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The Exploration of the Combined Application of Risk Management and Scenario Planning: Taking Chinese Electric Vehicle Manufacturers as an Example

Futures Studies
Master's thesis

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☐ **I have not used any AI-based tools.**

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Abstract

Electric vehicles (EV) are promising in addressing global warming issues, with China being the manufacturing hub. However, various risks exist for Chinese EV manufactures, and it is necessary to identify main risks that pose threats to the entire industry. The aim of this study is to identify the main risks for Chinese EV manufacturers by 2035 and corresponding strategies through the integration of two frameworks, which are risk management and scenario planning.

The research follows processes of one standard - ISO 31000 risks management. First, the horizon scanning through the PESTEL (Political, Economic, Social, Technological, Environmental, Legal) method is applied for the risk identification; then two high-level risks are selected based on risk analysis results for the scenario planning process. Four distinctive scenarios are constructed based on two risks with one additional wild card scenario. The results show that two main risks for Chinese EV manufacturers are 'disruptions in supply chains of battery critical minerals' and 'mismatches between technology breakthroughs in batteries and charging infrastructure', then risk management strategies are developed for all scenarios.

The conclusion in this study is that the risk management practice can be well integrated with scenario planning process for the development of Chinese EV manufacturers thorough strategic flexibility, and scenarios extend traditional risk management beyond the operational level into strategic planning.

Keywords: risk management, scenario planning, electric vehicles, Chinese electric vehicle manufacturing industry, horizon scanning, strategic flexibility

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1. Introduction

1.1. Background

According to the International Energy Agency (IEA), greenhouse gas (GHG) emissions from fuel combustions have risen by nearly 48% from 2000 to 2023 (IEA 2025a). Fossil fuels, such as oil and natural gas, are responsible for GHG emissions, including carbon dioxide, which accelerate global warming. In light of this issue, the development of renewable energy has received great attention. Among the renewable energies, ‘electrification’ sees great potential in helping to alleviate global warming. Since electric vehicles (EV) are pivotal to electrification and emissions mitigation, the development of EV has attracted the attention of many countries in recent years (IEA 2024, 25). Global EV sales increased by 3.5 million to 17 million globally from 2023 to 2024, with developing economies experiencing a huge increase, and China accounts for nearly half of all vehicle sales in 2024 (IEA 2025b, 10). China also accounts for more than 70% of EV production, being a manufacturing hub (IEA 2025b, 12). Together with the target of carbon peaking in 2030 and carbon neutrality in 2060 proposed by the Chinese government (Wang et al. 2021, 720), China has seen the strong potential of EV and has been dedicated to investing in EV production to achieve the sustainability goal. As a result, many manufacturers in China have dedicated themselves to developing EV in response to market trends, and the EV manufacturing market become competitive due to the proliferation of EV manufacturers, with the number of EV manufacturers rising from about 30 in 2015 to nearly 100 in 2022 (Xing et al. 2023, 154).

However, risks exist in EV manufacturers, ranging from policy risks to self-innovation risks, consumer acceptance risks, etc. It is important to manage those risks within a comprehensive framework. When facing these risks, enterprise risk management (ERM) practices can be applied to enhance manufacturers’ resilience. Adopting ERM can help EV manufacturers to systematically identify and address those multidimensional risks. As a result, the application of ERM practices should be explored in EV manufacturing industry in China. To further explore uncertainties in the EV manufacturing industry and how risks evolve over the next decade, scenario planning can be used in combination with ERM to prepare organizations to be adaptive and to develop strategies. Therefore, in this thesis, I aim to explore the integration of one ERM framework with scenario planning to examine potential risk landscapes and identify strategies for Chinese EV manufacturers by 2035.

1.2. Current EV manufacturing landscape in China

The structure of EV manufacturing is changing rapidly and forming a hierarchical market structure. The leading company, BYD, recorded sales of over 3 million New Energy Vehicles (NEVs) in 2024, accounting for one-third of the domestic market (Zhang 2025). Other Startups, such as Li Auto and NIO, have enhanced industry competitiveness by launching products covering a wide price range to balance the investments in their charging technology. However, some marginalized followers do not perform well in both core technologies and high-cost-effectiveness products; therefore, they are experiencing survival pressures (China International Public Relations Association 2026). The market share of China's NEV production is shown is Figure 1.

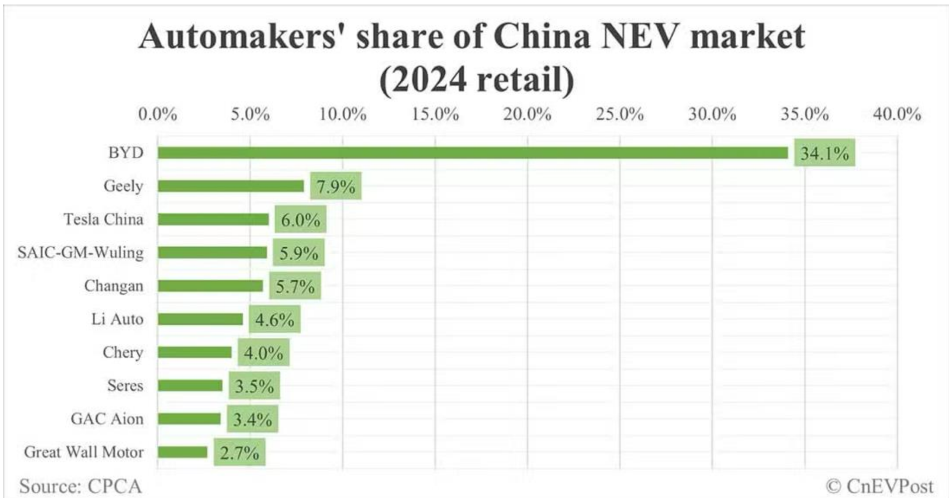

Figure 1. Market share of China's NEV production (Zhang 2025)

As shown in Figure 1, BYD is dominant in sales, with sales four times those of the second place. Moreover, 9 out of the top 10 manufacturers in the chart are Chinese local brands, with the exception of Tesla. In addition, competition intensifies with more than 100 EV manufacturers in China, and most manufacturers face declining profits despite the rising sales (Reuters 2025). Meanwhile, the two factors currently affecting customers' purchasing behavior in China are battery prices and charging networks, and many manufacturers are exploring business models for charging that align with their products. In addition, technological development remains unstable due to ongoing upgrades, pushing manufacturers to work on product differentiation and customer experience enhancement.

Furthermore, Chinese EV brands face stricter export restrictions, which result from higher tariffs and more stringent battery standards (Xiao et al. 2025). Last but not least, although the development of EV benefits from government support, new legislation still needs to be formed regarding new technology. For example, driverless vehicles are challenged by the public due to safety concerns. (Xiao et al. 2025).

On the other hand, the EV manufacturing industry is complex, with vehicle manufacturers at its core. Battery industry performance for EV plays a key role in the whole industry's efficiency and customers' choices. It can be judged that Chinese vehicle manufacturers are not often engaged in battery production and rely on batteries from specific battery suppliers. However, some EV manufacturers are engaged in battery manufacturing to some extent by strategic cooperation and joint R&D to customize battery products compatible with their vehicles. For instance, BYD's Blade Battery is developed totally independently through the insistence on R&D and manufacturing of core industrial equipment (BYD 2025a). The situation demonstrates that seemingly disconnected production processes in EV manufacturing in China are in fact interconnected, forming a highly interactive industry, as shown in Figure 2.

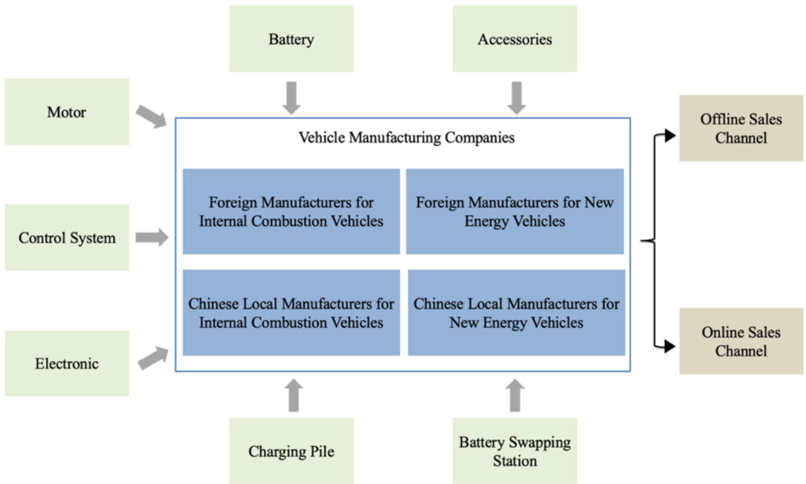

Figure 2. A schematic diagram of the NEV industry chain centered on vehicle manufacturers (Adapted from Xiao et al. 2025)

1.3. Research objectives and questions

This research aims to explore the integration of enterprise risk management (ERM) and scenarios to enhance the ability to manage risks for EV manufacturers in China from a holistic perspective, and the detailed objectives are listed as follows:

• Identify the main risks for EV manufacturers in China by 2035

As Masini pinpointed (1993, 32) that "in futures studies, the temporal dimension is closely related to the area being considered". Therefore, I choose the time horizon for my study based on several factors. First, I have realized that the EV industry is evolving rapidly across several aspects. For instance. I have analyzed several policies that were released both by the Chinese government and other official organizations. For example, China plans to build a modern energy system for the transport sector by 2035, when EV will become the new mainstream of vehicles (the State Council of the People's Republic of China 2025). In addition, the State Council of the People's Republic of China also announced the New Energy Vehicle Industry Development Plan (2021-2035) (IEA 2023), which stressed the collaborative development of EV with other fields such as energy production, traffic, and information technology. IEA (2025b) released projected data on EV trends, including EV sales, battery demand, and electricity demand, all of which are projected for 2030 based on data from 2020 to 2024, covering a 10-year time horizon. The time horizon for EV development in China was also referred to by scholars. Chen et al. (2023) conducted scenario analyses of NEV in China with a time horizon by 2050, and EV sales are estimated to peak around 2035.

