (Appendix B). However, it is important to highlight the fact that the narrow field of the research topic along with the nature of the scenario planning design and research which invites to intuition, made it difficult to generalise the result. Moreover, the rapidly changing business environment along with the short time frame of the conducted study creates results which are generalisable within the same time frame and with the specific context.

4. EMPIRICAL SETTING

The following chapter outlines the empirical setting for this study, with the purpose of introducing and creating an initial understanding of the research field. The chapter is initiated with an overview of the platinum group metals, the application areas and mining locations and a presentation of the foundation of the entire industry. This is followed by extended focus on PGM within the automotive industry, presenting the actors on the market, outlining the material flow, and establishing the most common set ups for purchasing PGM. This part will support the analysis of how the specific OEM can handle the future uncertainties in terms of involvement in the supply chain, guided by the second research question of this study. Moreover, this chapter is based on the both primary and secondary data collection.

4.1 PGM OVERVIEW

The platinum group metals is the six member family group of the rare and precious chemicals; platinum, palladium, rhodium, iridium, osmium and ruthenium. These are commonly referred to as solely PGM. These metals have been made an important part in the modern eras advanced chemistry and modern technologies. (Sverdrup & Ragnarsdottir, 2016) The metals have a wide spread of application areas raising from their chemical and physical properties of purity, catalytic properties, high melting points and resistance to tarnish. Properties making the metals an important part in industrial and end-consumer products. (Gunn, 2014) The major application areas of the metals are primarily within the automotive industry, in jewellery, industrial processes, the electronic industry and investments. Within the automotive industry, the specific chemicals of platinum, palladium and rhodium are the most important due to their application in the vehicles exhaust after treatment systems (EATS). Here the metals are reducing the toxic gas emissions. Moreover, PGM are used in fuel cells for generating electric power. As this study focuses on one of the segments of the automotive industry, namely the trucking industry, the metals analysed in following chapters are platinum, palladium and rhodium as the other are deemed as beyond the scope of the research. Lastly, the metals are traded and invested in exchange funds and in bars and ingots. The wide application areas create an increasing demand in the growing economy. (Johnson Matthey, n.d.a)

The precious metals exist concentrated in deposits in the metallic core of earth. These are mined from deposits primarily in the Bushveld complex in South Africa, Norilsk-Talnakh districts in Russia, the Northern Americas of Sudbury Basin, Canada and the Stillwater Complex in Montana, US. Finally, in the district of Dyke in Zimbabwe, as visualised in Figure 4.1. The bulk production of the metals is mined in South Africa. The rarity of the deposits makes the precious metals considered a scarce resource. (Johnson Matthey, n.d.a) The metals are mined from the deposits through underground mining and open-pit, primarily through human labour and mechanically. The process of producing pure metals include several processes post mining to separate the base metals such as nickel and copper from the platinum group metals. This is achieved through processes of refining, roasting, smelting and converting, to mention a few, in order to extrapolate the pure metals. (Gunn, 2014)

Figure 4. 1. Location of PGM Mining (Based on Gunn, 2014)

4.2 PGM WITHIN THE TRUCKING INDUSTRY

PGM are used in the EATS in vehicles to clean the harmful gas emissions. The automotive sector is the largest consumer of the metals of platinum, palladium and rhodium with approximately 70 percent of the gross demand (JM, 2019). More specifically, PGM is used in the autocatalyst, a cylinder made from either metal or ceramic. The inside is formed as a honeycomb which is coated with a solution of PGM and chemicals. This part is mounted inside a stainless-steel canister. It is the entire assembly of the autocatalysts and the steel canister, which is referred to as the catalytic converter, which is visualised in Figure 4.2. This is placed in vehicles exhaust line, between the silencer and the engine. The PGM reduce the toxic pollutants of carbon monoxide, oxides of nitrogen, hydrocarbons and particulate, which are the gas emissions that contributes both to acid rain, smog formation, smell and cancer-causing compounds. The solution of chemicals and the metals effectively convert over 90 percent of the gas emissions in the catalytic converter into primarily water and therefore serves to improve the air quality and reduce the carbon footprint. The technological advancements heavily impact the usage of the metals. (Johnson Matthey, n.d.b)

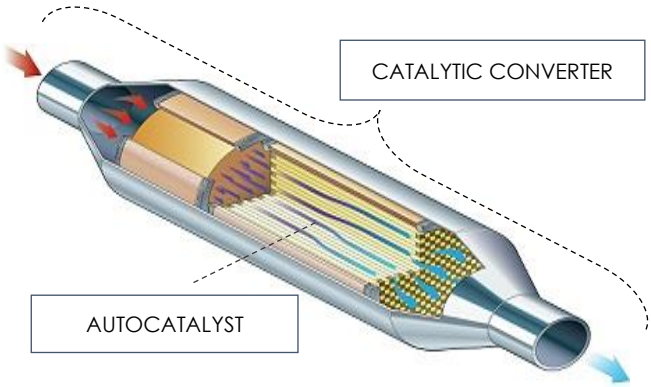


Figure 4. 2. Catalytic converter (Based on JM, n.d.b)

Looking into the PGM material flow for autocatalysts, multiple actors are involved. As visualised in Figure 4.3, PGM can be supplied from different sources, this will be further elaborated on below. The process of transforming the raw material into an assembled component in the EATS include PGM fabricators, Canister manufacturer and the OEM. Naturally, other suppliers are involved in the process, however, these are the main actors handling the PGM.

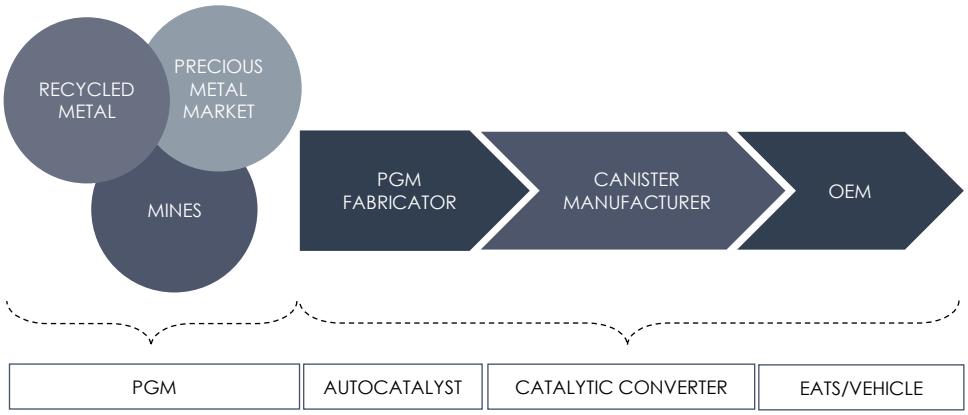


Figure 4. 3. Material flow of PGM

The raw material can be supplied through primarily three different sources. Virgin material directly from the mines, supplied as recycled PGM or through traders that have invested in PGM and own stocks. In 2018, the proportion of recycled material constituted approximately 30 percent of the total supply for platinum, palladium and rhodium (JM, 2019). Information regarding the proportion of which is owned by trading organisations differ from day to day. However, their stock is included in the supply from the mines or recycled materials.

When looking into the PGM fabricators that are producing the autocatalysts, there are three organisations working with this, Johnson & Matthews, BASF and Umicore. Furthermore, Johnson & Matthews and Umicore also have a market presence as recycling actor for PGM, extending their role in the material flow to also act as PGM supplier. There are multiple organisations working with the canning process, mounting the autocatalysts into a catalytic converter, such as Eberspächer, Boysen and Termeco. As for the final part of the material flow of PGM, there are several OEM actors manufacturing the trucks, such as Daimler trucks, Volvo Group and truck manufacturers from emerging markets. (Interviewee G, 2020)

Shifting focus from the material flow to the business relations and contractual agreements in the supply chain of PGM in the trucking industry, the complexity is magnified. As mentioned, there are several suppliers of the raw material and the PGM fabricator can also be a PGM supplier if they engage in recycling activities. However, the process of purchasing raw material of platinum, palladium or rhodium is fairly simple. As these precious metals are traded, there is an index price guiding the sales of PGM. Hence, the raw material can be purchased by any organisation or individual, either at a spot price per ounce or through structured agreements. For the trucking industry, the purchase of raw material is usually carried out by either the OEM, the PGM fabricator as it is the first part processing the PGM in the material flow, or through other setups involving a third party. (Interviewee G, 2020; Interviewee H, 2020) The purchasing process, and the role of the OEM will be further elaborated in 4.1.2 (Level of involvement in the supply chain).

Even though the PGM fabricator and the Canister manufacturer are directly connected in regard to the material flow of the PGM, there is usually no commercial agreements between these actors. Hence, they are not conducting business with each other, but solely providing different parts of the catalytic converter to the OEM. Their relation is usually bound by a logistics agreement, coordinating and regulating the material flow as directed by the OEM. It is the OEM that usually hold the commercial agreement with both the PGM fabricator and the Canister manufacturer. Hence, the OEM is the actor coordinating the process of transforming the raw material of PGM into a component assembled in the EATS, holding the business

relations with the PGM fabricator and the Canister manufacturer. (Interviewee G, 2020; Interviewee H, 2020) This is visualised in Figure 4.4.

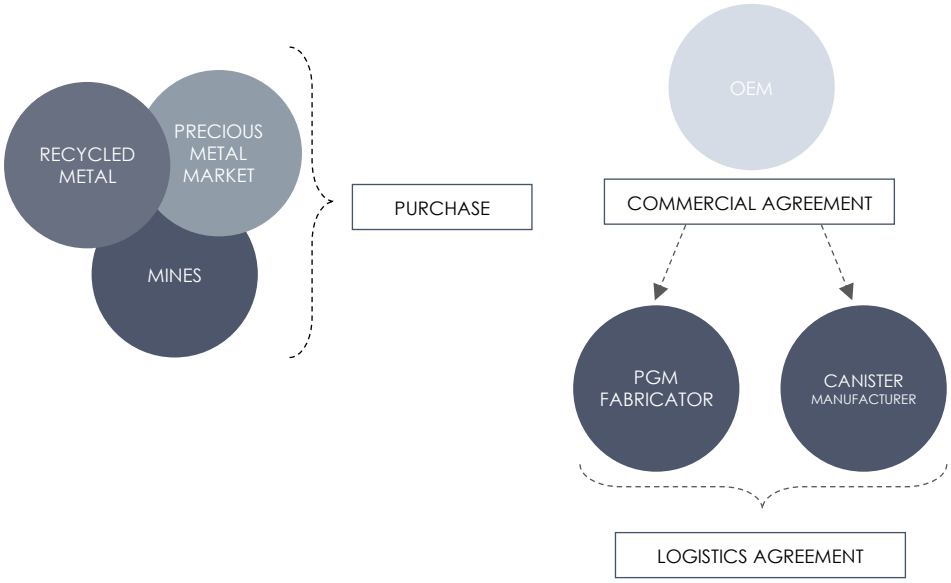


Figure 4. 4. Business relationships between actors in the supply chain of PGM

4.2.1 LEVEL OF INVOLVEMENT IN THE SUPPLY CHAIN

The OEM is as described the main coordinating part in the PGM supply chain for EATS, holding the commercial agreement with both the PGM fabricator and the Canister manufacturer. However, the commercial agreements between the OEM and PGM fabricator can provide different levels of involvement in the upstream supply chain, i.e. the level of involvement in the purchase of the raw materials. The purchasing process can be carried out by the OEM, the PGM fabricator, or through other setups involving a third party. Hence, the commercial agreement between the OEM and the PGM fabricator may include that the PGM fabricator is the actor purchasing raw material, resulting in a lower level of involvement in the supply chain for the OEM. Alternatively, it can exclude this activity, resulting in a higher level of involvement in the supply chain for the OEM, as they coordinate and perform this process by themselves. These two alternatives are according to Interviewee G, PGM market expert and Interviewee H, PGM market expert the most common, referred to as "direct buy", where the OEM purchase the raw material themselves or the "consignment model", where the PGM fabricator purchase the raw material as a part of the commercial agreement with the OEM. The different models require different setups and bring different opportunities and challenges for the OEM. This will be further outlined in the following section.

Starting with the purchasing model of direct buy, the OEM is responsible for the acquisition of the PGM themselves, purchasing directly from the mines, traders or from one of the PGM fabrication organisations that recycle PGM. As the OEM secures the supply needed for the catalysts demand, they thereafter provide the material to the actors holding the commercial agreement for the following processes (one of the PGM fabricators). The OEM are thereby charged only by the work carried out by the PGM fabricator and the Canister manufacturer.

In this setup the purchase of PGM is carried out internally at the OEM. This function could according to Interviewee E, raw material expert, Interviewee B, PGM procurement expert and Interviewee H be a part of an existing raw material purchasing team, by setting up an account at the PGM fabricator, or be a separate trading function. However, this setup requires capabilities for purchasing the PGM directly, which are to be considered as specific and not connected to the main product. According to Interviewee H, the level of involvement in the purchasing process can be adapted to the organisation's objectives. If the goal is to simply secure the supply without taking major risks, no substantial resources are needed. However, there is also an opportunity to closely monitor the market evolution to actively make smart

business decisions, such as purchase PGM when price levels are low. This in turn would require more resources. Additionally, smart business decisions, can according to Interviewee E include that the OEM can take advantage of speculative aspect on the market, bundle the market power, and thereby influence the risk. Which was also indirectly mentioned by Interviewee H, in relation to the commitment level of the OEM.

This purchasing model is according to Interviewee B, Interviewee G and Interviewee H cost effective as the cost of the EATS are majorly influenced by the prices of the PGM. Apart from this, Interviewee B describes administrative saving, as this setup would increase the access to information. Additionally, this purchasing deal offers a potentially higher amount of risk, however, may offer greater insight into the PGM market and the supply chain, which according to Interviewee E could be beneficial for sustainability. This is agreed on by Interviewee B who state that;

"We would get closer to the actors and could with pride monitor the sustainability aspect of PGM." - Interviewee B

The second purchasing model, the consignment model, is based on outsourcing the procurement of the raw material. The PGM fabricator which the OEM have the commercial agreement with, takes care of ensuring the supply of the metals. Hence, the OEM provide the PGM fabricator with a demand forecast based on the demand planning information over the next coming months. The PGM fabricator purchase the raw material needed to meet the demand to the days set index price. The OEM will be charged with the index price for the day of the delivery and an additional agency fee, covering the work and the risk of the PGM fabricator. Interviewee B describes this setup as a passive approach from the perspective of the OEM, which is illustrated by this citation,

"It's kind of like a tennis game, we are sitting on the sideline, not participating in the game, but just watching." - Interviewee B

However, according to Interviewee B and Interviewee E, this benefit the OEM through long payment periods (based on the agreement between OEM and PGM fabricator) and through a low level of involvement, hence not requiring any internal capabilities and processes. Interviewee E also argue that it is important to find a balance between what core capabilities and focus the OEM should have and what benefits that can be provided through shifting focus.

"This is basically a matter of strategy. We are a large organisation, what should we be good at? Do we want to be good at producing trucks or do we want to be good at trading material? What is our core competence?" -Interviewee E

When discussing the future setup of PGM, Interviewee D, procurement expert, mention aspects such as costs, competence, practical feasibility and potential savings. Similarly, Interviewee E highlights the importance of analysing financial numbers when deciding the setup for PGM. Interviewee B also mention these aspects, expressing that this is a business case (i.e. a case where costs and benefits should be compared). However, adding that sustainability, ecodesign and remanufacturing is important for their organisation in all areas. Interviewee B elaborate on the sustainability aspect for PGM, where clarity on the sustainability actions taken within PGM is needed. Both the aspect of social sustainability as well as the environmental aspect.

5. EMPIRICAL INVESTIGATION

The following chapter outlines the empirical investigation of this study. This is based on the findings of both the primary and secondary data collection. The chapter is initiated with an introductory overview of the identified development factors presented in a table, structured in accordance with the STEEP-framework. Following this, data relating to the respective factor is outlined more thoroughly were primary data and secondary data is presented in alternation.

5.1 DESCRIPTION OF DEVELOPMENT FACTORS

This chapter lay the foundation for the second step of the applied scenario analysis framework, "*Identifying development factors*" which will be developed in the coming sections. This step aims at finding and describing changes in the external and internal environment that will impact on the focal topic following the outside-in approach. The identification of development factors is based on the data gathered for this study, including both secondary data and primary data from the first, and second phase, as described in section 3.3 (Data collection).

Visualised in Table 5.1 is an overview of the development factors which has been identified through the empirical investigation. To retrieve a broad perspective, spanning over multiple fields and to organise the collection and description of the data, a framework has been used. The STEEP-framework with the categories; Social factors, Technological factors, Economic factors, Environmental factors and Political factors was chosen for this purpose. Regarding the gathering of the data, the initial phase primary data collection both guided the secondary data collection and created the basis for further in-depth interviews, also referred to as the second phase of primary data collection.

Table 5. 1. Development factors identified in the empirical investigation

SOCIAL FACTORS	TECHNOLOGICAL FACTORS	ECONOMIC FACTORS	ENVIRONMENTAL FACTORS	POLITICAL FACTORS
Sustainable development Control & transparency Blockchain & traceability	Development of new technology Innovations of catalyst	Demand evolution Supply evolution Price evolution Global economic state	Circularity Recycling Ecodesign	Stringent emission control legislation

5.1.1 SOCIAL FACTORS

Social factors relate to social sustainability issues impacting the evolution of Platinum Group Metals. As mentioned in previous chapter, the bulk production of PGM are mined in South Africa. The PGM mining industry is important to the socio-economic development in both South Africa as well as other locations supplying PGM. Hence, this section focuses on the social factors of the mining. Three development factors relating to social factors has been identified and will be elaborated further, starting with the sustainable development through the supply chain, followed by control and transparency and the potential of blockchain and traceability.

5.1.1.1 SUSTAINABLE DEVELOPMENT IN THE SUPPLY CHAIN OF PGM

Starting with the social sustainability development through the entire supply chain, the mining aspect is essential. The social sustainability of the mining industry of PGM was investigated by Swedwatch (2013) who looked into the position of several Swedish companies related to the PGM mining industry, either directly or through connections in the supply chain. The social impact of the PGM mining industry is considered to negatively impact the environment in the areas around the mines. The mining processes requires large amounts of electricity and water leading to reduced access for the surrounding communities. Moreover, the mining processes release emissions which deteriorate the air quality and redirect water flows. This in extension has been proved to negatively impact the agricultural operations of local communities. (Swedwatch, 2013) Furthermore, in June 2011, The UN Guiding Principles on Business and Human Rights endorsed the development of a new international standard which outlines what is expected of organisations in regard to respecting human rights. It states that "companies are expected to take responsibility for human rights in their entire value chain, whether or not it concerns suppliers or customers" (Swedwatch, 2013, p.5). Looking into the report as a whole it concludes that,

"A number of areas of serious adverse impacts human rights in the platinum industry in South Africa. All of the investigated Swedish companies in this report have failed in their responsibility to implement continual human rights due diligence, in accordance with the UN Guiding Principles." - Swedwatch (2013, p.5)

The report described the true state of the investigated Swedish organisations in the year of 2013. Interviewee F, sustainability expert, argues that the focus on social sustainability for PGM has increased over the last years. Further arguing that the investigation of the PGM mining industry carried out by Swedwatch (2013) resulted in an increased involvement and more active participation in addressing social problems. Moreover, Interviewee F describes that the efforts of the OEM have shifted from assigning the problems to their suppliers to instead actively investigate current actions taken to alleviate the challenges. The OEM has regularly been visiting mines in South Africa and is actively discussing social sustainability issues with their suppliers that have the direct connection or contracts with the mines. The formal involvement is limited to having a "Supplier Code of Conduct" controlling some aspects of the mining. Hence, the level of control and insights in the PGM mining industry is limited. Interviewee F also underlines that the OEM should not be held responsible for the social sustainability aspects of the mining industry.

There are several positive aspects of the mining that can be identified, such as employment opportunities and economic growth. Additionally, the mining companies are providing the employees with training, health monitoring, remedial care and permanent housing. Moreover, supporting social and economic development in local communities through Social and Labour plans that are developed in collaboration with the South African government. Examples of such projects include improvements to infrastructure, supporting schools, sanitation, and water supplies. (IPA, 2013) Interviewee F, also maintains that the mining industry of PGM should be considered as acceptable. There is no child labour and no illegal mining activities. Additionally, Interviewee F argues that the PGM mining is well organised, and that people are properly employed with a monthly salary. Furthermore, the actors of the PGM industry are doing good things and have embraced the sustainability-mindset by taking these issues seriously. The process to reach these accomplishments has been long but today it has reached a satisfactory state.

"They are doing good things, it might not be perfect, but nothing is, at least they are moving in the right direction." – Interviewee F

5.1.1.2 CONTROL AND TRANSPARENCY OF SOCIAL SUSTAINABILITY IN THE PGM MINING INDUSTRY

The International Platinum Group Metals Association (IPA) is a non-profit organisation that represents about 80 percent of the mining organisation, production and fabrication

companies in the PGM industry. Members of IPA includes South African PGM mining organisations and their customers on the fabricator side. Under the umbrella of IPA, the organisations work collectively towards increased sustainability through a framework of sustainability principles which they have developed.

An important part of this initiative are wide-ranging sustainability audits in the South African PGM sector. These audits and the sustainability assurance scheme are based on internationally recognised standards that are equal to Together for Sustainability´s mining standards, Initiative for Responsible Mining Assurance (IRMA), and ISEAL quality principles. These audits can also result in knowledge-exchange on both success factors connected to community challenges and also good practices. (IPA, 2013) This aspect was also brought up by Interviewee F as an example of positive developments for the PGM mining industry. However, it is according to Interviewee F important for the OEM to also receive information from the audits through their suppliers. Transparency is considered to be of great importance. Interviewee F argues that there is a resistance from suppliers on disclosing the configuration of the value chain as this can be considered as commercially sensitive information, potentially is linked to their pricing and sourcing strategies. However, since the same mining company often are the owner of multiple mines that can be up to different standards and have different working conditions, a consistent compliance cannot be guaranteed without transparency. Hence, Interviewee F argues that in order to improve efforts and achieve an increased sustainability there is a need for control and transparency in all parts of the supply chain.

Interviewee H, PGM market expert agree with this, and underline that the objective of transparency in the supply chain is that all actors access the same information for tracing sustainability objectives. However, commercially sensitive information could potentially be limited.

Interviewee F also emphasise that it will be important in the future for corporations to display their respective actions to become a sustainable organisation. Examples of this are accounting and financial numbers, presenting results of the audits and how they meet the results of these There are external forces pushing towards more transparent and open sustainability initiatives, where Interviewee F argues that there might become mandatory to not only have control and be transparent but also to be able to account for the actions taken.

5.1.1.3 BLOCKCHAIN AND TRACEABILITY

The Responsible Sourcing Blockchain Network (RSBN) is a blockchain network working towards environmental protection and strengthening of human rights in mineral supply chains. Through including actors from the entire supply chain, traceability and verification of responsible sourcing practices can be facilitated. Actors involved in this network include organisations such as Volkswagen Group, Ford, Volvo Cars and IBM. Working towards a digital supply chain for cobalt which is to be implemented in spring 2020. (RCG Global Group, 2019) This technology could also be applied for other materials in the future as illustrated by below statement;

"Next to expansion into other battery metals, including lithium and nickel, the platform is also actively working to progress the solution to support tracing other common metals including tin, tantalum and gold, also known as 3TG. Further announcements will be made over the initial pilot consortiums in the additional raw materials."- RCG Global Group

Interviewee D, procurement expert and Interviewee F both mention blockchain in relation to cobalt, agreeing with its traceability potential and securing the origin. Moreover, Interviewee F argues that there is potential to use blockchain for almost anything in the future as long as all supply chain actors realise the potential and wants to employ this technology. According to Interviewee D, there is no specific external forces driving this for PGM as of now, but there is a future interest;

"In general, we want to have a higher degree of control and information regarding provenience to be sure of what is used in the trucks, and PGM is according to me a material that should be further investigated. "- Interviewee D

5.1.2 TECHNOLOGICAL FACTORS

The technological aspect focuses on technological advancements connected PGM. New technologies impact incumbent technology connected to PGM which is directly connected to autocatalysts containing PGM and combustion engines. In this section, two development factors have been identified and will be further elaborated upon. The first regards the current development of new technology and the second relates to innovations of the autocatalysts.

5.1.2.1 DEVELOPMENT OF NEW TECHNOLOGY

As a result of the efforts of meeting the climate change goals, energy related carbon emissions need to be reduced by 60 percent by 2050. Part of this requires a shift to renewable energy sources and energy carriers with a low-carbon footprint. (McKinsey, 2017) All industries collectively need to participate to meet the goals. Hence, new technologies are emerging, aimed at creating more sustainable modes of transportation. One example is electromobility including battery electricity vehicles (BEV), hydrogen fuel cell vehicles (FCEV) and hybrid vehicles (HEV).

Fuel cells is an electrochemical device using the energy of a chemical reaction and convert it into electricity. The fuel in this technology is hydrogen and oxygen and the by-products of the reaction are heat and water. The material used in the catalyst to convert the hydrogen and oxygen is primarily platinum. (IPA, n.d.a)

According to IPA (n.d.a) it is possible that fuel cell engines in the future will substitute the combustion engine as dominant technology for different vehicles. Passenger cars, SUVs and forklifts have already realised commercial success in the U.S (JM, 2018), and for other vehicles such as busses, several prototypes has already been successfully deployed (IPA, n.d.a) There is only a matter of time before fuel cells will be adopted in other vehicles such as trains, trucks and trams (IPA, n.d.a; McKinsey, 2017; JM, 2018) Moreover, both established automakers such as Toyota, and start-ups such as Nikola Motors, have initiated the development of FCEV for heavy-duty and long-haul trucks (McKinsey, 2017; Roland Berger, 2018). Additionally, Hyundai Motor in cooperation with the organisation H2 Energy, have invested in this technology and starting in 2019, over a five-year period, they will provide 1,000 heavy-duty FCEV to the Swiss commercial vehicle market, along with an adequate supply chain for renewable hydrogen (Hyundai, n.d).

The potential for FCEV in the transportation sector (including all types of vehicles) for decarbonisation is great, and by 2050, fuel cell vehicles could constitute up to 20 percent of the total vehicle fleet. This is based on the vision of the Hydrogen Council, a group of 18 companies representing different industries. (McKinsey, 2017) However, predictions indicate that the internal combustion engine will remain as the major technology until at least 2030 (predictions varying from 50-90 percent). Hence, the technology predicted to be dominant during the next decade is the combination of combustion engines and electric power sources, in different applications such as hybrids and plug-ins. (AECC, 2018) The implications of using FCEV in the future on PGM demand is not yet clear since there are still several uncertainties to account for. However, an estimation carried out by JM (2018) is that FCEV platinum demand can potentially reach 5 percent of the autocatalysts demand in 2025 and the increasing penetration of FCEVs will keep driving demand growth 2030 and beyond.

Interviewee H argues that electrification of vehicles is a future mega trend (FCEV, BEV and HEV), however, agreeing with the notion of a slow shift towards this transition. Moreover, Interviewee H believe that in a short-term perspective, other megatrends such as more stringent emission legislation will prevent the catalyst market from shrinking. Interviewee E, PGM raw material expert also mention that shifting to electromobility is still far in the future and that the stringent emission control will increase the demand and consequently the prices short-term.

There are several barriers for fully adopting the FCEV technology. One challenge identified is the high capital cost required (IPA, n.d). Moreover, the total cost of ownership and the rate of technological development (JM, 2018). However, the report by McKinsey (2017) state that

industry experts believe that one of the barriers of employing this technology, the total cost of ownership, could converge and become competitive advantage with the internal combustion engine vehicles approximately 15 years from now (~2030).

On the contrary, there are challenges related to the de-carbonisation of heavy-duty vehicles that are driving the shift towards FCEVs and not BEV. This is primarily related to the large quantity of energy that needs to be stored in the vehicle. The nature of a heavy-duty vehicle in combination with the objective of carrying goods over long distances, lead to the conclusion that decarbonisation of these vehicles most definitely will include fuel cells and hydrogen (JM, 2018). The hydrogen battery technology implies that more energy in less weight can be stored, compared to using electric batteries which makes FCEV suitable for vehicles carrying heavy goods over long ranges.

Moreover, the growing adoption of BVE can support and drive the adoption of FCEV. Hence, these two technologies complement each other as different strengths and weaknesses can be identified for the technologies. However, how the technologies will develop and relate to each other is dependent on several factors, for example the evolution of the technology and the cost reductions stemming from scaling fuel-cell production. (McKinsey, 2017) FCEV and BEV are according to Interviewee F parallel technologies, where FCEV technology has not yet reached the state of technological readiness.

"However, that could change and would result in a shift of focus." - Interviewee F

Interviewee H agree that there are different technological opportunities for different types of vehicles. For heavy-duty vehicles, the largest potential for fully electrified vehicles (BEV) are city buses and smaller delivery vehicles. Whereas long-haul trucks face hurdles such as a high cost of ownership and capacity problems. Interviewee H suggest that renewable energy could be the way forward for long-haul trucks, which would still require an EATS and consequently the catalyst-demand would not decrease.

Interviewee F describe BEV as a sunrise technology, meaning that a lot of resources are dedicated towards the development of such, and combustion engines are described as a sunset technology. However, according to Interviewee B, the combustion engine will be used for a 10-20-year period, generating a continued use of PGM.

"Sunset and sunrise technologies are not applicable for PGM." -Interviewee B

As combustion engines in a long-term perspective will be phased out and substituted with new technology, the rate of the technological development and the choice of technology will directly affect the PGM. As the FCEV still make use of PGM and BEV essentially eliminate the need for PGM, this could result in very outcomes depending on the evolution.

5.1.2.2 INNOVATIONS AND TECHNOLOGICAL DEVELOPMENT OF THE AUTOCATALYSTS

As having a lower amount of PGM in the catalyst would generate a competitive advantage for the Fabricator companies, and result in less capital spent for OEMs, this is in multiple actors' best interest. Interviewee H express that their ambition is to optimise and minimise their use of the PGM internally and also externally in corporation with their customers.

"Our customers have different levels of focus towards this, some putting lots of energy into just meeting the legislation, and some are dedicating resources towards optimising and minimising." – Interviewee H

The technological development for petrol catalysts have according to Interviewee H reached a point where no further optimisation can be carried out. However, there is still potential for further optimisation of the diesel-catalyst. Moreover, there is potential to change the balance of the different PGMs used, both for petrol and diesel catalysts. This is agreed on by Interviewee B, who further express that it is confirmed that PGM cannot be substituted, and therefore the focus is rather dedicated towards reducing and optimising. Interviewee G, PGM market expert

agrees with this, explaining that the EATS consists of two parts, one reducing carbon monoxide and one reducing emissions that impact the air quality using PGM.

"You cannot operate the emission after treatment system without having both parts of the cleaning system." - Interviewee G

5.1.3 ECONOMIC FACTORS

The economic factors are relating to the economic side of the topic, such as price levels and fluctuation. The automotive industry quickly became the majority stakeholder in consuming the metals when the autocatalysts was introduced to the market. This caused an extreme increase in demand which in turn lead to large implications on the price evolution. (Gunn, 2014) PGM market reports indicates a continuing increase in the demand for the metals which are used in a wide range of application areas (JM, n.d.) At the same time, multiple scholars argue for future scarcity in the rare metals which will impact future evolution in PGM. Four development factors relating to the economic aspect of the topic has been identified, price, supply, demand and the global economic state and will be further discussed below.