Therefore, I choose 10 years as the time horizon of my thesis, not only the year 2035 is a critical point for EV development in China, but also a 10-year time horizon is distant enough to unveil changes of risk in many aspects, such as technology, policy, and market.

• The application of scenarios in ERM for Chinese EV manufacturers

The risk management and scenario planning processes can be combined to help organizations be sustainable and resilient over the long term. The strong interconnection between the two disciplines has been explored by some scholars. For example, Luís et al. (2021) have used risk assessment combined with scenario planning method in futures studies for long-term strategic planning, and they have argued that the combination of risks and futures methods can be complementary for organizations to make strategic decisions under uncertainties. The proposed integrated risk and futures framework is shown in Figure 3. They have conducted a strategic risk assessment, evaluated the long-term impacts of identified risks, and then formed strategies to manage interdependent risks. Although the article emphasized risks aligned with corporate strategic objectives, it offered insight into establishing a link between risk management and futures studies, and it also excited me to explore risk management strategies in the face of uncertainties.

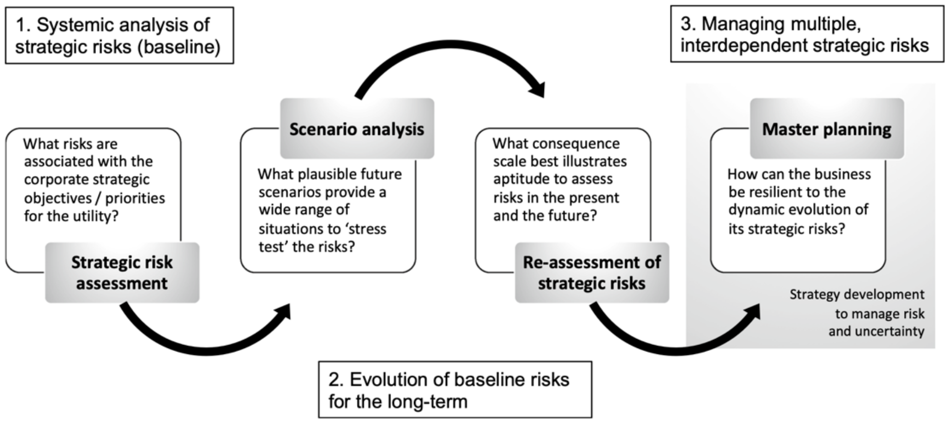

Figure 3. A schematic diagram of the NEV industry chain on vehicle manufacturers (Luís et al. 2021)

Additionally, to explore the company's adaptation strategies for climate change, Molarius et al. (2015) have integrated scenarios and risk-based methods, considering the uncertainties in climate change scenarios and perceived risks. The risk study method can be scenario-based or classical risk-analysis-based, and it relies on the planning period. As presented, the risk-analysis-based approach focuses on a shorter planning period than the scenario-based approach. It is reasonable use two methods combined in my study, given a 10-year time frame and the purpose of forming strategies for companies. However, it should be noted that although it is advisable for Chinese EV manufacturers to adopt strategic planning given the time scale, other planning methods might not work for them, but in the given article's context.

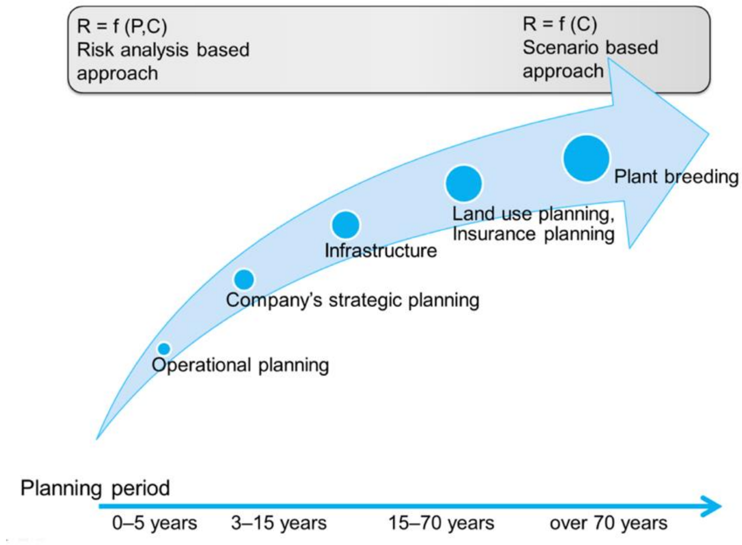

Figure 4. A schematic diagram of the NEV industry chain centered on vehicle manufacturers (Molarius et al. 2015 1022)

Bruaset and Sægrov (2018) have used a multiple-scenario approach for envisioning plausible futures in a case study in Norway. They have developed different scenarios and their potential consequences because they believed that long-term risks can be explored based on scenario analysis. Meanwhile, they have concluded that a combination of quantitative and qualitative methods is ideal in choosing representative scenarios. I agree with the role of scenarios in detecting risks, but conversely, I aim to use identified risks to build scenarios in this study, ensuring each is based on observed vulnerabilities of the Chinese EV manufacturing industry.

The applications of scenarios with risk management are applied in the cases above; however, such an integration in the Chinese EV manufacturing industry has not fully explored by others, and it is of great significance, since it helps manufacturers to be aware of the many possible results that risks may engender instead of a single one.

• ***The strategies EV manufacturers in China can take in the face of potential risks***

The role of scenarios in risk management should not be ignored (Fotr et al. 2015, 91), as they can provide organizations with contingency plans and early warning systems to act proactively. Indeed, as Ralston and Wilson (2007, 150) noted, scenarios can be used to evaluate specific strategies for organizations through risk assessments. It means that scenarios are not always about the description and narratives of possible futures, but powerful tools for organizations to discern gaps between scenarios and strategies. By forming scenarios, organizations can test their vulnerabilities and develop strategies to be resilient when facing unforeseen risks. Therefore, scenarios can be integrated into the risk management process, as they link the present and futures logically and can help organizations explore potential risks they may face, providing insights into changes in risk and thereby enabling effective measures to cope. Therefore, developing strategies through scenarios prepares Chinese EV manufacturers to act promptly in the face of risk changes.

Based on the objectives, the following questions will be explored in this research:

- *What are the key risks for Chinese EV manufacturers by 2035?*
- *What are the risk- oriented plausible futures for Chinese EV manufacturers in 2035?*
- *What risk management strategies can be formed both generally and specifically for each scenario?*
- *How can scenario planning facilitate risk management for Chinese EV manufacturers?*

1.4. Thesis Structure

The thesis contains 8 chapters. Chapter 1 is the introduction, which includes the background of choosing the topic, as well as research objectives and questions. Chapter 2 discusses the theoretical frameworks that I use for the thesis. The theoretical frameworks comprise two parts, namely ERM and scenarios. I am exploring the potential of combining two frameworks in my research. Chapter 3 is the methodology, which illustrates how my research proceeds. This chapter also states the reasons for my data collection method. Chapter 4 is the risk identification for EV manufacturers in China. In this part, I will use the PESTEL method to identify external risks affecting the mentioned organizations, and then use a risk matrix to identify two risks highly relevant to the Chinese EV manufacturers. Chapter 5 is the scenario planning process. Four scenarios will be formulated based on the two risks assessed in Chapter 4, and one additional wild card scenario is also constructed by selecting another risk factor. Chapter 6 presents the risk management strategy for each scenario, providing concrete actions ahead for the organizations to take in the face of risks. Chapter 7 discusses by incorporating general managerial implications for manufacturers and the coupling effect of risk management and scenarios. Chapter 8 is the conclusion section, which summarizes the analysis findings and provides further research directions, together with ethical considerations.

2. Theoretical Framework

2.1.1. ERM framework

Enterprise risks contain a variety of factors that influence an organization's activities, processes, and resources (Olson & Wu 2008, 4). Risks arise from both external (e.g., economic changes, financial market developments) and internal factors (e.g., human error, production disruptions, and system failure). Nocco and Stulz (2022, 82-83) pointed out that ERM can create value for shareholders and deliver both macro- and micro-level financial benefits. ERM can be seen as a measure to protect a company's ability to fulfill its business plan. Bromiley et al. (2015) conducted a review of the literature on risks and ERM to encourage management scholars to contribute to ERM, noting that ERM-related articles largely appear in accounting and finance journals. Indeed, ERM should be integrated with a company's management practices, since Olson and Wu (2008, 5) suggested that ERM views risk in the context of business strategy, while traditional risk management views risk as individual hazards. Therefore, ERM should be incorporated throughout the entire value chain rather than partially existing. Although Bromiley et al. (2015, 273) stated that ERM should be a common practice, how can ERM practices be formed and then utilized to help companies become sustainable? The answer to this question becomes increasingly obvious from the following scholars' statements.