5.1.3.1 PRICE EVOLUTION

The wide range of application areas of the metals in several industries combined with their rarity has impacted the historical price evolution. The price evolution is predominantly determined by the logic market relationships of supply and demand. (Gunn, 2014) This is argued in Alonso, Field, and Kirchain (2008) research which highlights the correlation of PGM supply as dependent on the price. Moreover, that the price itself varies with the difference between supply and demand. The price level of platinum since the catalytic converters introduction has evolved from 383,43 USD per ounce to today's price of 970 USD per ounce. This is a price increase of approximately 250 percent. An even greater increase is found in palladium where the price has increased from 85,95 USD per ounce to 2 555,05 USD per ounce over the same period of time. This is a tremendous increase of approximately 2970 percent. Finally, for rhodium the price increase was 2 694,57 USD per ounce to 11 665 USD per ounce, which is an increase of approximately 430 percent. (JM, n.d.b)

Along with the historically increasing price level, the metals prices are fluctuating as visualised in the Figure 5.1, 5.2 and 5.3 below. The Figures Y-axes displays the price levels and the X-axes display the time horizon. Although the prices have been increasing, for all of the metals, multiple peaks are visual. A peak for all of the three metals are in 2008 prior the financial crisis. For platinum the peak in 2008 was the price of 2 066,41 USD. For rhodium this peak was 9 786,9 USD. The price levels for all metals have continued to increase, however, this was prior the covid-19 pandemic (JM, n.d.b). Interviewee D and Interviewee E further acknowledge the fact that the volatile market makes the forecasting critical.

"It is extremely difficult to forecast the price development in the metals as it is heavily fluctuating." - Interviewee E

The study conducted by the researchers Sverdrup and Ragnarsdottir (2016) models that the metals price will continue to stay volatile in the future and is by their model forecasted to stabilise first in year 2040. This is argued to be typical for scarce metals which tend to have small stock in use in society and a low flexibility form accommodating rapid changes in demand. This will be outlined in coming sections. The 2019 PGM market report conducted by the Johnson and Matthey Corporation indicates a continuing increase in prices. However, this was prior to the covid-19 pandemic which already is indicating signs of influencing the entire economy. This has already caused the prices to shift. This is evident when examining the price evolution chart in Figure 5.1, 5.2 and 5.3, where from the 10th of March has started to decrease.

Sverdrup and Ragnarsdottir (2016) further highlights that future increases in oil price may serve as an amplifier in the price evolution of the PGM price. In the first quarter of 2020, the oil prices have dropped significantly which also may impact the PGM price moving forward, contributing to the already increasing and volatile price evolution.

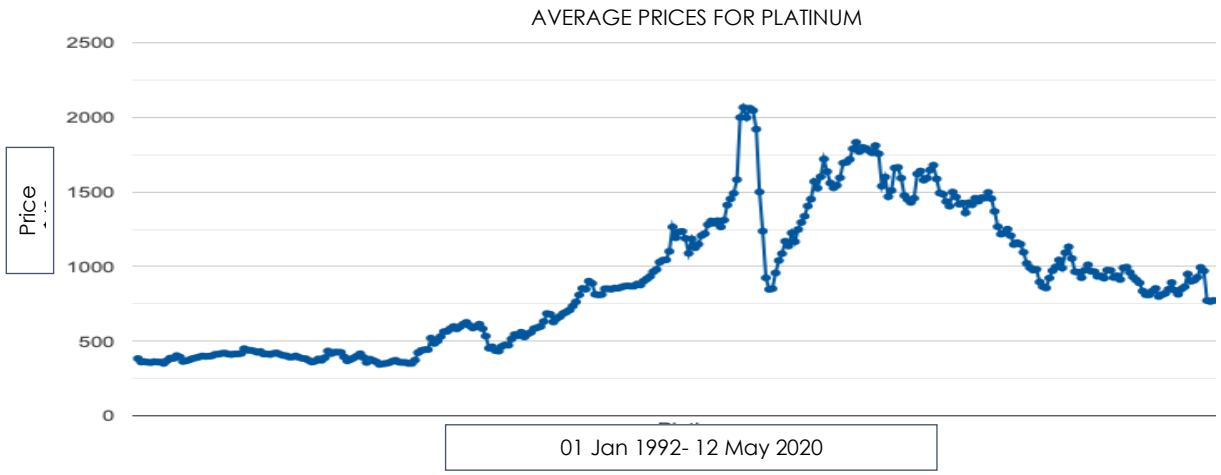


Figure 5. 1. Price evolution of Platinum (JM, 2020)

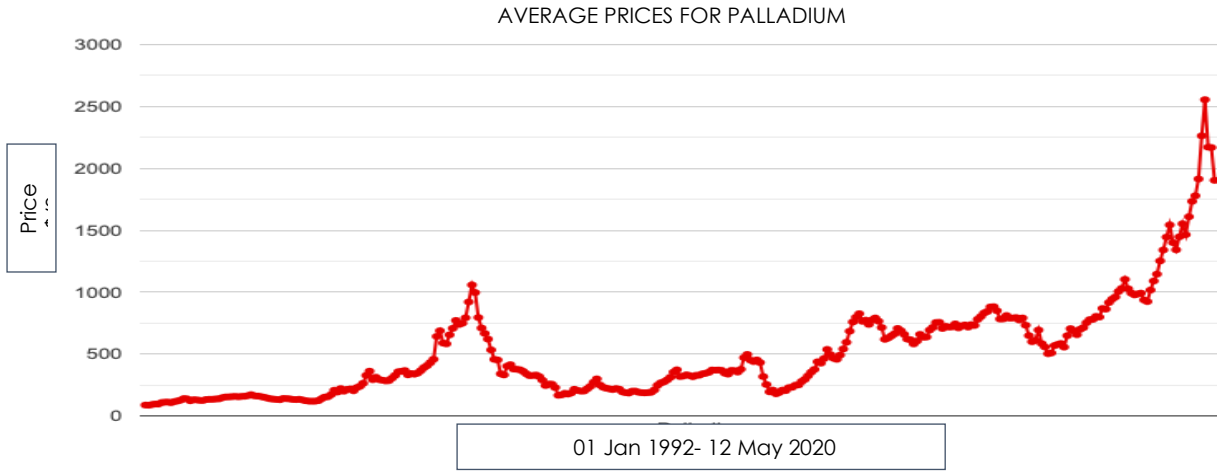


Figure 5. 2. Price evolution of Palladium (JM, 2020)

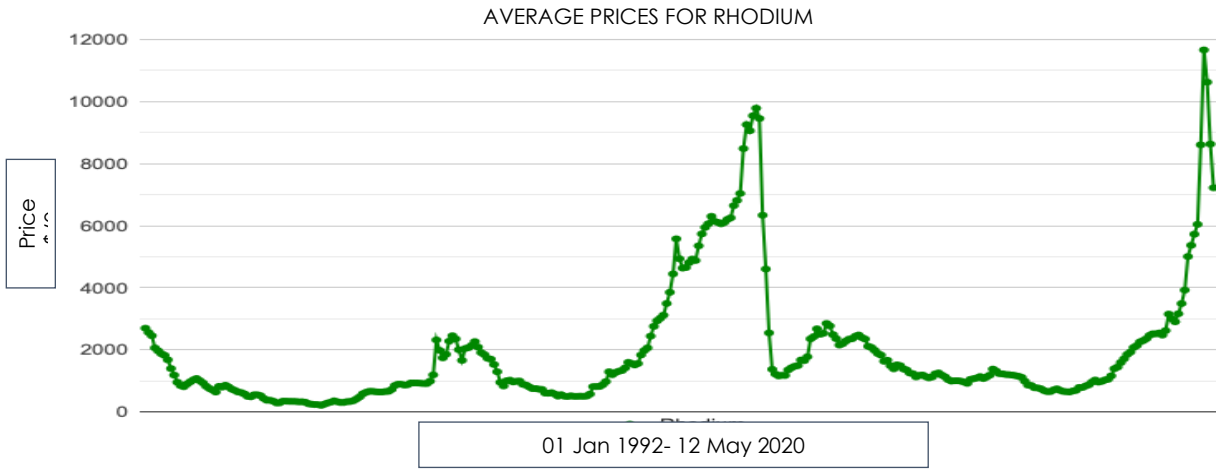


Figure 5. 3. Price evolution of Rhodium (JM, 2020)

5.1.3.2 SUPPLY EVOLUTION

The supply of the PGM is mined primarily in the South African Igneous Bushveld complex, holding 86 percent of the metals reserves and is expected to remain so. The research conducted by Sverdrup and Ragnarsdottir (2016) highlights that it is a well-known fact that there is a scarcity and a future peak in the PGM production.

"*Several authors have previously expressed concerns about the potential scarcity and future peak in platinum group metals production from mining and discussed the associated challenges and possibilities for the platinum group metals mining industry and the supply to the market.*" - *Sverdrup & Ragnarsdottir (2016 p.130)*

A scarce resource implies a limited physical market availability with highly and volatile price levels. This is interlinked with small buffering-stocks in society. Furthermore, that there is an imbalance in the present use of the PGM which in turn threaten the future long-term societal supply. This scarcity will be evident in the coming decades. (Sverdrup & Ragnarsdottir, 2016) This is further argued by Interviewee A, PGM market expert, whom express the challenge in the demand which exceeds the supply and how this impacts the market.

"That is a big challenge, and everything is linked so when there are no availabilities on the market you are using up your stocks and prices are going up." – Interviewee A

Sverdrup and Ragnarsdottir (2016) further argues that the PGM have historically always been in a state which they refer to as soft scarcity. This implies that the PGM supply to the market do not match the supply from the market. This is followed by increasing price levels which in the end will lead to a reduced demand. At some points in time there has been states of hard scarcity, a state which refers to supply levels which are inefficient to supply enough metals to cover the demand, leading to a market gap. The researchers further highlight that the future supply to society is substantially larger than the mining rate. Moreover, that the peak production is estimated in 2055, and peak in supply around the years of 2055-2066 meaning that the supply of the metals will continue.

The PGM report from Johnson and Matthey Corporation outlines the supply levels of the three PGM, platinum, palladium and rhodium. The supply of the platinum metal is steadily increasing, from the 2013 levels of a total supply of 5,846'000 oz to the level of 6,108'000oz. The numbers for palladium are also increasing with a total supply 2013 of 6,397'000 oz to 2018 levels of 6,880'000oz. Finally, the rhodium supply level 2013 of 701'000 to 2018 supply of 759'000 oz.

Similar to what the reports outline, Interviewee H, argues that there is little or no sign at all of a total shortage of the metals. The more likely effect is that it will cause price levels to increase.

"*A total shortage of the metals is not in sight, the fact is that prices will increase*"
– Interviewee H

Sverdrup and Ragnarsdottir (2016) argue that one large risk of the PGM supply is the heavy reliance of the South African Bushveld Complex. The South African complex holds the most concentration of the metals. This is a risk of the supply, both in regard to the societal risks as previously identified in 5.2, and also that the concentration immediately affects how much PGM that can be extracted. Interviewee H explains that the PGM deposits exist in hammocks with different layers in the core of earth. This cause the mining of the PGM to continually dig deeper, which continually will be more time consuming and ultimately costs more money leading to higher price levels. The opening of new mines to increase the supply of the metals is according to both Interviewee H and Interviewee E time consuming, and they further stress the large environmental effects of opening new mines.

5.1.3.4 DEMAND EVOLUTION

The demand of the PGM from the automotive industry, the jewellery industry, industrial processes and investments are large and increasing. The automotive industry is the major

consumer with approximately 70 percent of the gross demand for the autocatalyst. Secondly, the Industrial applications accounts for around 14 percent of the gross demand, nine percent for the jewellery industry and two percent for investments and lastly, five percent for other non-specified industries. The demand of the metals has historically been fluctuating. However, the trend for both palladium and rhodium are indicating increasing demand. (JM, n.d.a)

The historical demand evolution is according to the Interviewee E, raw material expert, primarily due to the different fields of use in the various industries. Within the trucking industry the increase in demand is argued to stem from the pressured situation with the stricter laws regulating the cleaning of the gas emissions. The stringent laws ultimately imply that larger amount of PGM is needed in each catalyst to meet the acceptable limits. (JM, n.d) This is confirmed by the Interviewee B, PGM procurement expert whom also highlight that the PGM properties are the only metals which can serve this purpose. It is depicted as "the holy grail" on the aftertreatment of exhaust gases.

In the 2019 PGM report (JM, 2019), the emerging markets of India and China are now also impacting the demand of the metals as an effect of their growing economies. This has led to an increased demand in vehicles which consequently has developed the need for a stringent legislation which has impacted the demand for PGM to meet the acceptable limits. (JM, n.d) Furthermore, Interviewee A argues that the intersection of the levels of demand with the levels of the rare metals supply comes with large challenges.

"There is a growing demand while the offer is limited and underproviding, so we are living based on some stock variable. But without the stocks we are not able to provide what is needed in the world. That is a big challenge, and everything is linked, so when there are no availabilities on the market you are using up your stocks and prices are going up."
-Interviewee A

Sverdrup and Ragnarsdottir (2016) has also outlined the correlation of a higher demand creating increased price volatility. Something that according to Interviewee A is evident when analysing the PGM evolution. Furthermore, that the higher demand, implies increasing cost of mining reflected in the increased price levels.

5.1.3.4 GLOBAL ECONOMIC STATE

The global economy has the last years been in a global economic upswing. This has ranged from the second half of 2016 until the first quarter of 2018 which resulted in both a stronger and broader economic activity and expanded growth rates in both developed and emerging economies. The last three quarters of 2018 was marked by a slowed down economy were the geopolitical tensions stemming from the no deal Brexit and the rising trade barriers resulted in greater sources of uncertainties which followed in the year of 2019 (IMF, 2019).

The development of the global economy is pointed out as driving force in the development of PGM by multiple of the interviewed experts. The economic boom that has been characterised the years following the financial crisis in 2008 has led to a higher demand of vehicles. This is interlinked to a higher demand of the PGM.

"The platinum group metals generally follow the global economy, if the global economy booms the raw material demand also booms." – Interviewee E

This citation exemplifies the cause and effect of the global economy and the PGM demand. Economic boom leads to more expensive material, due to the market logic of supply and demand. If the economy is doing well, there will be an increase in demand and with a limited supply, the prices goes up. When prices increase, investors get their eyes open and start investing in new mines to get more supply to balance the market to stabilise prices. The market is seldom in balance causing the prices to go up and down.

The latest economic outlook report from April 2020 is painting the picture of a global economic downturn caused by the Covid-19 pandemic. This is forecasted to be even greater than the

Great Depression from the financial crisis in 2008, affecting the entire global economy. The global economic state of the first quarter of 2020 is marked by high and rising human costs, and measures of protectionism in all world countries. The economy is forecasted to yield sharply downwards with -3 percent in 2020. With the pandemic being far from over, the sources of uncertainty for the global economy is rising with fallouts dependent on a whole range of factors. What is further blurring the forecast for future outlook of the global economy is that the pandemic is limiting the availability and application of economic tools to stimulate economic activity in to aggregate the demand. Leaving agencies and governments unarmed. The global economic state is surrounded by sources of uncertainty of future outcome. (IMF, 2020)

5.1.4 ENVIRONMENTAL FACTORS

The environmental category is associated with factors relating to the development of environmental aspects such as environmental regulations, recycling etc. In a study carried out by the IPA, a life cycle analysis of PGM is presented, with a focus on the environmental impact the materials impose. Starting with the mining process, the electricity consumption is high and the primary power grids used in South Africa, relies on burning hard coal. Electricity generated in this way, leads to relatively high emissions of carbon dioxide. Hence, the major impact on the environment from PGM is the mining and ore beneficiation, constituting 72 percent. However, the major environmental benefits of using PGM in the autocatalysts concludes that the reduction of vehicles gas emissions outweighs emissions generated in the process of producing the catalyst. (IPA, 2013) Nevertheless, there are actions and initiatives in the PGM industry aimed at improving the overall environmental sustainability through circularity, recycling and ecodesign, which will be further discussed in this section.

5.1.4.1 CIRCULARITY

PGM are primarily used in two distinct ways, either in industries or embedded in consumer goods. The major difference between these applications is the management of the PGM, where industries usually have developed a so-called closed loop system (Hagelüken, 2012). This in practice mean that they have a contract with PGM fabricators that process the used metals and include them in future deliveries. The industrial applications are leading the way in terms of recycling, with a recovery rate of over 95 percent (Hagelüken, 2012). The second way PGM is used, embedded in consumer products such as autocatalysts, constitute a so-called open loop, see Figure 5.4. In this application, recycling cannot be guaranteed due to the shifting ownership, difficulties of tracking and responsibility imposed on the consumer. To drive the recycling rate up, Hagelüken, Buchert & Ryan (2009) stress the importance of converting open loop systems into closed loop system.

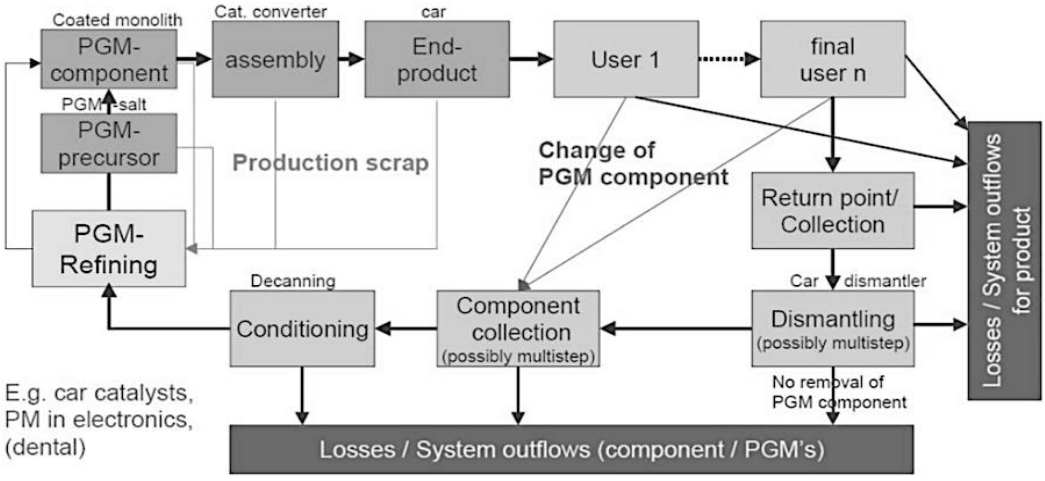


Figure 5. 4. Recycling path for PGM embedded in consumer durable products (Hagelüken et al., 2009).

The complexity of arranging the processes and the logistics supporting circularity is also brought up by Interviewee F, who argues that the long lifecycle and the multiple shifts in ownership for the vehicles pose a challenge for creating circularity systems for PGM. An additional aspect to consider, according to Interviewee F, is the different technologies in the trucking market, where some are considered to be technologies of the future, and some are considered to belong in the past. This can influence where and how organisations decide to allocate resources. For example, dedication towards developing a circular system. Interviewee F believes that the likelihood for such, could be larger within a rising technology like batteries rather than for PGM in combustion engines. Interviewee H agree with the complexity brought up, as well as the organisational aspect, stating that a prerequisite to engage in a project of this magnitude is to be able to allocate adequate resources. This complexity can be illustrated by these questions by Interviewee C, PGM raw material expert,

"What can we act on? Who will pay for changing the logistic if all trucks are to be part of circularity?"- Interviewee C

Interviewee G describe todays recycling process for autocatalysts as fragmented with multiple actors, such as specialised waste-managers or dealers, buying and selling old autocatalysts containing PGM. Interviewee G describe the recycling chain and circularity as per below,

"Today there is no OEM, such as Mercedes or Volvo, that have their own supply chain organising that the catalysts come back to their organisation." - Interviewee G

However, Interviewee G describe that their organisation actively supports OEMs to establish processes to retrieve better control of the recycling process and the loop-concept, for example through recommending supply chain partners for the collection process.

5.1.4.2 RECYCLING

PGM is a material that is used and not consumed, this means that there is potential for re-using the material multiple times (IPA, 2013). It is according to Hagelüken et al. (2009) crucial to recycle PGM in order for the use of metals to be considered sustainable. Moreover, recycling is considered to be ecological advantageous. The applications where PGM is embedded in consumer products are currently not meeting the rates needed for a sustainable use (Hagelüken et al., 2009). Today, the total level of PGM that is being recycled is much below the virgin material of PGM that is being used in all of the application areas (IPA, 2013). In the automotive industry, the recycling rates are approximately 50-60 percent (Hagelüken, 2012). However, the potential for recycling autocatalysts, from a technical perspective is high, with a recovery rate of 95 percent (IPA, 2013). There are still technical challenges for recycling PGM but collecting the waste and having a recycling chain with appropriate capacity and technical capabilities at different places in the world is described as the largest challenge (Hagelüken, 2012; IPA, 2013).

Hagelüken (2012) describe seven conditions for effective recycling of any material or product. (1) Technical recyclability, referring to the processes of recovering the intended material. Followed by (2) Accessibility, that is the ease of access to the part where the material is to be recovered from. For example, an autocatalyst is easy to dismantle from the vehicle. (3) Economic viability is the actual net value of recycling. Additionally, does the product need to be available for recycling through (4) Collection mechanisms. For the material to be recycled it needs to (5) Enter into the recycling chain, which is often problematic in countries without adequate infrastructure for such processes. (6) Optimal technical and organisational setup of the recycling chain is needed, which is the case for Europe in regard to autocatalysts. When all previous conditions are met, the final condition is to have (7) Sufficient capacity. Interviewee H, and Interviewee G, both representing different organisations working with recycling of PGM, confirm that the capacity for increasing the recycling of PGM exists. It is not the bottleneck, which is illustrated by Interviewee H, stating that

"If it is not sufficient, the PGM fabricators involved in recycling will invest to increase the capacity to meet the demand." – Interviewee H

In the trucking industry, where PGM is being used in the catalyst, it is only one part of a larger product. This mean that the recycling of the PGM primarily fails due to condition (5), as many cars are exported for second-hand use to countries that lack appropriate recycling chains. The reason for not having higher losses of PGM is due to the economic value of the PGM containing catalyst. It is concluded that the lifecycle system is the reason for not yielding higher rates of recycling and thus, is it the actors within that system that has the potential to improve it. (Hagelüken, 2012)

Waste containing PGM need to be seen as a valuable resource and Hagelüken (2012) recommend new business models in order to ensure the PGM supply and to achieve increased sustainability. To reach the full potential of recycling PGM from autocatalysts there is a need for increased awareness of the PGM value and the benefits of recycling the material from an economic and environmental perspective (Hagelüken et al, 2009). Moreover, the cooperation between participants in the recycling chain must be improved, aiming at achieving increased transparency and to rationalise the recycling system. There is also a need for improved technical capabilities of recycling and improved logistics. Lastly, the researchers emphasise the importance of having authorities certifying and regulating the recycling of PGM. More specifically, to supervise and certify recycling actors, eliminate actors that are not meeting the requirements and to regulate and control End of Life Vehicle exports. (Hagelüken et al., 2009)

Further commenting the rates of recycled material available at the market, interviewee C believe that there is enough material to increase the share of recycled materials drastically, to the extent where circularity is possible. However, a potential hurdle identified by Interviewee C, is the business model of PGM fabricator companies, where economic benefits and sustainability goals often are in conflict. Moreover, that there is a contradiction between acting sustainable and generating maximum economic profits.

"It does not make sense to increase the use of recycled materials from a business perspective, the business models are not fit for sustainability." – Interviewee C

Interviewee C suggest that the overarching goal of achieving greater sustainability could be the driver that can push all actor into circularity, increase rates of recycling and also pursue valuable partnerships. Contrasting, Interviewee H and Interviewee G describe that the organisations they work at are focusing on recycling, and that the recycling business is one of the revenue streams of their operations. Hence, making recycling a part of their business model. Additionally, Interviewee H describe an increasing demand for recycled PGM, both as a result of external pressure from customers but also through internal initiatives.

For the economic implications of substituting virgin material with recycled material Interviewee E, raw material specialist, disclose that they do not have full insight in the potential pricing differences of purchasing virgin versus recycled material. The price of purchasing the material from the supplier does not take this into account, and the same index is followed for both types of materials. Interviewee H and Interviewee G confirm that it is the same price level for recycled as for virgin. However, Interviewee H underlines that an increased rate of recycled material could result in less fluctuation in regard to the price. Interviewee E describe that to receive this pricing information, one needs to be present at the market.

"That is an advantage of being present at the market, you could potentially access a network and gain increased knowledge of how and where to purchase recycled materials."

– Interviewee E

The recycling rates of PGM are below desired rates. Prerequisites to increase the recycling rates of PGM has been described, where the recycling chain pose the largest challenge

(Hagelüken, 2012; IPA, 2013). However, looking at the recycling rates for platinum, palladium and rhodium over approximately the last decade, an increasing rate can be identified for all metals, as illustrated in Figure 5.5 (JM 2010-JM, 2019).

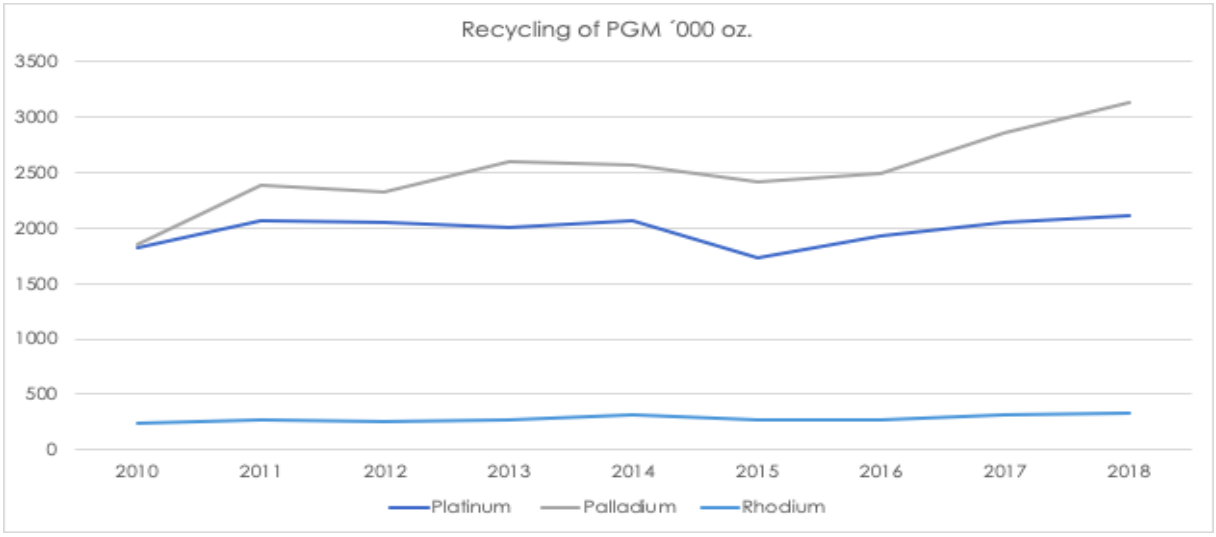


Figure 5. 5. Recycling rates for PGM 2010-2018 (Figure based on JM, 2010- JM, 2019)

5.1.4.3 Ecodesign

Interviewee C and Interviewee F mention ecodesign as a mean to increase sustainability in their operations. Ecodesign can be described as an approach where the product design and development integrate environmental aspects with the objective to improve the environmental performance of the product throughout its whole lifecycle (European Commission, 2009). This concept is closely linked to circularity and the circular economy approach through promoting a product design that is supporting processes such as remanufacturing and recyclability (Den Hollander, et al. 2017).

A key legislative tool to achieve a more resource efficient approach is the Ecodesign Directive, where reparability, durability and recyclability is promoted. In this directive, manufacturers placing products on the European market are required to improve their environmental performance through minimum efficiency requirements, requirements relating to water consumption and durability of certain components. (European Commission, 2009)

Interviewee C mention organisations such as Veja and Ikea as examples of how this concept has already been implemented. Despite the aspiration of becoming more sustainable, Interviewee C disclose that her organisation is currently designing linear products, but that there has been an increased interest in ecodesigning lately. Moreover, Ecodesigning can according to Interviewee C be directly linked to PGM, with opportunities connected to both environmental sustainability and economic sustainability.

"We can negotiate price but in the end it is more useful to design for circularity."
– Interviewee C

According to Interviewee B, ecodesign is not applicable for PGM. What needs to be further investigated is the recycling processes. PGM can be retrieved and recycled, but the processes to do so are not environmentally friendly as it requires chemical processes.

5.1.5 POLITICAL FACTORS

The final category outlines factors relating to laws, regulation, policies and politics which impacts the evolution of PGM. This, as the laws regulates the acceptable gas emission limits

from the exhaust of heavy-duty vehicles were the PGM are the only metals serving the purpose of cleaning the externalities to meet the standards. The historically stricter regulations are driven by the intensifying climate debate. This in turn requiring an increased amount of PGM in order to be compliant with the acceptable limits. Laws, regulations and policies are important tools for governments to reduce the externalities of the emissions, improve the air quality and to promote innovation in the vehicles and its engines. The coming regulations in the world regions therefore impact the PGM market will continue to do so in the future. (ICCT, n.d.a.)

5.1.5.1 FUTURE STRINGENT EMISSION CONTROL LEGISLATION

Gas emissions from the exhaust of heavy-duty vehicles are regulated with different standards applicable to different types vehicles in different world regions. To be able to sell vehicles within the various regions, these must be compliant with the standards. The world is divided into eight regions and the regions that are highlighted are Europe, Northern America, China, India and Russia as these highly impact the use of PGM. (JM, 2019) More stringent emission legislation globally is highlighted as a mega trend by Interviewee H. Below in Figure 5.6, is a visualisation of the current regulations, the coming regulations and the timeline is outlined.

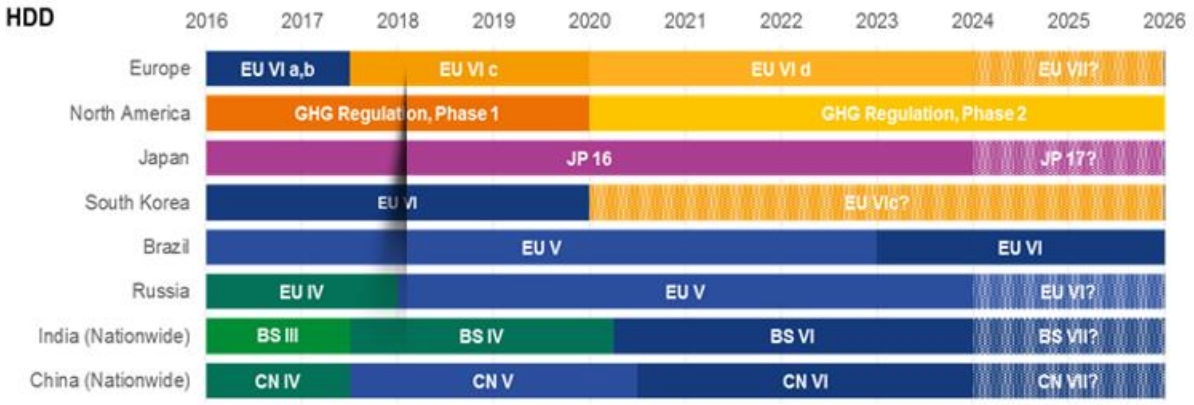


Figure 5. 6. Legislative development in Heavy-Duty Vehicles

Europe is considered to be in the forefront of making reality of the UN global sustainability goals and have today the strictest standards of acceptable limits. The emission standards applicable for HDV are referred to as Euro I-VI. The Euro VI standard is the current regulation adopted, which became efficient in the year of 2013. This standard introduced stricter exhaust limits as well as specific regulations relating to the testing of vehicles. This included the introduction of Particle Number (PN) limit which limits the number of particles per kilowatt-hour under the testing cycle of the vehicle's emission. Furthermore, On-Board Diagnostics test (OBD) which changes the evaluation of emission from emissions during everyday condition which is different from the previous test which was only at a particular moment in time. It also introduced new testing requirements in off-cycle and in-use PEMS testing to achieve real-world emissions. (ICCT, n.d.c) The current Euro VI d is expected to be efficient for the coming five years.