Ahmad and Teo (2024, 294) concluded that ERM is especially important for Small and Medium Enterprises (SMEs), as they often face obstacles, such as limited financial support and a lack of risk management expertise. They also presented a real-life case (a mid-sized European automotive components manufacturer) to illustrate the successful implementation of ERM practices. Although they believed that SMEs have difficulty adopting ERM practices, large companies also face the challenges. For instance, companies with several branches and factories in different locations may experience logistics issues if products from one place cannot be delivered to another place for assembly, which may not be encountered by SMEs. Therefore, ERM challenges bring both large and SMEs challenges. On the other hand, even if one example was presented in the mentioned article, risk landscapes differ across industries, so there should be an analysis for a specific industry regarding ERM (Ahmad & Teo 2024, 305). Jonek-Kowalska (2022) emphasized the importance of ERM's effectiveness. He stressed that risk management effectiveness can be assessed for the company as a whole, and this should always be a part of risk monitoring and control during the management process. The determinants of risk management effectiveness include behavioral determinants, such as risk perception and attitudes towards risk, and endogenous determinants, such as risk management process and methodology. For a company, both determinants are crucial; behavioral determinants help companies build a risk management culture for all employees, while endogenous determinants provide risk management personnel with instructions and procedures to systematically manage risks (Jonek-Kowalska 2022, 23-31 & 35-47). Olson and Wu (2008, 46) highlighted the necessity of ERM in supply chains for companies, because many uncertainties pose both external and internal risks, with external risks including nature, political system and competitors, and internal risks including available capacity, internal operation and information system. They also believed that the ERM framework is the prerequisite for organizations to accomplish objectives smoothly. Therefore, what are the frameworks for ERM? What kind of framework should a company choose to fit in with its strategy?

There are different frameworks for ERM, with four frequently used ones including ISO 31000, COSO-ERM, NIST RMF and COBIT (Efe 2023, 186). COSO-ERM was developed by Committee of Sponsoring Organizations of the Treadway Commission, which emphasizes five components: governance and culture, strategy and objective setting, performance, review and revision, and information, communication and reporting (Efe 2023, 193). Although the framework highlights the integration of strategy with risk management, it focuses more on internal governance with limited attentions on organizations' operational environment. For example, it is widely applied in financial services industry to improve internal communications among different levels of management (Efe 2023, 195). Other two frameworks including NIST RMF (National Institute of Standards and Technology) and COBIT (Control Objectives for Information and Related Technologies) are related to information security risks and information technology respectively, which are not align with my study focus. In contrast, ISO 31000 is suitable to adopt in my study's context. It was introduced by International Organization for Standardization (ISO). First, it has established the basic principles of risk management, and the standard can be flexibly used regardless of the size of organizations, operating sectors, or types of risk, such as in aerospace, healthcare, energy, and construction industry (Efe 2023 197), since it is formed based on the ideas from different domains (Flaus 2013, 44). This harmonization enables many organizations to implement the standard universally. Meanwhile, the three main components in ISO 31000 are risk assessment, risk treatment, and risk monitoring, with risk assessment involving identifying, analyzing, and evaluating risks (Efe 2023, 188). The process is highly compatible with my focus in this study, as it considers risks in external operational environment and risk dynamic evolution, confirming that risk management is a prerequisite of decision-making. In short, ISO 31000 suits best in the study.

Flaus (2013) has thoroughly analyzed ISO 31000 from socio-technical and industrial systems' perspective. First, he put forward the definitions of 'risk', and several are presented as follows (Flaus 2013, 21):

• Risk is the combination of the probability of an event and its consequences.

• Risk is the uncertain consequence of an event or an action on something with a given value.

• Risk is defined as a set of triplets $<S_i, P_i, C_i>$, where S_i is the ith scenario, P_i is the likelihood of S_i, and C_i is the consequence of S_i.

The general risk management process is shown in Figure 5:

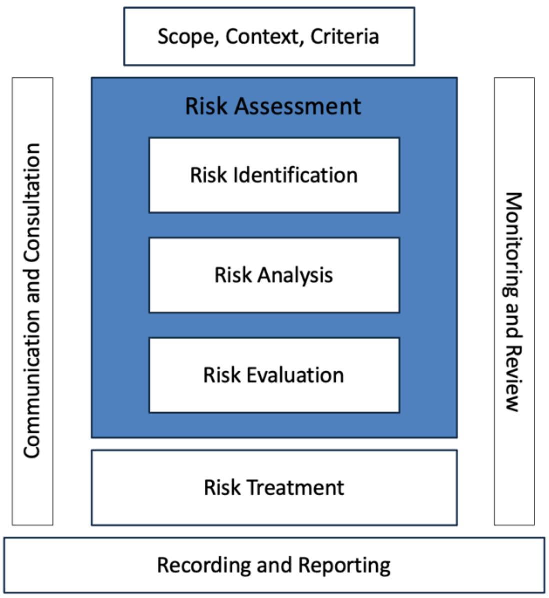

Figure 5. The risk management process (Adapted from ISO 2018)

1) Scope, Context and Criteria

This process is the base for the following risk assessment, and the following four processes should be defined:

• External context. This includes the regulatory and legal context, the social context, and the involved stakeholders and their views.

• Internal context. This includes an organization's strategic goals, cultures and values, internal resources and abilities, existing information flow process, internal policies, and decision-making mechanism.

• Risk management process. This includes goals and objectives, the target and responsibilities of the risk management process, and the risk management entity's position within the organization.

• Risk assessment criteria. This includes methods to determine the level of risk (likelihood and importance of consequences), the level at which a risk may be considered tolerable, and the possible consideration of a combination of several risks.

2) Risk assessment

• Risk Identification

As risk identification is the first and an important process in ISO 31000, it is about creating a list of risks sources, impact areas, the possible causes and consequences of risk events (Hutchins 2018). Some risk identification tools are listed in Table 1.

Table 1. Risk identification method (Adapted from Hutchins 2018)

Sources	Descriptions
SWOT analysis (Strength, Weakness, Opportunity, Threat)	Commonly used as a planning tool for analyzing a business, its resources and environment both internally and externally
PESTEL (Political, Economic, Social, Technological, Environmental, Legal)	Commonly used as a planning tool to identify and categorize threats in the external environment
Brainstorming	Creative technique to gather risks by group members who verbally discuss in a 'no wrong answer' environment
Scenario analysis	Uses possible future events to anticipate how threats and opportunities might develop
Survey/Questionnaires	Gather data on risks. Surveys rely on the questions asked

Among the sources, PESTEL analysis is a useful tool for identifying an organization's external risks, and it is also one of the useful risk visualization methods (Institute of Risk Management 2018, 19). PESTEL exhibits foresight, as it helps to discern long-term risks that form trends (such as policy changes, technological innovation, etc.). Plus, it focuses on the combination of organizations' strategies and external environment, preparing organizations to be alert and agile in the face of change. PESTEL analysis is strong in foresight, as emerging risks can be identified through trends in certain areas. Besides, the straightforward configuration of the framework is easy to understand for people who are not familiar with the concept, and therefore, if used in an organization, PESTEL analysis can be completed by people from different departments.

• Risk Analysis

The aim of this process is to estimate the level of risk, and two parts are included (Flaus 2013, 48):

i. The likelihood value of the effect linked to this risk
ii. The importance of this effect, which is characterized by its severity.

Basically, according to the triplet mentioned earlier <S_i, P_i, C_i>, one scenario could incur many consequences. For instance, in a scenario of a person falling, the consequence can be defined by {bruising, reversible injury, irreversible injury, death}. Normally, the most representative consequence here is the reversible injury, and as a result, the likelihood and severity of this consequence are selected to determine the level of a person's fall (Flaus 2013, 64).

The likelihood and severity of a risk can be assessed both quantitatively and qualitatively. Quantitative risk assessment provides a way to determine the likely impacts of an activity, and therefore evaluate whether the risk is acceptable or tolerable. It also allows for the calculation of values for direct comparison of risk levels. (Aven 2011, 2)

In the quantitative assessment for likelihood, a probability value is given. However, in an organization, it is rare to see the same risk recurring. As a result, the probability is determined by the opinion of experts, so it is often hard to calculate the exact probability. In the quantitative assessment for severity, the most widely used indicators is in workplace accidents, it is called the fatal accident rate (FAR) (Flaus 2013, 69):

$$FAR = \frac{Number\ of\ death\ observed}{Number\ of\ hours\ of\ work} 10^8$$

However, although death could happen in many industries, not all risks will generate accidents, and not all accidents will cause people's deaths. In an organization's operations, losses stemming from a single risk can take many forms, including financial losses, time losses, reputation damage, and environmental damage. Therefore, it is not ideal to use this equation to assess severity for all types of risks in an organization.

The qualitative method can be used to determine the severity of a risk, and the severity level is described using words expressing degree, such as catastrophic, critical, marginal, and negligible. One example of the severity of levels is shown below:

Table 2. An example of the description and level of severity with concrete losses (Adapted from Flaus 2013, 24)

Description and level		Consequences of the undesirable event
Catastrophic	**1**	May produce one or more consequences of the type: • death, total permanent handicap, irreversible injury • significant environmental impact • financial loss greater than or equal to ten million dollars.
Critical	**2**	May produce one or more consequences of the type: • partial permanent handicap, work-related injury or illness leading to the hospitalization of at least three members of staff • significant, but reversible, environmental impact • financial loss greater than or equal to one million dollars but less than ten million dollars.
Marginal	**3**	May produce one or more consequences of the type: • work-related illness or accidental injury leading to the loss of at least one day of work • moderate reversible environmental impact • financial loss greater than or equal to 100k dollars but less than one million dollars.
Negligible	**4**	May produce one or more consequences of the type: • work-related illness or accidental injury leading to the loss of less than one day of work

	• minimal environmental impact • financial loss of less than 100k dollars.