Interviewee G argues that the legislation regulating the acceptable emission limits, is expected to continue to become stricter in all world regions. This is a result of the climate change and the negative externalities such as air quality in cities. Interviewee G argues that more stringent emission legislation is expected in Euro VII but exactly what it will imply is not clear, which is illustrated by the following citation:

"We have grey areas concerning the future regulations, but we have quite some increases in the world. It is not entirely defined yet, how strict this legislation will be, but the entire industry is

expecting something big to happen in the area around 2024-2026. Euro VII is expected to be significantly stricter than Euro VI." – Interviewee G

Interviewee G furthermore outlines the correlation between more stringent legislation and increased PGM demand. This as meeting the acceptable limits will require larger catalyst with higher amount of the PGM.

Another important region is the Northern Americas. The current legislation applicable is the GHG Regulation Phase One, introduced in 2014 which regulated both the fuel consumption limit and the gas emissions for HDV. (ICCT, 2016) The new regulation of GHG Regulation Phase Two will be introduced sometime during 2020 and will build upon the first phase, providing stricter limits. (JM, 2019)

According to Interviewee G, the Northern American markets future development of emission standards is surrounded by great sources of uncertainty. This stems from the American Greenhous legislation standpoint, which in turn is impacted by the presidential association which is neglecting in the environmental problems. Hence, it is difficult to predict if the new regulations will in fact become stricter or remain.

Another interesting fact argued by Interviewee G is that emerging markets will increasingly impact the PGM evolution.

".. the regions of India and Asia pacific are for the first time introducing a serious legislation on gas emission so there is an additional demand on catalysts. In China there is a stricter legislation on exhaust gases on vehicles and also new emerging markets coming up where people are shifting their transportation with cars instead of motorcycles."
– Interviewee G

Similarly, this is argued by Interviewee H whom further emphasise that emerging markets stringent emission legislation are going to impact the PGM evolution, driving an increase in demand which ultimately also will impact the price levels to increase.

Legislation applicable in China is the China V standard which is deemed as equivalent to Euro V. Future legislation has been finalised to China VI standard which will be introduced in two phases, China VI a in 2021 and later in 2023 China VI b. (ICCT, 2018a) These will be equivalent to Euro VI stringency. The current legislation in India is the BS VI is based on the Euro IV and the future legislation BS VI, will be introduced in April 1st, 2021. (ICCT, 2018b)

There are multiple sources of uncertainty surrounding the future legislation on emission control both in regard to the level of stringency and the exact time introduction. The JM market report (2019) highlights that future emission legislation is shifting, moving from the solely focusing on stricter regulation degree (tightening gas emission limits) to consequently focus on a different kind of standards, (the ways of testing the vehicles). This development will result in stricter legislation which in turn leads to a continuing increased PGM consumption. Interviewee G argues that there will be future stringency, but the questions are when and what limits to expect.

"We have grey areas around the emission control legislation in the future, but we will have large increases here in the world." – Interviewee G

6. SCENARIO ANALYSIS

The following chapter outlines the conducted scenario analysis and its process. The structure of the analysis was developed to fit this study and to answer the research questions. The following chapter is structured in accordance with the four steps in the applied scenario analysis framework, visualised in Figure 6.1. The chapter is initiated with the first step "Definition of scope" where the goal and frame of the analysis is set. Step two, "Identifying development factors", was conducted through the empirical investigation presented in chapter five. The third step, "Trend and uncertainty analysis", determines whether the developmental factor is considered to be impactful and hence, qualifies for further analysis. Moreover, this step aims to further appoint and categorise which impactful development factors that are defined as trends and which are defined as uncertainties. This is followed by an in-depth analysis of the trends and uncertainties to increase the understanding of the future evolution and to find the two most critical uncertainties. These are then used to develop the scenarios in the fourth and final step: "Scenario development".

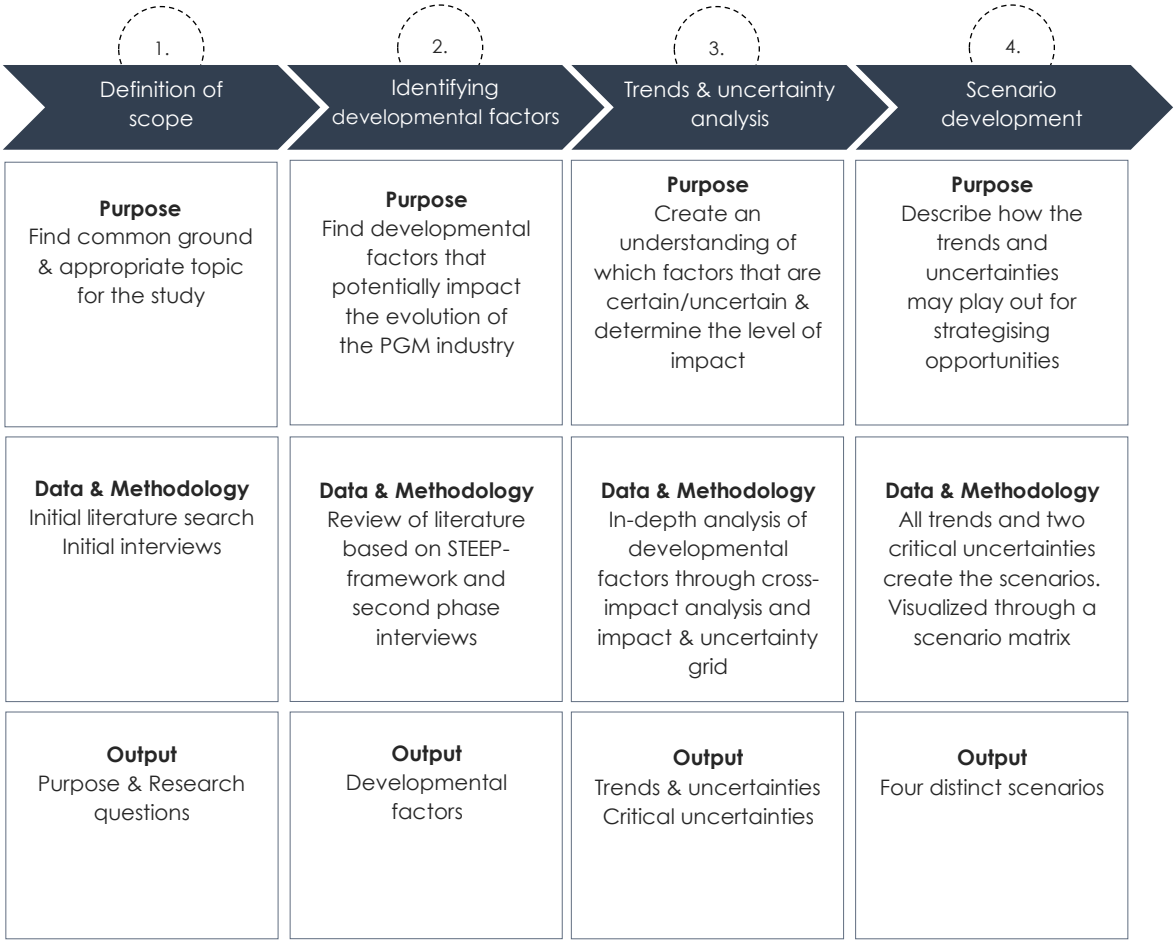


Figure 6. 1. Applied scenario analysis framework

6.1 DEFINITION OF SCOPE

The initial step in the scenario analysis is to define the scope, which corresponds to the purpose and the research questions formulated for the study. The methodology for this is described in the third chapter, 3.2 (research design). However, a brief review is presented below.

Goal of the scenario project: The primary goal of the scenario project is to generate plausible future scenarios of the Platinum Group Metals evolution within the trucking industry and how the specific OEM can manage the future uncertainties, focusing on their level of involvement in the supply chain.

Strategic level of analysis: The strategic level of analysis is deemed to be at industry level. This because the overarching purpose of the research aims at generating plausible future scenarios for the Platinum Group Metals evolution for the whole trucking industry. However, as the second research question of this study is targeting the specific OEM, implications of the different scenarios will be outlined from the perspective of the OEM.

Participants/Stakeholders: Eight respondents representing different areas of expertise.

Time horizon: Five year-horizon as it is considered to be short enough to generate probable and imaginable scenarios, and at the same time long enough for critical external changes to take place (Schwenker and Wulf, 2013).

6.2 IDENTIFYING DEVELOPMENT FACTORS

The second step of the scenario analysis is the identification of development factors. This step is based on the previous chapter, Empirical investigation, where a combination of secondary data from the literature review and primary data from the qualitative interviews, resulted in the identification of thirteen development factors. These factors, illustrated in Table 6.1, will be further analysed in the next step of the scenario analysis.

Table 6. 1. Developmental factors identified in the empirical investigation

DEVELOPMENTAL FACTORS	
1. Sustainable development 2. Control & transparency 3. Blockchain & traceability 4. Technological development 5. Innovations of autocatalyst 6. Demand evolution 7. Supply evolution	8. Price evolution 9. Global economic state 10. Circularity 11. Recycling 12. Ecodesign 13. Stringent emission control

6.3 TREND AND UNCERTAINTY ANALYSIS

The third step is to further analyse the identified development factors. This is a three-stage levelled analysis were the identified development factors first are determined as impactful or not based on three criteria outlined in 2.2 (applied scenario analysis). Development factors fulfilling these criteria will be deemed impactful and will qualify for further analysis in relation. If the development factor is not deemed impactful it will be disregarded. The impactful development factors will be further classified as trends or uncertainties with regards to the fourth criterion outlined in 2.2 (applied scenario analysis). Moreover, the trends and uncertainties interconnectedness and correlation will be analysed in-depth in the third level of analysis through the Cross-Impact analysis for the trends and the Correlation matrix for the uncertainties. The final level of analysis was the uncertainty grid, which allowed for an evaluation of the trend and uncertainties through visualisation. Moreover, it supported the visualisation of potential clusters as well as the processes of selecting the two dimensions for the scenario development

The first two criteria refer to the data collection, where the factors need to be mentioned in literature and by at least one expert. Additionally, it needs to be relevant to the scope of the study. Thus, development factors with a longer time horizon than five years and factors not applicable to the strategic level of analysis will be disregarded. All of these criteria determine the development factor as impactful or not. The fourth criterion, related to the classification of the factor as either a trend or an uncertainty, is the level of certainty for the outcome of the developmental factor. Hence, a trend is defined as a development factor brought up in both literature and by respondents and relevant for the scope, i.e. impactful, with a relatively high degree of certainty for the outcome. An uncertainty is defined as a development factor brought up in both literature and by respondents and relevant for the scope, i.e. impactful, with a high degree of uncertainty for the outcome. Illustrated by an example, the development factor of sustainable development was mentioned in literature (Swedwatch, 2013; IPA, 2013) and by Interviewee F. Moreover, it is relevant to the scope and lastly there is a consensus that audits will be implemented and that all actors in the supply chain need to implement further actions. Hence, it is considered to be a trend. On the contrary, the development factor of global economic state was mentioned in literature (IMF, 2019) and by Interviewee E and is relevant to the scope. However, the outcome is highly uncertain. Hence, it is considered to be an uncertainty.

Whether the development factors can be considered to have a relatively certain outcome or not was thoroughly discussed in collaboration with the expert interviewees. This to establish their future direction. Moreover, the analysis is based on the authors knowledge, which is gained from both phases of the gathered primary data and the secondary data. Also, additional discussion with one of the expert interviewees was carried out, to anchor the results. Table 6.2 illustrate how the identified development factors from the empirical investigation correspond with the criteria. If the development factor meets the criteria it is marked by (x), and if not, it is marked by (-). If the development factor does not meet the three first criteria, it has not been further analysed in accordance with the fourth criterion and is market by (not evaluated).

Table 6. 2. Development factors identified through empirical investigation

DEVELOPMENT FACTORS	MENTIONED IN LITERATURE	MENTIONED BY EXPERTS	RELEVANT TO SCOPE & TIME	HIGH DEGREE OF CERTAINTY
Social factors				
1. Sustainable development	X	X	X	X
2. Control and transparency	X	X	X	X
3. Blockchain and traceability	X	X	-	Not evaluated
Technological factors				
4. Technological development	X	X	X	-
5. Innovations of autocatalyst	-	X	X	Not evaluated
Economic factors				
6. Demand evolution	X	X	X	X
7. Supply evolution	X	X	X	X
8. Price evolution	X	X	X	X
9. Global economic state	X	X	X	-
Environmental factors				
10. Circularity	X	X	X	-
11. Recycling	X	X	X	-
12. Ecodesign	X	X	X	-
Political factors				
13. Stringent emission control legislation	X	X	X	X

The two development factors, Blockchain and traceability (3), and Innovations of autocatalyst (5), did not meet the three first criterion. The first as it does not meet the criterion of relevance, which is based on the lack of current application for PGM. The second as it does not meet the criterion of being mentioned in literature. Even with an iterative approach providing the possibility of finding literature related to the factor after it was brought up in the interviews, no relevant and credible literature was found. Hence, eleven developmental factors were deemed as impactful for the study and further qualified for analysis in accordance with the fourth criterion regarding their level of certainty for the outcome. Six of these factors were considered to meet the criterion of having a high degree of certainty and was thereby classified as trends. Five of these factors were considered to not meet the criterion of having a high degree of certainty and was thereby classified as uncertainties. This is illustrated in Table 6.3.

Table 6. 3. Trends and uncertainties

TRENDS	UNCERTAINTIES
1. Sustainable development 2. Control & transparency 3. Demand evolution 4. Supply evolution 5. Price evolution 6. Stringent emission control	1. Technological development 2. Global economic state 3. Circularity 4. Recycling 5. Ecodesign

Based on the classification of the trends and uncertainties, following sections will further seek to analyse their interconnectedness, correlation and implications for the PGM evolution and in extension the specific OEM. This in-depth analysis of the trends and the uncertainties will further create the base for mapping the trends and uncertainties in the Impact and uncertainty grid.

6.3.1 TREND ANALYSIS

From the development factors, six trends that will characterise the evolution of PGM were derived. All six trends will constitute the foundation of the scenarios. This as the trends have a degree of certainty of outcome but may have different level of impact on the topic as well as their interconnectedness among each other. It is essential to analyse the trends and their directions more thoroughly to reveal patterns which will hold under the scenarios. The following section aims at providing a short description of these trends and provide a deeper understanding of them through the cross-impact analysis.

Trend 1. Sustainable development: An increasing engagement from all actors in the PGM supply chain to have responsible sourcing of raw materials

The social impact of the PGM mining industry is considered to negatively impact the environment in the areas around the mines. Moreover, according to UN Guiding Principles on Business and Human Rights, companies should take responsibility to protect human rights in their entire value chain. This applies to suppliers as well as customers, which several Swedish companies have failed to do (Swedwatch, 2013). Experts confirm that the industry has been problematic but that there are several initiatives from multiple actors in the value chain pursuing increased sustainable development. As there are still room for improvements in the mining industry there is a need for further sustainable development actions. This in combination with the fact that the industry is being closely monitored, the trend of all actors in the PGM supply chain engaging to resolve the issues is evident.

Trend 2. Control and Transparency: extended requirements on control and transparency in the PGM mining industry

As pressure on increased control and transparency in the PGM mining industry intensifies through new audit processes and national laws, companies active in the supply chain need to adhere to this (IPA, 2013). Multiple respondents mention this aspect, but the complex supply chain with multiple actors having different objectives constitute a hurdle for complete

openness. Moreover, control and transparency regulations in the PGM mining industry are as of now not implemented as enforcing law, however, frameworks of sustainability principles are being developed. Wide-ranging sustainability audits such as (IRMA), and ISEAL are becoming efficient as standards which will increase the requirements of control and transparency on actors in the PGM mining industry.

Trend 3. Price Evolution: future increase in price levels and volatility
Historically, the PGM scarcity and exceeding demand has led to an imbalanced market which dually has affected the metal's price levels and volatility. The price levels have continually been increasing. Multiple scholars argue for the future scarcity in the metals. Furthermore, the researchers Sverdrup and Ragnarsdottir study (2016) confirms that the metals prices will continue to increase and continue in volatility as an effect of this.

Trend 4. Demand evolution: increased demand from emerging markets
The wide application areas have made PGM an important part of the modern society. The latest JM 2019 report confirms the historically increasing demand trend. With PGM being a "Holy grail" for the automotive industry for the cleaning of gas emission and no technology being able to replace its existence, the greater size of autocatalysts combined with the emerging markets of China and India leads to the trend of increased demand of PGM.