From Table 2, we can see that some quantitative measurements are still used to determine the severity level, even though the severity level itself is a qualitative indicator, especially regarding the financial loss. The financial loss can be calculated roughly in cases such as a building fire. However, this is hard to do for other risks. For instance, regarding the risk of supply chain disruptions, no one can predict the potential effects, including the number of working hours affected and the financial losses due to reduced productivity. As a result, severity can be described in a fuzzy way to reduce the uncertainty. Another example of levels of severity is presented in Table 3. It describes severity in a fuzzier way, as it does not define concrete numbers for losses.

Table 3. An example of the description and level of severity without concrete losses (Adapted from Flaus 2013, 24)

Severity level	Human impact	Impact on means of production	Impact on quality of production	Impact on quality of production
Minor (1)	No impact	No influence	No loss	No influence
Major (2)	Mission interrupted	Degraded operations	Loss which may recovered by one team	Poor quality, but may be brought up to standard
Critical (3)	Unsafe situation	Influence on product quality or on safety	Loss which cannot be recovered by one team	Products cannot be brought up to standard
Catastrophic (4)	Risk of death or physical accident	Halt to production or accident	Loss from which no recovery is possible, or risk of accident	Halt in production or accidental creation of a dangerous product

- Risk Evaluation

Risk evaluation can be done using a risk matrix that combines both likelihood and severity. One example of a risk matrix is shown:

	IS Insignificant	V1 Highly unlikely	V2 Unlikely	V3 Possible	V4 Common
G4 Catastrophic	IS	Medium	High	Very high	Very high
G3 Critical	IS	Medium	High	High	Very high
G2 Major	IS	Low	Medium	High	High
G1 Minor	IS	Low	Low	Medium	High
IS Insignificant	IS	IS	IS	IS	IS

Figure 6. The example of a risk matrix (Flaus 2013, 24)

Insignificant risks are also included in the matrix. For severity, insignificant severity means the outcome of such a risk can be ignored and will not affect the organization's normal operation. Insignificant likelihood means the risk could never happen or there has been no such example before.

Although the modeling and computational capabilities and data availability make it easier to quantitatively complete risk assessment (Zio 2018, 186), it is difficult to quantify each risk and then gather them together, because risks are diverse in a large organization, and the quantification process can be affected by both human errors and software failures. Sometimes, multiple simulations are run to test model assumptions, which is time-consuming.

• Risk treatment

There are four options for risk treatment in ISO 31000, which is referred as '4Ts' (Flaus 2013, 49):

1) Treat the risk, with the aim of reduction or mitigation. This can be achieved by reducing the likelihood or severity of the risk.
2) Terminate the risk, with the aim of avoidance. Organizations choose not to be exposed to activities that generate risks.
3) Transfer the risk. It includes the share of risks with other parties, for instance by insurance.
4) Tolerate the risk. Organizations accept the risk with consciousness.

Figure 7 shows the relations between '4Ts' and two evaluation factors of risks, and it illustrates the suitable risk treatment method under different likelihood and severity degree of risks (Flaus 2013, 49). For example, when the risk is evaluated with a high likelihood value but a very low severity level, it is advisable to take risk tolerate strategies. It is also noted that the other three risk treatment methods are applicable if both the likelihood and severity values are high. The choice of selecting risk treatment actions depends on the difficulties and cost of the plan with the consideration of regulatory and social responsibilities. Meanwhile, the actions themselves normally should not pose new risks to be effective enough. The curve in the chart represents the ‘threshold’, which means that the risk is tolerable if it falls into the area under the curve, while the risk is not tolerable in the upper area.

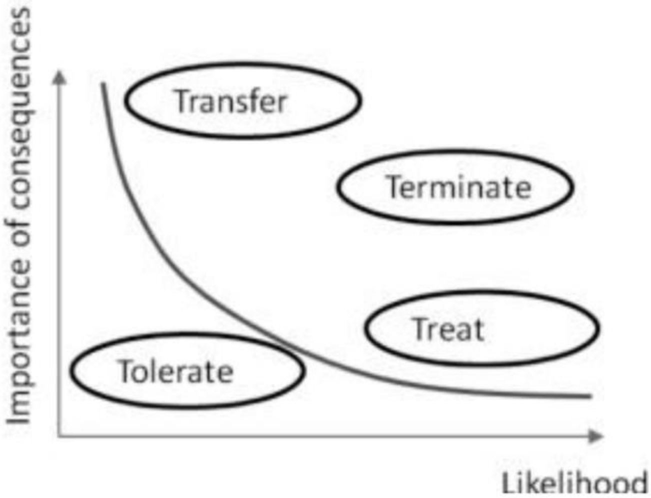

Figure 7. Treatment of risks (Flaus 2013, 49)

Although it is advisable to develop different processes to manage risks based on the characteristics of organizations (de Oliveira et al. 2017, 632), Hamir and Md Sum (2021) conducted a literature review of general risk management processes and concluded that there are four common steps: risk identification, risk analysis, risk treatment, and risk monitoring and review. Even if those four steps are frequently mentioned in many articles mentioned in the review, the importance of risk evaluation should not be ignored, since it is a prerequisite to form decisions for treating risks (Hamir & Md Sum 2021, 29).

Although literature offers frameworks and methods for ERM, gaps exist. The research mostly remains at the generic level, and the exploration of risk landscapes in specific areas is scarce, especially for the Chinese EV manufacturing industry. In addition, although empirical evidence shows that tools such as PESTEL and scenarios can be used in the risk management process, there are few sources that demonstrate the combination in a specific industry. Therefore, in order to fill this gap, the combination of ERM and scenarios for Chinese EV manufacturers should be investigated.

2.2. Scenario planning framework

Being a futures studies method, scenarios have been used for quite a long time. The history of scenarios can be dated back to the Manhattan Project, when scientists tried to predict the effects of an atomic bomb explosion. After that, other companies such as the Rand Corporation, the Stanford Research Institute (SRI), and the Hudson Institute Royal used scenarios for corporations. Scenarios were then popularized by Dutch/shell for business companies. Although interest in scenarios declined in the 1980s, it has surged again afterwards, since managers began to pay attention to the uncertainty in the business environment (Miller & Waller 2003, 94).

The definition of scenarios varies across scholars and the industries in which experts work. Fotr et al. (2015, 75) have summarized the concepts of scenarios from the views of several scholars. Scenarios offer views of alternative futures and are helpful in preparing for futures uncertainties. Meanwhile, scenarios should be constructed with the interplay between trends and uncertainties, combining qualitative and quantitative characteristics. Another definition of scenarios is that they are formed according to factors that are uncertain and have a decisive impact on the system. What is more, the interlinking of driving forces that form scenarios will both create opportunities and pose risks to the system; therefore, scenarios help identify alternative futures.

On the other hand, Börjeson et al. (2006, 725) have divided scenarios into 6 types based on the questions. They are *What will happen? (predictive) What can happen? (explorative) How can a specific target be reached? (normative)*

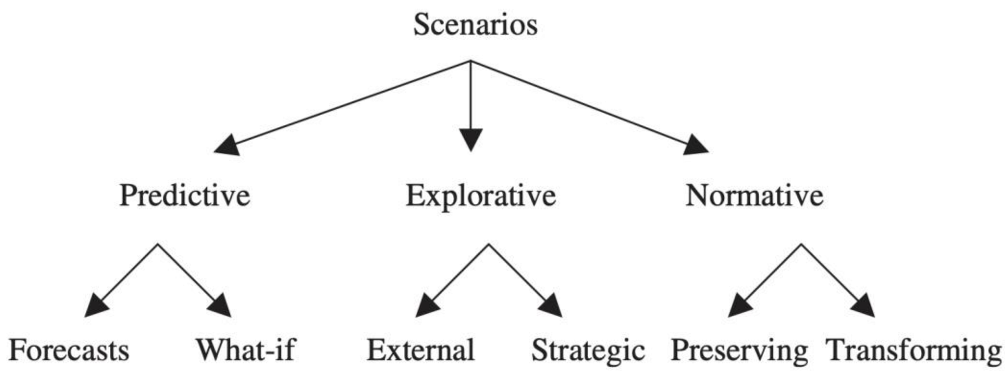

Figure 8. Six types of scenarios (Börjeson et al. 2006, 725)

The summary of key aspects of scenarios is also shown in Table 4.