Trend 5. Supply evolution: the scarcity, increasing demand and lagging supply resulting in the supply not meeting demand
The PGM is a finite resource existing in the core of the earth requiring time consuming processes for extraction and refinery. Multiple researchers express concerns about future scarcity in the metal supply in coming decades. Sverdrup and Ragnarsdottir (2016) argues that PGM has experienced a level of hard scarcity were the supply is inefficient to meet the demand, leading to a market gap. Although the PGM market reports (JM, 2019) paints the pictures of increasing supply levels and experts are denying a total shortage, the increasing demand implies large difficulties in securing sufficient levels of supply.

Trend 6. Future stringent gas emission legislation globally: increased amount of PGM needed to meet the acceptable limits
Accelerated by the climate change debate, the UN sustainability goals and air quality, all world regions are expecting stricter emission legislation in the coming years. This is a fact confirmed by multiple experts and stakeholders within the industry. The exact limits are being disputed but confirmed are the stricter acceptable limits and the testing of vehicles. The European legislation is considered the to be industry leader in stringency which the world regions will follow. (JM, 2019) The emerging markets of India and China which during the coming years will leapfrog in standards adds to the trend of stringency in emission legislation which will affect the PGM evolution.

6.3.1.1 CROSS-IMPACT ANALYSIS OF TRENDS

The cross-impact analysis follows the approach of Lindgren and Bandhold (2003) and analyses the trends with the primary objective of developing a deeper understanding of their interconnectedness. This include analysis of how the trends impact one another and which trends that are considered to be driving the development of other trends. This finally highlights their combined impact on the future evolution of the PGM within the trucking industry.

Figure 6.2 visualise the interconnection between all trends, rated from -2 to 2, where 0 implies that no correlation between the trends exist. The level of interconnectedness spans from 1 to 2 for positive interconnection and from -1 to -2 for negative interconnection. Each trend is systematically put in relation to the other trends, to evaluate if a relationship exists. The trends interconnectedness is analysed in both directions, as it is possible that a relationship exists one way but not the other. As an example, the number of 2 illustrate a strong positive interconnectedness, such as the one between T3 (demand evolution) and T5 (price evolution), where increased demand also generates higher price levels. The numbers are summarised (not considering if it is positive or negative), and the trend with the highest sum in the right column is considered to drive the development of other trends. The trend with the highest sum in the

bottom row, is considered as the most dependent on the development of other trends. A further discussion on the primary driving trends and the interconnectedness will be outlined below. Furthermore, the number -2 illustrate a strong negative correlation between the trends, such as the one between T4 (supply evolution) and T5 (price evolution), where an increased supply result in lower prices as the market becomes more in balance.

	T1. SUSTAINABLE DEVELOPMENT	T2. CONTROL & TRANSPARENCY	T3. DEMAND EVOLUTION	T4. SUPPLY EVOLUTION	T5. PRICE EVOLUTION	T6. STRINGENT EMISSION LEGISLATION	SUMMARY
T1. SUSTAINABLE DEVELOPMENT		0	0	0	0	0	0
T2. CONTROL & TRANSPARENCY	1		0	0	0	0	1
T3. DEMAND EVOLUTION	0	0		-2	2	0	4
T4. SUPPLY EVOLUTION	0	0	1		-2	0	3
T5. PRICE EVOLUTION	0	0	-1	0		0	1
T6. STRINGENT EMISSION LEGISLATION	0	0	2	0	-1		3
SUMMARY	1	0	3	2	5	0	

Figure 6. 2. Cross-impact analysis of the trends (Based on Lindgren & Bandhold, 2003)

From Figure 6.2, three important relationships of interconnectedness between the trends is outlined as these are deemed to be essential to understand the future evolution. First, T3 (demand evolution) is identified as the major driving trend as it significantly impacts multiple trends, including supply evolution and price evolution. T3 of increased demand of Platinum Group Metals leads to a continued scarcity, referred to as hard scarcity, by the researchers Sverdrup and Ragnarsdottir (2016), of the metals as T4 (supply evolution) even at today's level fails to meet the demand. Furthermore, T3 imply a positive correlation with T4 (price evolution), which implies that an increase in demand also generates an increase in price level.

Secondly, it is important to highlight the interconnectedness between T6 (stringent emission legislation) and T3, where a positive correlation of 2 is identified. Further stringent emission legislation is prevalent in the near future for regions worldwide. According to multiple of the interviewees, the stricter legislations implies an increased amount of PGM needed in each vehicle in order to meet the future acceptable limits. This higher dependency of PGM results in turn in an increased demand. This is a driving relationship which was outlined by multiple of the interviewees, which in extension further spur the supply evolution and the price evolution.

Finally, T1 (sustainable development) is as visualised in the cross-impact analysis solely interconnected with the T2 (control & transparency). The trend of increased control and transparency is driving in the sense that it ultimately accelerates the trend of increased sustainable development in the mining of the metals. Other than this specific relationship, the sustainable development trend is on-going in the periphery, something that must be regarded. However, there is no interconnectedness identified, this trend is decoupled.

6.3.2 UNCERTAINTY ANALYSIS

From the development factors, five uncertainties that will characterise the evolution of PGM were derived. The following section aims at providing a short description of these uncertainties and provide a deeper understanding of them through the correlation-analysis. This to support the process of finding the critical uncertainties that will be used for the final step of scenario development.

Uncertainty 1. Technological development: What technologies will become the leading technology in the future, and within what time frame can a potential shift be expected?
New technologies are emerging, aimed at creating more sustainable modes of transportation to meet the UN climate change goals 2025. Examples of this is electromobility including BEV, FCEV and HEV (McKinsey, 2017). The technological development and their implementation rate is widely debated, some claiming that it is possible that fuel cell engines will substitute the combustion engine as the dominant technology (IPA, n.d.a) and others predict that the internal combustion engine will be the major technology used until at least 2030. Furthermore, that a combination of combustion engines and electric power sources, in different applications such as hybrids and plug-ins will be used for the next decade (AECC, 2018). Several challenges such as high cost of ownership, infrastructure and the rate of development result in several uncertain factors (JM, 2018; McKinsey, 2017). The respondents agree that a shift of technology will most likely happen in the future, where combustion engines will be substituted with another more environmentally sustainable technology. However, when that will happen and what technology that will be deployed for the different vehicles remain uncertain.

Uncertainty 2. Global economic state: What will be the economic effects in the aftermath of the Covid-19 pandemic?
After years of global economic upswing, in the late 2018 the economy started to show signs of a slower paced economic activity and weaker financial growth and stability. The year of 2020 was forecasted by the International Monetary Fund to endure a rise in economic growth in their final World economic Outlook report (2019). However, this turned out completely different as an effect of the covid-19 pandemic. The pandemic is currently turning the global economy upside-down. Multiple of the interviewees points out the global economy as a driving force in the PGM evolution. With the covid-19 paralysing the global economy, the economic state in 2020 is surrounded by great sources of uncertainty. Moreover, the economic tools to stimulate the economy are not applicable or able to aggregate activity, leaving the economic effects in the aftermath of the Covid-19 pandemic highly uncertain. The relationship between the global economic state and the PGM was highlighted by multiple of the interviewees, this raise the uncertainty of what the global economic effects in the aftermath of the Covid-19 will be, and in extension, what the effect on the PGM evolution it will impose.

Uncertainty 3. Circularity: Will this concept be implemented in the trucking industry for PGM?
Creating a closed-loop system or circularity indicate positive effects on the sustainability of PGM. As of now, there is no actor actively working towards this, which can be traced back to the complexity of the supply chain and the resource allocations needed. However, this present an opportunity to increase the sustainability rates, and to create a more secure supply. However, sources of uncertainties evolve around what actor that will be engaging in this and whom will make the investment to support this system. Moreover, there are competing technologies such as BEV challenging the creation of circularity for specifically PGM.

Uncertainty 4. Recycling: How can the recycling rates for PGM be increased?
The recycling rates of PGM in the industry are below desired rates, but a large potential for increasing the recycling rates can be identified (Hagelüken, 2012; IPA, 2013). Over the past decade, the recycling rates for platinum, palladium and rhodium have increased (JM 2010-JM 2019. Experts underline that there is a focus on recycling, and that there is an increasing demand for recycled PGM, both as a result of external pressure from customers but also through internal initiatives. Moreover, experts claim that increased rates of recycled material may potentially relieve some of the pressure of the supply and stabilise prices. This is a large incentive for taking further actions. That the industry is driving the development towards increased recycling rates is certain. However, how to further increase the recycling rates remains unclear. This as there are hurdles to overcome, such as the need for improved cooperation between participants in the recycling chain, improved logistics and authorities certifying and regulating the recycling of PGM (Hagelüken et al., 2009).

Uncertainty 5. Ecodesign: Is the concept of ecodesign going to be further applied in the design processes for emission after treatment systems?
Ecodesign is a mean in order to become more sustainable and experts indicate an increased interest for this approach. As there are already organisations employing the approach in

combination with legislative tools such as the Ecodesign Directive this indicate an increasing awareness of the benefits of ecodesign. However, as of now ecodesign is not implemented in design processes for emission after treatment systems, and experts' express hurdles to do so. Hence, how and when a potential application of ecodesign in these specific design processes is characterised by a high degree uncertainty.

6.3.2.1 CORRELATION ANALYSIS OF UNCERTAINTIES

The correlation analysis follows the approach of Schoemaker (1995) and aims to further analyse the uncertainties and to develop a deeper understanding of their correlation. Thereby determine what uncertainties and how these will characterise the evolution of the PGM. This process will further support the scenario development with a deeper understanding of the uncertainties, creating the base for answering the research question of how the specific OEM can manage the uncertainties.

The uncertainties potential relationships and impact on each other is visualised in the correlation matrix in Figure 6.3. If the occurrence of outcome #1 for uncertainty X affect the chances of occurrence of outcome #1 for uncertainty Y, a correlation between the uncertainties is evident. If the chance goes up, there is a positive correlation (+), if the chance is lowered, the correlation is negative (-). If the relation is neutral or impossible to determine, no correlation is found and it is marked with a (0) (Shoemaker, 1995). If the correlation is unclear, or could be either positive or negative, depending on how the uncertainty play out and following actions, it is marked with (+/-).

	U1. TECHNOLOGY	U2. GLOBAL ECONOMIC STATE	U3. CIRCULARITY	U4. RECYCLING	U5. ECODESIGN
U1. TECHNOLOGY		0	0	0	0
U2. GLOBAL ECONOMIC STATE			0	0	0
U3. CIRCULARITY				+	+
U4. RECYCLING					+
U5. ECODESIGN					

Figure 6. 3. Correlation analysis of uncertainties (Schoemaker, 1995)

From the correlation analysis of the identified uncertainties, it is evident that some positive correlation between uncertainties exists, however, the main part of the uncertainties are stand alone. U1 (technology) is deemed not to correlate with any of the other uncertainties and the same is applicable to U2 (global economic state). Hence, it is not identified that the technological development is impacted by the global economic state as the research and development is an important activity regardless of the state of the economy.

Positive correlations that are identified through the analysis are the uncertainties related to environmental sustainability, U3 (circularity), U4 (recycling) and U5 (ecodesign), all correlated to one another. For example, implementing circularity impose a direct positive effect on the recycling rates. Moreover, it further promotes ecodesign. This makes the correlation positive. The logic of this is that as the fundamentals of circularity is to reduce waste and design for re-use and recycling and using the resources more efficiently (Stahel, 2016). All of the uncertainties related to the environmental aspects are part of a positive spiral impacting and accelerating each of the uncertainties in the same way as exemplified above.

6.3.4 IMPACT AND UNCERTAINTY GRID

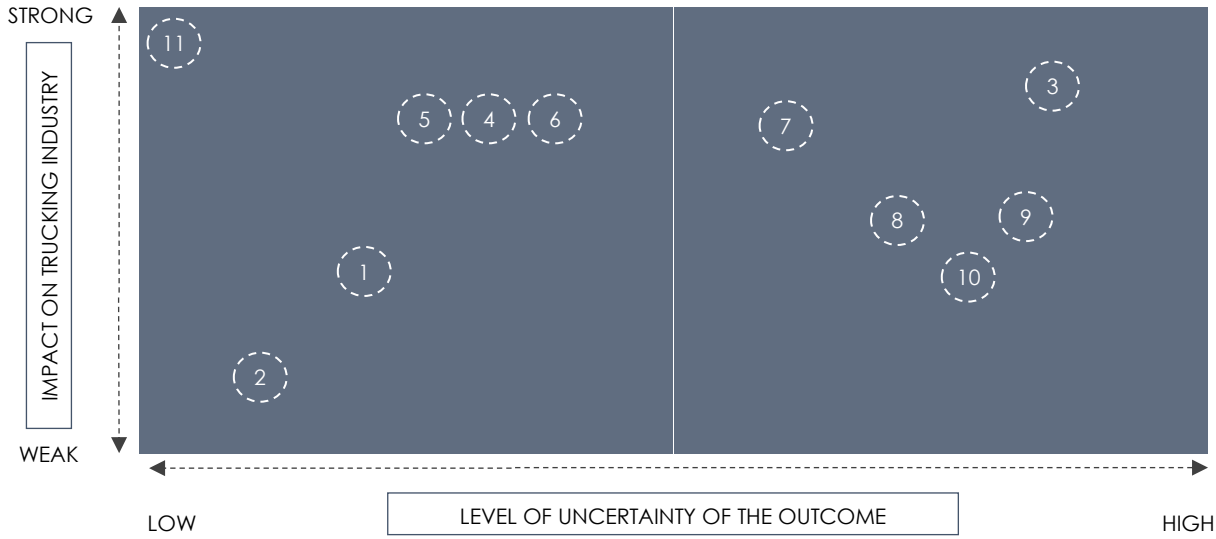
To conclude, from the above levels of analysis, it is evident that some trends are interconnected, impacting the future evolution of PGM. An exhausted supply not being able to meet the increasing demand, driven by the trend of stringent emission legislation worldwide, results in higher and more volatile prices. This is combined with an increased focus on environmental sustainability which in itself is characterised by a high degree of uncertainty regarding whom will be the leading actor, potential legislations imposing actions, and how it will affect the business, Additional uncertainties such as the global economic state in the aftermath of the ongoing pandemic and unclear technological development will also influence the evolution, and depending on the direction of development, this can have different impact in the future PGM evolution.

As the scenario analysis aims at describing plausible futures, all identified trends constitute the base for all of the scenarios. The scenario variations stem from the different interactions with each other, potentially having different level of impact and correlation in combination with the uncertainties (Schwenker & Wulf, 2013; Schoemaker, 1995). It is the outcome of the uncertainties in the scenario analysis that create the variations in each scenario. Hence, it is important to select critical uncertainties related to the topic and relating to the time horizon, in order for the scenarios to be useful (Lindgren & Bandhold, 2003; Schwenker & Wulf, 2013; Schoemaker, 1995).

As the identified development factors have been categorised as impactful or not impactful, and as trends or uncertainties, the impact and uncertainty grid in this final level of analysis developed by Schwenker and Wulf (2013) supports the further in-depth analysis of the level of impact and level of uncertainty the development factors have in relation to each other. Moreover, the impact and uncertainty grid enable a visualisation of the uncertainties which will support the selection of the most critical uncertainties for the scenario development.

All impactful developmental factors are plotted in the grid, visualised in Figure 6.4, where the impact on the trucking industry is illustrated along the y-axis, and the level of uncertainty of the outcome is illustrated along the x-axis. As this study aims to describe the future PGM evolution for the trucking industry and to generate value and insights for the specific OEM on how to manage these uncertainties, the level of impact that the trends and uncertainties will have and the degree of uncertainty of the outcome have been evaluated for the trucking industry. The level of impact on the trucking industry is considered to be the degree of transformation a developmental factor brings in relation to how the operations are currently configured. The level of uncertainty in regard to the outcome of the development factor refers to the level of predictability of the outcome.

Factors with a relatively lower degree of uncertainty of outcome and a strong impact on the trucking industry are found on the left side of the matrix, referred to as trends. Factors that are identified to have a high degree of uncertainty for the outcome and a strong potential impact on the trucking industry are found in the upper right corner, referred to as critical uncertainties. Two critical uncertainties can be used as stand-alone dimensions for the scenario development, or alternatively, multiple related critical uncertainties can be clustered into two major critical uncertainties setting the dimensions of the scenarios (Schwenker and Wulf, 2013). The mapping of the uncertainties and trends is based the cross-impact analysis and the correlation analysis, which provided a deeper understanding of the development factors interconnectedness and impact. Hence, the plotting of the respective trends and uncertainties in terms of their level of impact and their level of uncertainty are based on the authors knowledge gained from the empirical investigation. Moreover, further elaboration with one of the expert interviewees with broad PGM market expertise, increased the quality of the grid, as it provided an opportunity for additional expert insights as well as an opportunity for making appropriate adjustments. Based on the evaluation of the trends and uncertainties, the two most critical uncertainties, either clustered or stand-alone, that will impact the trucking industry the most will be derived and be used as the base for the scenario development (Schoemaker, 1995).



DEVELOPMENTAL FACTORS	
1. Sustainable development 2. Control & transparency 3. Technological development 4. Demand evolution 5. Supply evolution 6. Price evolution	7. Global economic state 8. Circularity 9. Recycling 10. Ecodesign 11. Stringent emission control

Figure 6. 4. Impact and uncertainty grid (Adapted from Schwenker & Wulf, 2013)

Based on the different levels of analysis and through this final impact and uncertainty grid, the authors argue that the uncertainty relating to new technological development (3) is the most critical as it requires the largest transformation in relation to how the operations are currently configured and that level of uncertainty for how it will play out over the following five years is high. This uncertainty cannot be bundled with other uncertainties as no correlation is found. Hence it will alone constitute one of the two axes in the scenario development. The uncertainties relating to environmental sustainability, circularity (8), recycling (9) and ecodesign (10) can be clustered as they have a positive correlation that can be derived from the fact that these relate to a common phenomenon. The authors argue that their accumulated impact on the trucking industry outcompete the other uncertainties, making this cluster the second critical uncertainty.

Scenario dimension #1- Relevance of PGM as a result of new technological development
One of the critical uncertainties for the future evolution of the PGM within the trucking industry is the new technological development. This dimension is based on U1 (new technological development). There is no doubt that PGM will be used for at least five years, the two opposites of the dimension rather describe how much resources that will dedicated towards the operations connected to PGM, such as innovations, development, purchasing, etc. In one end, PGM is becoming less relevant due to the rapid technological development, promoting battery electric vehicles. In the other end, combustion engines will be the dominant technology for a long time, supported by the introduction of new technology including both fuel cell electrical vehicles using PGM and battery electric vehicles. These two different outcomes will have a large impact on industry dynamics as it might impact both the supply chain configuration as well as the business operation design for truck manufacturers.

Scenario dimension #2- Sustainability focus of PGM
The second dimension that will impact the future evolution of PGM within the trucking industry is based on the clustering of the interconnected environmentally sustainable uncertainty aspects of U8 (circularity), U9 (recycling), and U10 (ecodesign) as stated in the previous section. All of which has been deemed to have a positive correlation. Multiple expert respondents argue that the sustainability focus is influencing the entire industry, moreover that the sustainability focus is intertwined with the economic objectives of the future setup and strategy of PGM for the specific OEM. The supplier code of conduct and the request of recycled materials indicate an ambition towards a more sustainable sourcing of PGM. However, more clarity, transparency and further initiatives are asked for to increase sustainability focus. The question of whether economic objectives and sustainability objectives are mutually exclusive or compatible is essential and can shape the future in two different futures. Additionally, the question of which actor that will drive this sustainability movement is incorporated. Is it the OEM or the actors further up in the supply chain which should engage? A high degree of uncertainty regarding how and to what extent sustainability will be influential and included in the future strategy and setup of PGM is evident.

6.4 SCENARIO DEVELOPMENT
The scenario development aims at fulfilling the purpose of the study by creating four plausible scenarios describing the platinum group metals evolution for the trucking industry in five years. Additionally, as this study also aims to create value and generate insights for the specific OEM, the implications of each scenario will be outlined from the perspective of the specific OEM in a narrative storyline.

Based on the trend and uncertainty analysis, six trends are setting the direction for the future evolution of the PGM and will have an impact in all scenarios. Furthermore, four out of five uncertainties are generating the two scenario dimensions, each put to the extreme value to illustrate two widely different outcomes. The remaining uncertainty (U2, global economic state) is present as a part of the analysis of the scenarios. The scenarios are visualised in a scenario matrix, based on Schwenker and Wulf (2013), visualised in Figure 6.5. Furthermore, to enhance the understanding of the scenarios and to provide clarity to the readers, the scenarios are named, and a narrative storyline is developed for each scenario. This provide an understanding of how the trends and uncertainties correlate and what events that will occur in the four different scenarios, as well as outlining the implications of each scenario from the perspective of the specific OEM.

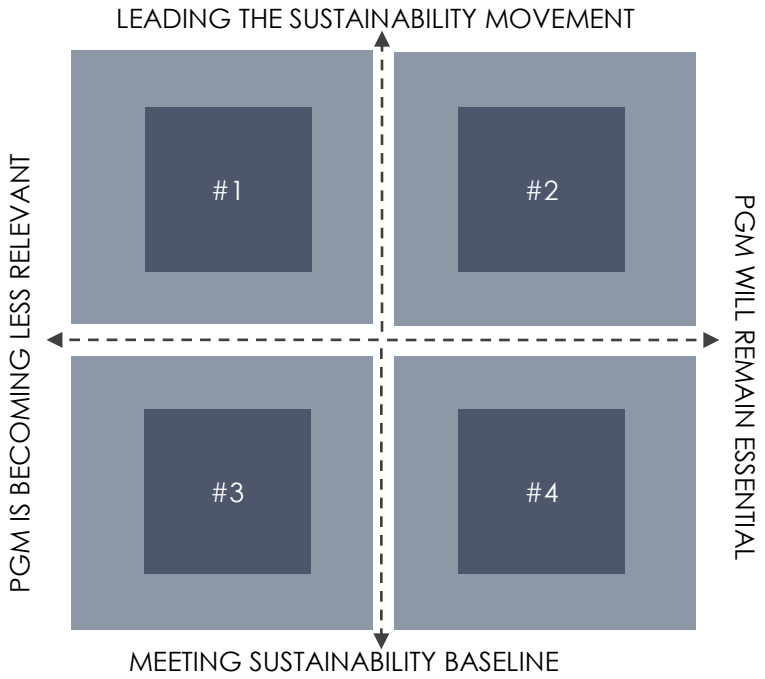


Figure 6. 5. Scenario matrix

SCENARIO #1 SUSTAINABILITY IS KING

The first scenario is characterised by an extraordinary dedication towards PGM sustainability, which permeates the entire supply chain and its stakeholders. Initiatives and concepts of circularity, ecodesign and an increased demand for recycled materials are gaining momentum, which also serve to guide the technological development. The rapid technological development within the industry has initiated the start of the long journey of shifting from the dominant technology, combustion engines, to electrical vehicles and hybrids. This slow transition will in the long term imply a decreasing relevancy of PGM within the industry.

This development, where the role of the PGM as the "holy grail" is starting to shift, implies a lower relevance for the PGM in next coming years. However, the increasing demand of PGM, driven by the importance of the PGM in the modern eras technologies, the stringent emission regulations along with the supply that fails to saturate the market, are still causing the cost of the PGM to increase both in price level and in volatility. The relevancy of PGM is starting to decrease, however, a continuous demand for PGM can still be observed, which needs to be satisfied. The increasing sustainability focus is promoting circular material flows and ecodesign, which in turn result in increased rates of recycled material. This results in less pressure on virgin material demand, as recycled material is relieving some of the pressure on the market.

The social sustainability movement, driven by the climate change is seen as an opportunity for the OEM to both lead themselves and other actors. As they have a major stake within the PGM supply chain, being a large consumer of the material, there is an opportunity to leverage this position. Through acting as the industry leader, pushing all actors along the PGM supply chain to switch to more sustainable solutions, the OEM can achieve real change. Creating closed-loop systems and designing for circularity and ecodesign is one way forward to meet the need for the demand of PGM still needed. The OEM can use the momentum to both symbolise their value as a sustainability leader causing other actors to follow and demand sustainability along the entire value chain, and also serve as means to relieve some of the pressure on supply of the material.

With regards to the technological development, it implies that the OEM will not take an active stake or engage in a higher involvement within the fragmented supply chain of PGM. Instead a sole focus on their area of expertise, which is manufacturing trucks, is likely, and additional activities related to PGM is likely to be outsourced. The resources and capabilities are therefore earmarked to the strive for pushing the actors for more sustainable solutions, hence, Sustainability is king.

SCENARIO #2- DOING GOOD BY DOING WELL

The second scenario is characterised by a technological development where combustion engines remains the dominant technology and will do for a long time. New technology including both fuel cell electrical vehicles using PGM and battery electric vehicles are introduced. However, considering a slow rate of technological development and the fact that adopted technologies still include PGM, the metals remain highly relevant. This scenario is also characterised by a dedication towards increasing the sustainability focus for PGM, which is imposed on all actors in the supply chain. The PGM evolution within the trucking industry is indicating an increasing demand for recycled material, and concepts such as ecodesign and circularity is gaining momentum. To solely adhere to baseline levels in the sustainability strive is not enough.

This development, where PGM is still highly relevant, is contributing to the increasing demand of PGM, which is also driven by the wide application areas of PGM, the growth of emerging markets and stringent emission regulations. This in combination with an exhausted supply is further intensifying the imbalanced PGM market, characterised by increasing prices, and high volatility, potentially leading to future supply shortage. However, the increasing focus on sustainability is promoting higher recycling rates and a circular approach, which potentially could relieve pressure on the market and mitigate price fluctuations. Joint efforts in the supply chain pursuing initiatives such as creating a closed-loop system or significantly increase the quote of recycled material is made possible through this clear sustainability focus. As PGM is still relevant for the OEM in the foreseeable future they need to secure their supply and manage the high cost of PGM. With the increasing sustainability pressure, the OEM need to simultaneously manage the challenges associated with becoming more sustainable.

This scenario creates opportunities for the OEM to utilise synergies of engaging in the supply chain, claiming a more active stake. Through a high level of involvement in the supply chain, the OEM can gain both economic advantages and increase their sustainability focus. Through excluding intermediaries in the procurement process of PGM, the OEM can choose their desired level of risk, and also further influence and control the economic aspect. Hence, they can purchase PGM based on internal strategic decisions, leveraging market opportunities. Moreover, through a high involvement in the supply chain, it is possible for the OEM to increase their level of sustainability. This, as higher involvement in the supply chain increase the level of transparency and support increased bargaining power.

Managing the challenges outlined in this scenario through a high involvement in the supply chain, the OEM can leverage their position. They can support both economic objectives through excluding intermediaries and gaining control, and sustainability objectives through higher transparency and influence. Hence, the opportunity for the OEM to actively work towards increased sustainability and to become a source of inspiration for other actors is presented, and by doing good they will be doing well.

SCENARIO #3- IN IT FOR THE RIDE

The third scenario is characterised by the fast-paced technological advancements and the dominating technology of combustion engines that is demanding high amounts of PGM is in decline. Electromobility and fuel cell vehicles which needs less or even no PGM amounts are becoming the dominant technology in the foreseeable future. Hence, PGM is becoming less and less relevant in the years to come. Additionally, the sustainability engagement within the industry is low, and the actors are merely engaged to meet the legislative minimum standards.

Even though the PGM is becoming less relevant for the industry, hard scarcity of PGM as an effect of the stringent emission regulations, forces the industry to increase their demand to meet the defined acceptable limits. This along with the wide application areas of PGM spur the price evolution with increasing price levels and price volatility as the supply fails to meet the exceeding demand. The baseline engagement to sustainability efforts were circularity and recycled materials fails to relieve the pressure adds to the imbalanced market. This impacts the actors within the industry and in turn the cost of the EATS, which is relevant for the OEM.

This scenario is barely news for the OEM as the increasing prices levels follows the historical evolution observed in previous decades. The OEM may manage the increasing prices through leveraging the opportunities provided by the technological advancements were less amounts of PGM is need. Resources which in other scenarios would be allocated towards sustainability systems and processes can in this scenario be dedicated towards innovating next coming technologies that will completely eliminate the PGM demand. The OEM can utilize their capabilities and strengths within their core business processes to innovate and optimize the amount of PGM used in each fuel cell engine. Moreover, this scenario implies that the OEM will adhere to a low engagement within the supply chain and assign a strategy of outsourcing the PGM procurement. This as resources solely should be directed towards the sunrise technologies demanding less or even no PGM. Hence, a low level of involvement in the supply chain will be evident for this scenario. Additionally, the sustainability debate of ecodesign, recycling, circularity and sustainable development is most likely to be driven by the upstream actors in the supply chain and not by the OEM itself.

In this scenario, the OEM can leverage their technological advancements to focus on their core business processes and thereby start the exit of the PGM. Resources can be dedicated to their research and development which will focus to innovate, and shift technology and the sustainability strive is led by other industry actors. The OEMS are In it for the ride.

SCENARIO #4- MONEY TALKS

This final scenario is characterised by the fact that PGM remains highly relevant, as the dominant technology for the coming five years will be the combustion engines. This is an effect of the slow-paced technological development within the industry where the technological advancements still include PGM. This in extension result in a constant or increased demand of PGM. Additionally, in this scenario the sustainability focus within the industry is low, and the actors are only engaged to meet the absolute minimum requirements imposed through regulations and legislations.

As PGM remains highly relevant for the following five years, this is heightening the pressure on the supply as the demand continues to increase. Through the low sustainability focus, no actions or resources are directed to increase the recycling rates, or to create circular material flow. Hence, the possibility to relieve pressure on the supply through increasing the rate of recycled material is non-existent. As a result, an even more imbalanced market with higher price levels and price volatility is the reality for the OEM. As PGM is one of the most expensive material-group used within the trucking industry and thereby the major cost driver for the EATS, this will have a large impact on the costs for the OEM.

In this scenario, the OEM can manage the increasing prices through engaging in a higher level of involvement in the supply chain. It is most likely that the OEM is managing the procurement of PGM themselves, hence controlling their own supply, their level of risk and ultimately the costs. Through engaging in an active role, the OEM can seize the opportunity to make smarter business decisions that can influence the costs. Additionally, initiating initiatives such as creating a closed-loop system or significantly increase the quote of recycled material is associated with costs and resources, and a joint effort from all actors in the supply chain would be necessary. As sustainability is not an area of focus, and no actors are pursuing sustainability beyond the minimum requirements, there is no incentives for the OEM to further engage in sustainability initiatives. This implies that the OEM is doing the bare minimum to meet current legislations and to satisfy the crowd.

This scenario presents the opportunity for the OEM to be in the driver's seat, controlling their supply, their costs and their level of risk, resulting in potential for savings. Working with increased sustainability is secondary and the economic benefits of a higher involvement in the supply chain is the main reason, hence, Money Talks.

7. CONCLUSIONS

The following chapter conclude the research presented in this study. It aims to fulfil the purpose of the study through answering the research questions. This is followed by suggestions regarding future research.

7.1 ANSWERS TO RESEARCH QUESTIONS

Through this exploratory and qualitative study, the impact of the Platinum Group Metals (PGM) evolution within the trucking industry in a five year-horizon has been investigated. This has been carried out through the identification of impactful development factors, established through an empirical investigation including findings from ten interviews and from reports, articles and academic papers. The following research questions have guided the research;

Research question 1: What is the future evolution of the Platinum Group Metals within the trucking industry in five years?