Table 4. Summary of key aspects of scenario types (Börjeson et al. 2006, 736)

Summary of key aspects of scenario types

Scenario category/type	Quantitative/qualitative	Time-frame	System structure	Focus on internal or external factors
PREDICTIVE—what will happen?				
Forecasts	Typically quantitative, sometimes qualitative	Often short	Typically one	Typically external
What-if	Typically quantitative, sometimes qualitative	Often short	One to several	External and, possibly, internal
EXPLORATIVE—what can happen?				
External	Typically qualitative, quantitatively possible	Often long	Often several	External
Strategic	Qualitative and quantitative	Often long	Often several	Internal under influence of the external
NORMATIVE—how can a certain target be reached?				
Preserving	Typically quantitative	Often long	One	Both external and internal
Transforming	Typically qualitative with quantitative elements	Often very long	Changing, can be several	Not applicable

The concept of likelihood or possibility is used to estimate the outcome of scenarios in the predictive category, while a series of scenarios that provide different possible developments are presented in the explorative category, and normative scenarios focus on the objectives and search for the paths to realize them (Börjeson et al. 2006, 726-729). From my point of view, the likelihood or possibility also applies to explorative and normative scenarios. In the explorative scenarios, the likelihood is weaker than in predictive scenarios, since the aim is not to predict the most probable outcome but to explore a set of plausible futures. Whereas in normative scenarios, the likelihood is more about the feasibility of the path towards a certain target, and adjustments are necessary to achieve the goal.

In futures studies area, Minkkinen et al. (2019) have constructed a typology of six foresight frames to discern the criteria for differentiating foresight approaches. In this typology, scenaric frame is applied to explore uncertain futures by positing alternatives with no assigned probabilities (Minkkinen et al. 2019, 6). Here, the notion of ‘assigned probabilities’ requires to be clarified. It would be inappropriate to claim that a specific scenario carries no probability, since it involves multiple factors, and the effects of their interplay cannot be fully understood without systematic exploration. At the same time, it is also reasonable to claim that there is no accurate numerical estimate of the likelihood of one scenario. As a consequence, the probabilities are assigned subjectively rather than evaluated empirically through conventional statistical methods.

What is more, we can discern that scenarios can be predictive, explorative, and normative (Börjeson et al. 2006), underscoring their roles. Whereas a scenaric frame can differ from a predictive frame or a transformative frame based on the level of pursued change and perceived unpredictability. The distinctions between the two categories are not contradictory but further enhance the role of scenarios in the foresight and futures field, since they have manifested from different dimensions. From my perspective, the six foresight frameworks are not isolated but interconnected. For example, a scenaric frame can be turned into a transformative frame where the level of pursued change is stronger under certain circumstances. An organization that first applies a scenaric frame to explore possible development routes can resort to a transformative frame then if it is found that the existing pathways are becoming less viable under uncertainties. Therefore, transformative framework exhibits normative influencing by actively forming novel paths that lead organizations towards new goals. As a result, different frames are applicable in different context, and the interconnectedness among frames should also be considered when apply.

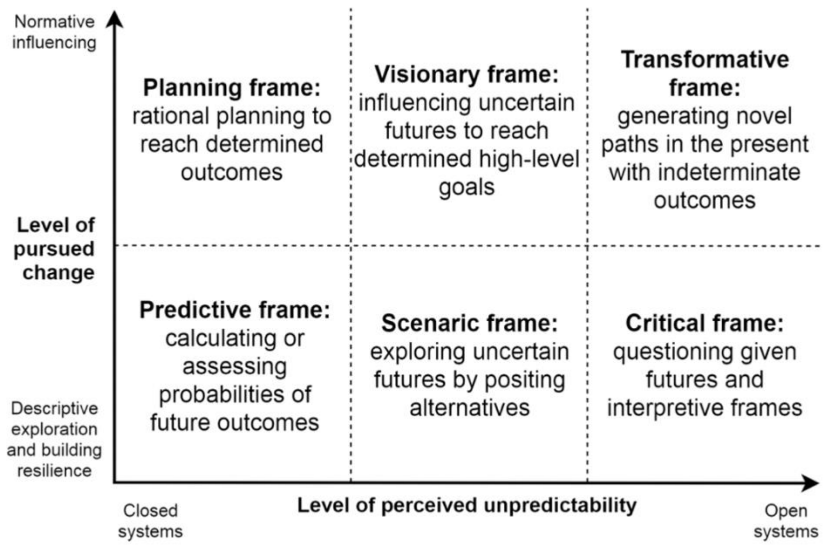

Figure 9. The typology of six foresight frames (Minkkinen et al. 2019, 5)

Scenarios have been used widely across government, business, and non-governmental organizations for many years, and they offer both individuals and organizations ways to address challenges and opportunities and to learn the potential impacts. (Cairns & Wright 2017, 1). Since futures are uncertain, a range of alternative futures should be considered to explore as many possibilities as we can (Ralston & Wilson 2007, 15). As a result, scenarios can be used to describe plausible alternative futures instead of predictions. Therefore, scenarios should be seen as the exploration of many possibilities, whereas predictions are the descriptions of what will happen, which is obviously uncertain for us.

However, uncertainties arise when facing the possibilities of futures. Scenarios can be applied to turn those uncertainties into advantages for organizations (Ralston & Wilson 2007, 18). Instead of eliminating uncertainties, scenarios teach us to 'think the unthinkable' and reduce the vulnerability to surprises, and therefore offer more flexibility, resilience, and responsiveness in this fast-changing world.

With regard to uncertainty, it emphasizes the degree to which future developments and outcomes are unpredictable (Ralston & Wilson 2007, 108), whereas risk refers to the uncertain consequences of an event or action on something with a given value (Flaus 2013, 21). In other words, risk can be understood as the manifestation of uncertainty under specific circumstances, and uncertainties can generate risks. For instance, in the EV industry, there are uncertainties regarding regulations on importing EV from China into European countries, and if there are restrictions on the imports, Chinese EV manufacturers may face risks such as financial losses. Therefore, uncertainties help us to explore potential risks and then take preventive measures beforehand.

Scenarios should be constructed following specific steps, and scholars have presented some concrete phases for the building process (Peterson et al. 2003; Ralston & Wilson 2007; Cairns & Wright 2017). Although they are different regarding the types of scenarios, several main steps are included:

1. Identify the focal issue or decision. This step should focus on the futures of trends and forces that greatly affect the organization. It should also include a link to an action that relates to strategic decisions (Ralston & Wilson 2007, 51). The focal issue in this study is how Chinese EV manufacturers remain resilience in the face of evolving risks up to 2035.

2. Identify key decision factors in the local environment. This step includes a thorough statement of focus and identifies critical areas of uncertainty that scenarios help to address (Ralston & Wilson 2007, 85).
3. Determine the driving forces. This step focuses on the external arenas that scenarios should cover, so the driving forces should be determined as inclusively as possible at the macro-level (Ralston & Wilson 2007, 87).
4. Impact/Uncertainty matrix. This step includes assessing the importance and predictability/uncertainty of driving forces and finding the forces with high impact and high uncertainty, since this will lead to different futures that show how uncertainties play out (Ralston & Wilson 2007, 109).
5. Form scenarios. This step includes selecting scenario logic first. A 2-axis structure is sufficient to form scenarios based on the factors identified in step 4 (Ralston & Wilson 2007, 119). It is reasonable to develop 3-5 scenarios for a scenario project (Amer et al. 2013, 34).
6. Scenario implications. This step includes developing storylines in a chronological order and selecting who and why of what happens. Scenario title, brief description, and narrative would be included (Ralston & Wilson 2007, 126).
7. Strategy screening. This step is to develop decision recommendations, including what the organization should do with flexibility and capacity to identify growth opportunities (Ralston & Wilson 2007, 149).

Then I will explain the reasons to select the scenario planning techniques. The processes are inspired by the SRI model from Stanford Research Institute International, and they belong to 'intuitive logics' (Ralston & Wilson 2007, 21). It emphasizes a qualitative set of plausible futures in narratives by identifying driving forces through intuition and brainstorming expert opinions. Amer et al. (2013) compared several scenario planning methods, including intuitive logics, la prospective methodology, and the probabilistic modified trends (PMT) methodology. The last two methods rely on quantitative analysis via computer simulations, and the concept of 'probability' is particularly used in the PMT methodology (Amer et al. 2013, 28). The method considers the conditional probability of the occurrence of unprecedented events. However, the concept is included in the risk assessment process to identify high risk as driving forces in scenario planning rather than as accurate calculation factors for simulation. Meanwhile, intuitive logic-based scenarios do not require computational calculations, making them easier to comprehend. Given the time limit and the need to avoid conceptual overlap, the intuitive logic-based scenario planning process is suitable for my study.

Meanwhile, the aim of building scenarios in this study is to explore ‘what can happen if specific risks are prominent in the next ten years?’ and ‘what strategic measures can we take for different scenarios?’ Therefore, the scenarios are explorative according to Börjeson et al. (2006), since they help organizations consider different development pathways and provide insights for users interested in alternative developments. This differs from normative scenarios that focus on methods to achieve a specific goal, which is not the core of my study, as I do not aim to set a common goal for all scenarios but to develop strategies with adaptability. Therefore, scenarios in my study are explorative and based on intuitive logic.

2.3. The interplay between risk management and scenario planning

Based on the risk management process of ISO 31000 and the scenario planning process, I aim to explore the interplay between the two frameworks. The schematic illustration is shown in Figure 10.

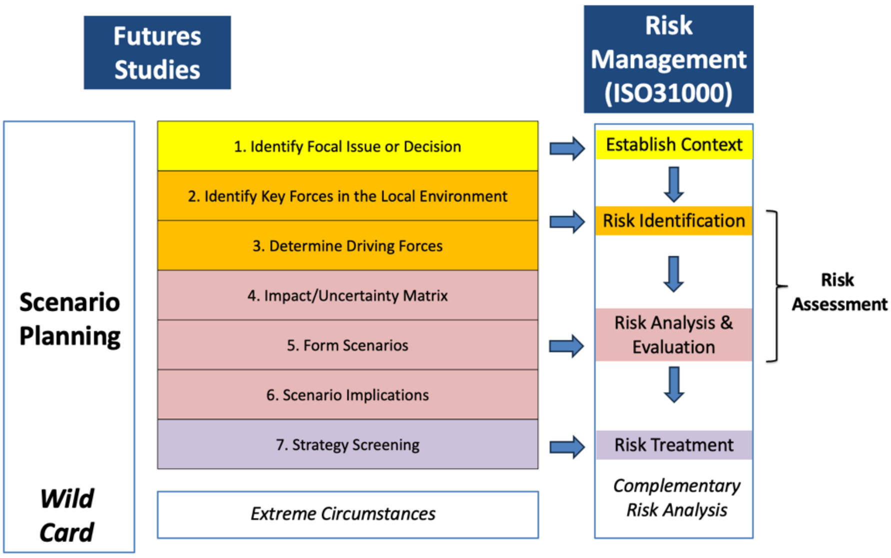

Figure 10. The interplay between scenario planning and risk management (Created by the author)

In the risk management process, establishing context involves understanding both the external and internal environments of organizations, while identifying a focal issue or decision in the scenario planning process clarifies the forces in the operational environment that affect organizational developments. Both steps define the target and scope for later analysis. However, it is noted that my study only focuses on external environment and internal factors are not primary consideration of this study, as the aim is to identify emerging risks affecting future development of Chinese EV manufacturers. Risk identification in the risk management process aims to uncover hidden risks that may have potential side effects on organizations, while identifying key forces and determining driving forces in scenario planning assist in achieving this. In the risk analysis and evaluation, a risk matrix is established to identify high-level risks, which requires evaluating both likelihood and consequence. On the other hand, the impact/uncertainty matrix in scenario planning highlights the consequences and uncertainties associated with driving forces. Risks with high likelihood are considered in the former, while uncertainty in the latter represents outcomes that are not certain to occur. As a result, although the concept of 'likelihood' differs in the two frameworks, they can be complementary rather than contradictory. Risk management is used to ensure the stability of organizations in the short term, while scenario planning concentrates on the exploration of risks arising from uncertainties, enabling their sustainability in the long run. In a word, not only the current situation but also short- and long-term factors are incorporated with the combination of risk management and scenario planning. Last but not least, risk treatment is applied in the risk management process to eliminate risks that could negatively threaten organizations' development, and to determine how to take concrete actions and what should be done to prevent the generation of such risks. This could be achieved by developing a strategy during the scenario planning process.

3. Methodology

3.1. Research Design

The research aims to identify the key risks for Chinese EV manufacturers in 2035 and explore the interplay between risk management and scenario planning. Scenario planning will be used to explore different plausible futures for the industry, enabling industry participants and their stakeholders to understand the impacts of main risks and to develop corresponding strategies. The research mainly uses a qualitative method, including horizon scanning (based on the PESTEL analysis) and scenario planning. Meanwhile, a semi-quantitative method is also used in the risk assessment part. Through horizon scanning, I will identify risks that will impact Chinese EV manufacturers over the next 10 years based on data from the PESTEL analysis. After identifying existing risks, I will use the risk analysis method to determine the 2 highest-level risks for the 2*2 scenario planning process. In the end, strategy development is completed based on the different scenarios. In addition, I will create one wild card scenario by selecting a risk factor to explore the impacts of extreme circumstances on the industry.

3.2. Horizon scanning

The aim of my study using horizon scanning is to identify weak signals that could pose risks to Chinese EV manufacturers. According to Palomino et al. (2012, 356), "*horizon scanning is the systematic examination of potential threats, opportunities, and possibly future developments, including – but not restricted to – those that are at the margins of current thinking and planning. Horizon scanning is about exploring novel and unexpected issues, as well as persistent problems or trends*".

There are two general approaches to horizon scanning: network-based and web-based. The former refers to new information being collected from informal networking, such as workshops and conferences. The latter means that the web provides a vast volume of changing and publicly available information in real time, and this can be achieved through web-based sources such as online literature, news, etc. (Palomino et al. 2012, 356-359). For my study, I used a web-based horizon method to collect data by typing keywords into both searching engines and academic databases, such as

“Chinese electric vehicle industry”, “risk management”, “risks in electric vehicle industry”, and “the future of electric vehicle industry”.

Meanwhile, as shown in Figure 11, a generalized web-based horizon scanning process for decision-making is proposed. As suggested, the process demonstrates a well consistency with the objective of this study. First, I follow the horizon scanning process in the chart through an iterative process of information organization, which narrows the search scope to those most related to my study aim. In addition, based on the horizon scanning result, I apply another futures studies method – scenarios, hoping to form concrete decisions for organizations.

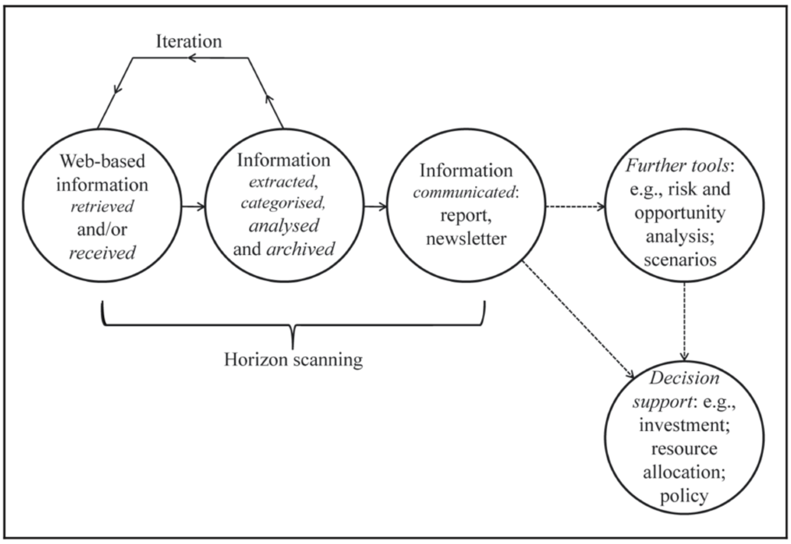

Figure 11: Web-based horizon scanning process (Palomino et al. 2012, 359)

Horizon scanning can serve as a risk identification method by detecting weak signals that are still not registered or paid less attention to in the conventional risk landscape. Weak signals refer to the information on a system’s possible change toward an unknown direction, and the estimation of their impact or a response is incomplete (Mendonça et al. 2004, 206). Many weak signals exist before wild cards happen (Mendonça et al. 2004, 205). As such, weak signals may develop into risks, with some exhibiting wild card characteristics. Some signals can be transformed into risk through evaluations. As Hiltunen (2006, 57) noted, weak signals can be difficult to track down amid other signals and noise. Horizon scanning is about detecting early signs of developments, including risks. For example, the Risk Assessment and Horizon Scanning program in Singapore explored emerging strategic issues through documents and internet pages. Plus, one of the aims of the Netherlands STT (Stichting

Toekomstneeld der Techniek) Horizon Scan 2050 is to seek signals for change and potential unknown unknowns, aiding long-term risk analysis by reviewing documents and conducting interviews (Cuhls, 2020, 4, 7 & 13). What is more, risk assessment is an important element of the horizon scanning process, as it helps to identify key risks that need further attention. The standard risk assessment methodology - ISO 31000 - is applicable for achieving the risk assessment with the consideration of the horizon scanning time frame (Institute of Risk Management 2018, 11). However, it should be noted that weak signals from horizon scanning do not indicate low probability of events; instead, they are difficult to detect. As a result, weak signals reflect our current awareness of the system, while risks reflect possible futures evolution of the system, and the concepts should not be mixed.

On the other hand, emerging risks indicate that their damage is not always well known or understood, such as new technologies and new contexts (Flaus 2013， 29). As horizon scanning is thus viable for detecting emerging risks.

Sometimes, weak signals can be wild cards. Mehrabanfar (2014, 212) cited that the concept of a wild card event was first introduced by Petersen, who defines wild cards as ‘events that happen quickly and the social system cannot respond effectively’. There are also other explanations of wild cards. Rockfellow (1994, 14) identified a wild card as ‘an event with low probability of occurrence, but high impact if it happens’. He also estimated that the likelihood of such an event is less than 10% and that it poses threats to international business. Mendonça et al. (2004, 203) referred to wild cards as ‘the incidents with foreseeable low probability and high potential impacts and strategic consequences for an organization’, and noted that some wild cards can be detected by scanning weak signals. Meanwhile, wild card events can be seen as a watershed in history and a sign of societal change (Mendonça et al. 2004, 203). This point was also stressed by the other authors, as Aguilar-Millan (2013, 144) noted that surprising events with low probability and high impact can be defined as wild card events in the futures literature, and that these events could be disruptive for the plans in futures. Hiltunen (2006, 66) divided wild cards into two categories: irreversible (e.g., a shift in Earth’s axis) and reversible (e.g., a stock market crash). The author has also summarized a series of wild card events based on the reviewed literature (2006, 69), such as the crash of WTC Tower 9/11, the rights of robots, asteroid or comet hits on Earth. In recent years, wild cards have also been disruptive. For example, the COVID-19 crisis has severe impacts on the global economy (Safón et al. 2024), and the author highlighted the importance of an organization's adaptive capability.