From the empirical investigation, thirteen impactful developmental factors were identified, shaping the future evolution of the PGM within the trucking industry. The impactful development factors categorised as trends held a strong impact on the topic and a low to medium uncertainty in regard to the outcome. The trends, which are the foundation of the evolution of the PGM within the trucking industry over a five year- horizon are; Sustainable development, Control and Transparency, Price Evolution, Demand Evolution, Supply Evolution, and Stringent Emission Regulations. The established interconnectedness between the trends outlined three important relationship. First, demand evolution is the major driving trend as it significantly impacts other trends such as the price- and supply evolution. Additionally, the increased demand steaming from the burden of the Original Equipment Manufacturers (OEMs) to meet the future stringent emission regulations, implies a future scarcity in PGM supply were the demand levels exceeds the level of supply. This leads to a continuing imbalance on the market which in turn spurs on the price evolution which will continue to increase in both price level and volatility. Finally, the trend of sustainable development connectedness with the trend of increased control and transparency in the PGM supply chain is ongoing in the periphery were multiple actors in the PGM are engaging to resolve the issues.

Moreover, the impactful development factors considered to have a strong impact on the topic and to hold a great aspect of uncertainty, qualifies into the category of uncertainties. These include; Recycling, Ecodesign, Circularity, Technological Development and Global Economic State. Clustering the three uncertainties related to sustainability result in the first scenario dimension. The increased focus on environmental sustainability, characterised by a high degree of uncertainty regarding whom will be the leading actor, potential legislations imposing actions, and the effect it will have on the business, describe a PGM evolution that could follow different paths. The second scenario dimension is the unpredictable technological evolution that will influence the evolution of PGM within the trucking industry differently depending on its outcome. The high uncertainty surrounding the global economic state will also influence the evolution of PGM within the trucking industry but is not deemed as critical.

As these factors are difficult to manage due to their unpredictable nature, with multiple potential outcomes, each affecting the evolution of PGM within the trucking industry differently, it is essential to understand their impact. Through using the two opposite values of the identified critical uncertainties, four plausible scenarios of how a specific OEM can manage the future uncertainties were generated. Both describing the future evolution of the Platinum Group Metals within the trucking industry in five years and answering the second research question of this study.

The first scenario, "*Sustainability is King*", is characterised by a high dedication towards PGM sustainability, which permeates the entire supply chain and its stakeholders. The rapid technological development within the industry has initiated the start of the long journey of shifting to more sustainable alternatives, decreasing the relevancy of PGM within the industry. The second scenario, "*Doing Good by Doing Well*", is characterised by a technological development where combustion engines remains as sthe dominant technology and will do for a long time making PGM highly relevant in the foreseeable future. This scenario is also characterised by a dedication towards increasing sustainability focus for PGM, which is imposed on all actors in the supply chain. The third scenario, "*In it for the Ride*", is characterised by the fast-paced technological advancements with developments were the dominating technology of combustion engines demanding high amounts of PGM is in decline. Additionally, the sustainability engagement is low within the industry were the actors are merely engaged to meet the legislative minimum standards. The last scenario, "*Money Talks*", is characterised by the fact that PGM remains highly relevant, as the dominant technology for the coming five years will be the combustion engines, which in extension result in a constant or increased demand of PGM. The sustainability focus within the industry is low, and the actors are only engaged to meet the absolute minimum requirements imposed through regulations and legislations.

Research question 2: Based on the evolution of Platinum Group Metals within the trucking industry, how can the specific Original Equipment Manufacturer manage the future uncertainties in terms of involvement in the supply chain?

The four plausible future scenarios outlined in this section describe the implications of each scenario for the specific OEM. As a mean to meet the implications of each scenario, the level of involvement in the supply chain will be further discussed.

For the first scenario, "*Sustainability is king",* the escalated sustainability debate in society spurs the OEMs to engage in the strive to become leader in securing a sustainable future. With regards to the technological development, the OEM should not take an active stake or engage in a higher involvement within the fragmented supply chain of PGM. Instead a sole focus on their area of expertise, which is manufacturing trucks, is likely, and the additional activities related to PGM is likely to be outsourced. The resources and capabilities are therefore earmarked to the strive for pushing the actors for more sustainable solutions, hence, Sustainability is king.

In the second scenario, "*Doing good by doing well", t*he PGM is highly relevant which is further driving the demand to exceed the supply. However, through a high focus on sustainability actions, recycled PGM can relieve some of the pressure on the market, potentially mitigating the price fluctuations and increasing prices. Hence, as PGM is still relevant for the OEM in the foreseeable future they need to secure their supply and manage the high cost of PGM. Moreover, with the increasing sustainability pressure, this implies that the OEM need to simultaneously manage the challenges associated with becoming more sustainable. Through a high involvement in the supply chain, the OEM can work towards multiple objectives and leverage their position to support both economic and sustainability objectives.

Characterising the third scenario "*In it for the ride,* is that the OEM is primarily focusing on innovating and improving their core business processes to meet the challenge of the volatile PGM evolution. The focus on sustainability with ecodesign, recycling, circularity and social sustainability are not considered to be the OEMs responsibility, instead it should be driven by the upstream actors in the supply chain which are spurred by the sustainability debate in society. The OEMs are dedicating their resources to innovating their next coming technology as technology in the future might shift were technologies cleaning emissions without PGM such as electromobility technology.
In the last scenario, "*Money talks",* the increasing demand of PGM and the constrained supply, create an imbalanced market. As the sustainability focus for PGM is low, requiring the actors to adhere to baseline levels, no actions are taken to increase recycling rates or create circular

material flows. Hence, there will be no relief on the market and the supply will become even more constraint. This result in even higher prices and more volatility. In this scenario, the OEM can manage the challenges through a higher involvement in the supply chain. A higher level of involvement in the supply chain create the opportunity for the OEM to control their own supply, influence their level of risk and hence, also manage the increasing costs.

All scenarios pose challenges for the OEM in terms of managing the uncertain PGM evolution. Moreover, each scenario describes a plausible development of the critical uncertainties generating different external conditions for the trucking industry, each characterised by different opportunities and challenges. The OEM can through adapting their level of involvement in the supply chain successfully manage these. These four scenarios present an overview of the plausible evolution of the PGM within the trucking industry and the implications of each scenario in terms of level of involvement in the supply based on the analysis carried out in this study.

7.2 FUTURE RESEARCH

This study has taken on an exploratory approach with the aim of providing insights in the future evolution of PGM in a five-year horizon from the aspect of an OEM. However, this topic leaves room for further investigation. The future evolution of PGM and the potential scarcity is a relatively unexplored research topic and most of the knowledge rest from outputs provided by the private sector. However, as the PGM are important components in many of our modern technologies, the potential scarcity is an important topic for future research in order to assure a sustainable development of the metals. A sustainable development were the development meets the needs of the present without compromising the ability of future generations to meet their own needs. On that note, future research within the future evolution on PGM is an important area of research. More and deeper studies concerning the future scarcity is needed. After conducting this study, the authors have observed some areas for future research which will follow.

Firstly, the scenario analysis method which guided the process of the conducted study was modified and customised to fit this specific study. This had the implications of a briefer scenario analysis were some of the traditional steps had been removed. Usually, a phase of following-up the developed scenarios after some time has passed exist. This in order to monitor the developments of the industry. This measure is the first suggestion by the authors. Moreover, assign probabilities for the four scenarios to further broaden the understanding of the likeliness of what the most favourable scenario for the specific OEM could be.

Secondly, as the research strategy of the conducted study was solely a qualitative approach, this may reflect in some shortcomings. According to the authors Bryman and Bell (2018) the quantitative approach accompanied by the qualitative approach may weigh up these shortcomings. Hence, the second suggestion is to add a quantitative approach were a quantitative analysis of the findings of the study can provide a further depth to the analysis.

Lastly, the perspective of the study has been from an organisational point of view which has impacted and limited the generalisability level of the study. Therefore, taking more of a wide spanning approach with multiple stakeholders' perspective on this topic would provide further depth and insight which potentially could contribute to a higher level of generalizability and also contribute to the scarce literature existing.

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Appendix

Appendix A- Compilation and analysis of theoretical framework

Step	Names of the step & Author	Explaination
1	Define scope (Schoemaker, 1995) Definition of scope (Schwenker & Wulf, 2013) Identify Focal Issue or Decision (Schwartz, 1996) Preparations (Lindgren & Bandhold, 2003)	Time & Scope + past analysis Framing Checklist Outside-in approach Time & Scope + past & present analysis
2	Identify Major stakeholders (Schoemaker, 1995) Perception analysis (Schwenker & Wulf, 2013) Key forces in the local environment (Schwartz, 1996) Tracking (Lindgren & Bandhold, 2003)	Stakeholder mapping 360° stakeholder analysis of Macro-Factors Micro-Factors Threats & Opportunities
3	Identify basic trends (Schoemaker, 1995) Trend and uncertainty analysis (Schwenker & Wulf, 2013) Driving forces (Schwartz, 1996) Analysing (Lindgren & Bandhold, 2003)	Micro and Macro-Factors Impact & Uncertainty ranking Macro-Factors Analysis + Scenario building
4	Identify key uncertainties (Schoemaker, 1995) Scenario building (Schwenker & Wulf, 2013) Rank by importance & uncertainty (Schwartz, 1996) Deciding (Lindgren & Bandhold, 2003)	Analysis of the factors deemed uncertain Based on critical uncertainties- Matrix Analysis of Factors Strategising based on scenarios
5	Construct initial Scenario themes (Schoemaker, 1995) Selecting scenario logic (Schwartz, 1996) Strategy definition (Schwenker & Wulf, 2013) Acting (Lindgren & Bandhold, 2003)	Based on strategy, preparedness or importance Based on importance- Matrix, volume or spectrum Core strategy + additional actions Implementation of strategic actions
6	Check for Consistency & Plausibility (Schoemaker, 1995) Monitoring (Schwenker & Wulf, 2013) Fleshing out the scenarios (Schwartz, 1996)	Compatibility test Implementation of strategic actions Elaborate scenarios through all factors identified
7	Implications (Schwartz, 1996) Develop learning scenarios (Schoemaker, 1995)	Scenario and strategy are connected Scenario and strategy are connected
8/ 9/10	Identify research needs (Schoemaker, 1995) Develop Quantitative Models (Schoemaker, 1995) Evolve toward Decision Scenarios (Schoemaker, 1995) Selection of leading indicators & Signposts (Schwartz, 1996)	Exploring blind spots Internal consistency checked quantitative Evolve decisions, develop scenarios etc. Monitoring through chosen indicators

Green = Definition phase
Red= Scenario building
Black= Additional research

Yellow= identifying factors
Purple= strategising

Blue= Analysis
Grey= Monitoring

Appendix B- Interview guide

Background to the study and presentation of who we are
Platinum Group Metals have a wide range of application areas, and the majority consumer of PGM is the automotive industry, which stands for approximately 70 percent of the gross demand. An increasing demand of these metals in all industries is causing the demand to exceed the supply, and PGM can be considered a scarce resource. This has created an imbalanced market with volatile prices. This market evolution is not sustainable in the long term. Multiple forces, trends, and technologies will shape the market evolution of PGM within the trucking industry over a five-year horizon. This is why we are conducting a scenario analysis of how the future might unfold. Scenario analysis is a forecasting method that combines all these factors and presents a range of different plausible futures to serve as a base for insights and potential strategic actions.

Purpose and realisation of interview
The interview will approximately take 1 hour to conduct, and it is aimed at exploring your view and knowledge of PGM in general, and connected to different topics such as the market, sustainability, political factors, procurement and other topics. We will mainly discuss the evolution of the PGM within the trucking industry as this is essential for the study. This interview discussions will be used in order to identify major trends within the industry as well as major uncertainties that will ultimately build the scenario analysis.

INITIAL QUESTIONS.

- Do you wish to be anonymous?
- Do you wish for the company or organisation that you represent to be anonymous?
- Do you approve that we record this conversation?
- Please tell us about your professional role and your previous experience.

PGM & MARKET FACTORS (Economic + political)

- Can you elaborate on the application areas of PGM?
- Can you describe the supply chain of PGM? (All actors, connections, partnerships, stakeholders)
    - Are there any collaboration or partnerships existing in the PGM industry?
    - What is your interpretation of the power dynamics in the industry?
- How would you describe the market evolution of PGM over the last decade?
    - In your opination, what forces have been driving this evolution?
- What do you think will be the future evolution of PGM?
    - Please elaborate on who will be affected, and how it will affect the organisations.
    - Will business be as of now or will there be any shifts?
    - Will different actors be affected in different ways?
- What do you believe is driving the evolution of the PGM within the trucking industry?
    - Please elaborate further on potential trends or uncertainties.
- In your opinion, what challenges and opportunities do you associate with PGM within the trucking industry?
- What are the market drivers for the consumption of PGM?
- How would you explain the price evolution of PGM?
    - What factors affect the price fluctuations in the PGM market?
- How would you describe that the political and legal aspects influence the evolution of PGM within the trucking industry?
- Are there any future factors that can or will affect it? How? Which actors?

PGM & SUSTAINABILITY (Social + environmental)

- Please elaborate on how you work with sustainability in regard to PGM.
- How would you describe the evolution of sustainability of PGM over the last decade?
    - In your opinion, what forces have been driving this evolution?
- How do you think the future evolution of sustainability of PGM will look like?
    - In your opinion, what forces have been driving this evolution?

- What challenges and opportunities of sustainability for PGM do you believe there is?

- Can you elaborate on existing or future collaborations between actors for the sustainability of PGM?

PGM & TECHNOLOGY

- Can you elaborate on how you work with PGM from a technological point of view?
    - Are there innovations for the catalysts minimising the use of PGM?
    - Can PGM be substituted?
    - Are there collaborations between actors in regards of the technical aspect?

- Please elaborate on your perspective and thoughts on the potential effect new technological development might have on the PGM evolution.
    - What are the potential effects?
    - When can we potentially expect new technology challenging the use of PGM in catalysts?

CONCLUDING QUESTIONS

- Is there anything you would like to add to this topic?
- Would you like to take part of the final thesis when it is done?

Appendix C- Email template

Dear,

We are two students from the School of Business, Economics and Law at University of Gothenburg, currently writing our master´s thesis concerning the topic Platinum Group Metals (PGM). We believe that you can support us in our thesis work through your knowledge and hope that you would like to participate.

Background to the research
The thesis is related to an increasing demand of PGM in all industries, causing the demand to exceed the supply. Hence, PGM is considered a scarce resource and this has further created an imbalanced market with volatile prices. This market evolution is not sustainable in the long term. Multiple forces, trends, and technologies will shape the market evolution of PGM within the trucking industry over a five-year horizon.

This is why we are conducting a scenario analysis of how the future might unfold. Scenario analysis is a forecasting method that combines all these factors and presents a range of different plausible futures to serve as a base for insights and potential strategic actions.

The interview
The interview will approximately take 1 hour to conduct, and it is aimed at exploring your view and knowledge of PGM in general, and connected to different topics such as the market, sustainability, political factors, procurement and other topics. We will mainly discuss the evolution of the PGM within the trucking industry as this is essential for the study. This interview discussions will be used in order to identify major trends within the industry as well as major uncertainties that will ultimately build the scenario analysis. No preparation is needed, and you can be anonymous if you wish.

If you find that you would like to support our thesis work, we look forward to scheduling a meeting with you, and propose following date and times;

- Week XX between 9.00-17.00

Please revert back to us with a date and time that suits you or if there are any further questions.

Best regards,
Sara Arnhjort & Karin Rundqvist

Appendix D- Example of thematic analysis

First step of thematic analysis		Example	Second step of thematic analysis
Code	Predetermined theme (STEEP)	Interview 03-03-2020 (Interviewee G)	Emerging theme
Yellow	Social		
Pink	Technological		
Red	Economic	Yes, it is scarce, and you cannot solely mine it you always get it in a combination and there is a physical limit in rhodium globally. There is a physical demand for rhodium and in my experience, this is the first time that we see something happening where we are reaching physical limitations more than the price speculations. And you cannot open a new mine in a year. You need several years to even expand and open mines.	Supply evolution Demand evolution
Green	Environmental		
Blue	Political	Other thing is that the regions such as India Asia pacific are for the first time introducing a serious legislation on gas emission so there is an additional demand on the catalysts and in china there is a stricter legislation on exhaust gases so yes it good for the coaters and for the substrator so that is what we say that with less combustion cars.	Stringent emission legislation