Although scholars offer different interpretations, the obvious characteristics are that the possibility of wild card events is relatively low, but their consequences are huge; therefore, it should be included in the scenario planning process to expand the boundary of risk landscapes and help form strategies. After all, wild cards can abruptly disrupt an organization's planned development path. In a word, it is an essential part of scenarios. Sometimes, a global wild card that may affect many industries at different levels. For instance, COVID-19 posed a significant threat to many offline industries, including tourism, aviation (Nicola et al 2020, 188-189). On the contrary, some industries have shown great resilience, such as online education (Das et al. 2022, 174-175). Therefore, when considering wild card scenarios for Chinese EV manufacturers, the wild card should be narrowed to the one most closely related to the industry. In other words, the wild card scenarios ought to be analyzed at the industry level. On the other hand, organizations' responses to the same wild card within the same industry vary, and this variance depends on the organization's resources. Hence, the wild card events are not only manifested by industrial characteristics but also by the organization's own abilities. Nevertheless, differences in organizational capabilities do not deny the existence of a shared wild card within the industry. This is because organizations operating in the same industry have commonalities in many aspects, such as technological directions, critical resources, and regulatory environments. As a consequence, some wild cards can affect the entire industry. Therefore, it is necessary and valid to consider wild cards at the industrial level, enabling organizations within the industry to develop general adaptive strategies.

3.3. Reasons for choosing the secondary data collection method

There are several types of secondary data, including survey, document and multiple source (Saunders et al. 2019, 342). I choose multiple-source secondary data, meaning that they can be extracted entirely from document. The data can be obtained from books, journal articles, industry reports, government publications, etc. (Saunders et al. 2019, 342)

I analyze secondary data for my study and evaluate my secondary data sources based on several criteria as proposed by Saunders et al. (2019, 367-368). First, they have shown the overall suitability to my study. It means that the data contains the information that respond to my research questions and objectives. One of my research questions is ‘What are the key risks for Chinese EV manufacturers by 2035’. The research question is future-oriented and focusing on long-term factors. Therefore, the data collected from academic literature, industry reports and news are methodologically viable, as they capture a systematic overview of risk at the industry level rather than organization-specific. Second, the data exhibit precise suitability. Even though the data are secondary, they have been processed by others first and already undergone statistical analysis (Mazhar et al. 2021, 7), and they remain academically justifiable. Journal articles are often peer-reviewed, which enhances the objectivity and reliability of the sources. Industry reports serve as a source of information. Although some may reflect institutions’ perspectives, they are always produced by agencies or consulting firms that provide insights based on systematic data collections and analysis. This process also involves the ideas of sectoral expertise. In addition, I aim to explore up-to-date development in the field, and news covers the latest signs and even trends that may indicate changes in the industry, and it presents new perspectives in a timely manner, therefore, it aids me to be aware of the evolving factors within the field. Third, the benefits of obtaining secondary data outweigh the overall costs, as they aid me to explore the research question with limited financial and time constraints. Ethically, although I aim to investigate a specific question in China, to further improve data validity, I include views from people in China and in other countries throughout different sources to minimize subjectivity as much as possible.

On the other hand, considering my research process, scenario planning can still work well without forming a workshop team that collects primary data. I follow the main steps in the scenario planning process, such as identifying key forces and determining driving forces by systematically reviewing secondary data, and I use the risk management framework to improve the credibility of scenarios. As a result, the combination of personally built scenarios and secondary data collection methods is feasible for this thesis. However, it should be pointed out that the scenarios are built on my own knowledge and understanding of this field and reflect a degree of subjectivity. This aligns with the building process of scenarios regarding the participants with different experiences, whose reflections and judgments in deciding driving forces vary (Ralston & Wilson 2007, 71). Therefore, again, multiple secondary data sources are included to reduce the subjectivity and ensure the credibility of my analysis results.

3.4. Criteria to choose data sources

Although risks exist in both external and internal operational environments, I mainly identify external risks affecting Chinese EV manufacturers. External risks arising from the macro environment could cause upheavals for organizations and even the whole industry. The risks will be identified through a PESTEL analysis, which helps to identify those with a major impact on the development of the Chinese EV manufacturing industry. On the other hand, internal risks – such as corporate governance, financial control, and process safety will not be examined in detail in this study, because those factors are different across organizations, therefore being organization-specific. As a result, this study aims to explore the macro-level risk landscape for Chinese EV manufacturers by 2035 and develop strategies.

The risks are identified at different levels, ranging from global risks affecting the Chinese EV manufacturing industry to specific risks within it. Meanwhile, the diverse risk sources are from article reviews, industry reports, policy analyses, and new sources. Those sources are carefully selected from a total of approximately 60. I omit some sources because they focus on the financial performance of such manufacturers from an investor's perspective and therefore lack systematic risk identification. Some sources emphasize risks in other countries, and while this can offer me insights into identifying risks in China, it is ideal for me to focus on sources with a global view and highly related to the Chinese EV industry. In addition, there are also different perspectives, combining data from international agencies with academic research from both China and abroad. The summary of different material sources is shown in Table 5. The four sources are complementary in identifying risks, as journal articles and industry reports provide analytical rigor, while policy analyses and news provide the timeliness with contextual insights.

Table 5. Different risk identification resources (Created by the author)

Risks Source	Numbers	Reasons to choose
Journal Articles	11	The selected articles were produced mainly in recent years (2018-2025), and they provide theoretical foundations for identifying risks from different perspectives in the long run

Industry Reports	7	The reports provide quantitative trend analyses with up-to-date data, and they also show the consensus of the industry experts. The reports are drawn with strategic outlooks as well
Policy Analyses	7	To illustrate Chinese EV manufacturers' possible development direction under local policies and the influences of global regulation environment by providing foresights
News	7	Reflect the latest developments and changes in the industry to show dynamic risks. The source is also complementary to the three sources above from the perspective of the public

3.5. Scenario planning based on risk analysis process

To build scenarios using a 2*2 matrix, two driving forces will be selected for scenario planning. Based on the risk management framework, they will be selected from the identified risks. The next step is to map out an impact/uncertainty matrix to build scenarios. It should be noted that the driving forces with the highest impact and the uncertainty levels are selected in the scenario planning process, and the number of driving forces is not fixed. Uncertainty in scenario planning is the degree to which future developments and outcomes are not predictable. It means that when experts can't agree, there is some level of uncertainty (Ralston & Wilson 2007, 108). In other words, uncertainty reflects our understanding to give values to the likelihood and severity of risks based on the gathered information, and it shows our confidence level for risk analysis. It is ideal to determine two key driving forces in this study to form a 2*2 matrix with 4 scenarios. As a result, risk analysis is used to help determine the driving forces. However, it should be noted that in the ISO 31000 risk management framework (Flaus 2013, 72), The risk with the highest level is determined by both the highest likelihood and the highest severity. The uncertainty is unknown here, since it is not an indicator of risk level, but the condition for the existence of risk. If we are sure of a risk with 100% certainty, it is a fact, not a risk. After all, risk is the effect of uncertainty on objectives (ISO 2018). On the other hand, in the scenario planning process, the likelihood of driving forces is unknown because it involves exploring many alternative futures rather than predicting, and no one can say which scenario is the most possible. The summary of observed differences is shown in Table 6.

Table 6. Differences between risk management and scenario planning in terms of likelihood, severity, and uncertainty (Created by the author)

	Likelihood	Severity	Uncertainty
Risk Management	high	high	*unknown*
Scenario Planning	*unknown*	high	high

Driving forces can be chosen based on scenario planning criteria combined with risk management criteria. In other words, I will choose driving forces with the highest level of likelihood, severity, and uncertainty simultaneously. As Bell (1997, 106) pointed out, prediction is involving in the notion of 'risk', which is an inherently future-oriented concept. Discussing 'what is the most severe risk' involves predicting futures with chancy, multiple outcomes. Bell (1997, 107) has also illustrated that constructing scenarios for exploring different futures always engages the process and the act of prediction, since the process requires evaluating the effects of different conditions, assumptions, or models on the phenomenon whose possible futures are under consideration. Meanwhile, Bell (1997 103) cited the view of Masini, former president of the World Futures Studies Federation, who said that predicting only one future is not the purpose, and futures research should rather reveal alternative possibilities and analyze the risks concomitant with these possibilities and consequences. At last, Bell (1997, 107) concluded that it is essential for futurists to evaluate possible and probable futures according to some scale of values and judge how desirable various alternative futures are, therefore encouraging responsible actions.

As a result, the risk management framework provides a method for evaluating both likelihood and severity, given a scale of values. It is not contradictory for a factor to have a high level of likelihood and a high level of uncertainty at the same time. Uncertainty represents our understanding or knowledge in estimating the likelihood, and high uncertainty means we have very limited information or insufficient understanding to explore possible directions on a given time scale. For example, the transition to solid battery for EV in China has both high likelihood and high uncertainty. It is highly possible since there is support from both the government and enterprises. It is also highly uncertain because we are not sure about the widespread adoption of this battery, given safety and customer acceptance, among other factors.

The risk level of each factor is calculated using the risk severity, likelihood, and uncertainty scales. The scales are shown in Tables 7, 8, and 9, which will be used later to create a risk matrix. The risk matrix is widely used across various fields, including quality management, production safety management, and supply chain management. Several studies have applied the risk matrix. Fan et al. (2024, 4) summarized the risk matrix used in the maritime sector, and the results showed that the mean probability index is 5.67 and the mean consequence index is 4.78. Panyukov et al. (2022) analyzed the problems and possible improvements in the failure mode and effects analysis (FMEA) risk assessment system in the auto industry, and they found that the significance of consequences for the product or enterprise is divided into 5 categories, and the probability of failure detection is divided into 4 categories. Dewi et al. (2020) analyzed the production risk in the steel manufacturing industry, with 5 levels in both factor probability and impact factor. Karasan and Erdogan (2021) conducted a risk assessment using a combination of experts' evaluations in textile manufacturing, assigning risk frequency and probability to 5 categories. In general, a 5*5 matrix can be used in the manufacturing industry, since risks are categorized neither simply nor complexly, making it easier to prioritize high-risk items for action. In contrast, a 3*3 risk matrix oversimplifies, grouping different types of risks into the same category, whereas a 10*10 risk matrix takes longer to categorize risks and makes it difficult for users to differentiate risks due to the number of categories. Therefore, a 5*5 risk matrix is constructed in my study. The uncertainty level is categorized into 3 levels, reflecting the degree of obtaining information and for risk analysis, not the magnitude of risk. The uncertainty then manifests as unpredictability in how risks may evolve over time, which justifies the scenario planning.

Table 7. Severity level for the study (Created by the author)

Level	Degree	Descriptions
1	Negligible	Nearly no impact on the operation
2	Minor	Little impact with rapid recovery
3	Moderate	Moderate impact with changed strategies
4	Major	Serious impact in 10 years possibly
5	Catastrophic	Catastrophic impact to the whole industry

Table 8. Likelihood level for the study (Created by the author)

Level	Degree	Descriptions
1	Almost Impossible	Little chances to happen in the next 10 years
2	Unlikely	Sporadic disruptions with several occurrences
3	Possible	Detected weak signals
4	Likely	Could be the trend
5	Frequent	Already happen and will be the megatrend

Table 9. Uncertainty level for the study (Created by the author)

Degree	Descriptions
Low	The information for risk analysis is sufficient, allowing for confidence in assessing likelihood and severity, and the evolution of risk is predictable
Medium	The information for risk analysis is subject to change, allowing for a lack of confidence in assessing likelihood and severity sometimes, and the evolution of risk is partly predictable
High	The information for risk analysis is limited or evolving, making it difficult to define the value of likelihood and severity, and the evolution of risk is unpredictable, with several directions

4. Risk Assessment in the Chinese EV Manufacturing Industry

4.1. Risk identification

Generally, risks in the manufacturing sectors are identified. For instance, those risks are listed from the perspective of HOTEEL (Human, Organization, Technical/Technological, Environmental, and Legal). As shown in Table 10, although it is a mix of external and internal risks, it did not identify the priority of certain risks or which risks organizations should pay attention to. As a result, it can only be used to identify risks generally in manufacturing sectors, which can serve as a foundation for identifying risks specifically in the Chinese EV manufacturing industry.

Table 10. Risks in the manufacturing sectors (Adapted from Oduoza 2020, 1294)

Human (Health and Safety)	Organization	Technology	Economy/Finance/Politics	Environment	Legislation
Accidents	Supply chain	New Product	Cash flow	Emission	Contract
Injury	Competition	New Process	Budget	Effluent	Dispute
Process Safety	Quality assurance	Patent	Economy stability	Weather	Legislation
Noise	Labour skill	Technology uncertainty	Debt	Temperature	Laws
Diseases	Training	Material quality	Political stability	Pressure	Standard

4.1.1. Risk Identified from Global Report

On the other hand, the risks in the EV industry can be identified through trend analysis. The IEA released an annual report regarding EV development (IEA 2025b), and even though the demand for EV increases greatly globally, one main hidden risk for Chinese EV production is overcapacity. (IEA 2025b, 36) This situation is further exacerbated by tariff changes across several regions, which push some Chinese manufacturers to establish new plants overseas, mainly in Europe and Southeast Asia. In addition, even though sluggish economic growth persists in many countries amid uncertainties, the EV sales will not be greatly affected, thanks to EV's already competitive price compared to conventional cars and China's trade-in policy. Meanwhile, the drop in the price of energy will exert a negative influence on the purchases of EV, especially in regions with low fuel taxation like China. However, although oil prices remain low, battery electric cars are still cheaper than conventional cars because of low electricity prices and high charging utilization rate (IEA 2025b, 86). Uncertainties also arise from the charging. Some ultra-fast charging projects are underway in China (IEA 2025b, 103), which require EV manufacturers in China to be innovative in developing models compatible with these projects. For instance, one Chinese EV manufacturer has built battery swap stations for EV in China, jointly with other automobile manufacturers (IEA 2025b, 129). On the other hand, although the surplus in the supply of critical minerals for batteries is expected to persist over the next few years, one risk is that low prices stemming from the surplus could discourage future investments, and as a result, the supplies of lithium and nickel could be in short supply. Therefore, technological innovations in other battery types could serve as alternatives to the risk of critical mineral supply (IEA 2025b, 137). Mass EV production will also increase the electricity demand, and the share of EV in China's electricity demand is expected to rise from 1.2% in 2024 to 3.6% in 2030 (IEA 2025b, 153). One risk here is that increasing demand requires reliable infrastructures for electricity supply, and innovations in charging and electricity storage systems are key to facing this risk. Last but not least, the report also noted that the government should adapt to tax policies. China's fossil fuel taxes are projected to decline by 2030, which will be offset by the electricity taxes (IEA 2025b, 155). However, it is still unclear how the situation will change after 2030.

Raimi et al. (2024, 14) mentioned in *Global Energy Outlook: 2024 Peaks or Plateaus* that rapid growth in sectors like electric vehicles and semiconductors, together with electrification, would drive increasing demand for energy, especially electricity. Meanwhile, the supply of critical minerals for EV batteries would also be volatile in the next few years (Raimi et al. 2024, 21). As a result, further concerns about supply chain diversification are raised, particularly in China, where many minerals are processed, including 75% of cobalt and 40% of copper (Raimi et al. 2024, 22-23).

McKinsey & Company (2024) has released the report titled *Global Energy Perspective 2024*, which indicated that the most resilient outlook for sustainable fuels is projected to be in road transport (McKinsey & Company 2024, 25). EVs are significant in this sector, and they will require a large number of critical minerals (e.g., battery materials). The unclear long-term demand for critical minerals for EV batteries is influenced by the downstream technology and geopolitical uncertainties (McKinsey & Company 2024, 11).

Bloomberg NEF (2025, 8) demonstrated that EV is a powerful driver of electricity demand, and this effect will be enhanced by the drop in EV battery efficiency in cold weather. On the other hand, the EV battery industry is experiencing overcapacity, with the average utilization of battery production plants in China remaining below 50%. Plus, EV uses mainly conventional liquid batteries, and because of the safety and high energy density of solid-state batteries for the next generation, they have been invested in and mostly manufactured in China. However, commercialization requires high costs in research and development, and uncertainties emerge from novel critical minerals supplies and public acceptance. However, one clear fact is that autonomous vehicles are getting more attention, with a projected 6 million robotaxis by 2035 (Bloomberg NEF 2025, 8). The report also pinpointed that long-term demand (by 2040) for battery metals will be strong, even though near-term growth will be slow. In short, uncertainties in technological innovation may alter demand for critical minerals.

Based on interviews with 42 senior executives across the supply chain, S&P Global Mobility (2025, 2) found that supply chains in the automotive sector faced several challenges in 2024, including supply chain disruptions, rising raw material costs, and regulatory compliance. Plus, the shortage of skilled labor in the automotive sector is also an issue, as more skilled workers are needed to develop products to help EV companies remain competitive. For example, the potentials of AI within vehicles will be further explored beyond driver monitoring systems and in-cabin monitoring, requiring laborers with innovative thinking. This point echoed the view that the changes in the EV industry require talents with complex backgrounds about the latest innovations, since the proportion of advanced technicians in the Chinese EV industry is still lower than that in developed countries (China Industrial News Network 2025).

The International Council on Clean Transportation (2023, 1) has summarized nine trends in the development of China’s electric passenger market and have ascertained that China will continue to face challenges related to the need for competitive domestic brands, supply chain security for raw materials for EV manufacturing, and charging infrastructures. The international reputation of the Chinese brand is still limited, together with the difficulty of meeting different standards across countries. These factors are barriers for EV manufacturers in China (The International Council on

Clean Transportation 2023, 2). In addition, although the majority of batteries and electric motors for the EV were manufactured in China, some components manufactured in China, such as power semiconductors for EV, still account for relatively small segments (The International Council on Clean Transportation 2023, 7). The risk here is that the supply of critical minerals for batteries might be disrupted by policies and innovations in battery technologies, which are highly uncertain.

4.1.2. Risks Identified from Policies Analysis

• Policies in China

Zhao et al. (2024, 3) indicated that the purchase subsidy for the EV in China has been gradually decreased since its introduction in 2011 because of the relatively high cost compared with traditional vehicles, undermining attractiveness for consumers; they also noted that the development of autonomous driving technology can be seen as a measure to foster urban safety and mobility, requiring EV manufacturers to innovate and enhance advancement. Fan et al. (2025) concluded that government subsidies and technological progress in EV battery technology can reduce the green premium, with production costs included. This emphasizes the importance of policy support and R&D investments to help EV adoption. According to the State Council of the People's Republic of China (2020), electric vehicles are expected to be the mainstream of vehicle sales until 2035, and fuel cell vehicles are expected to be commercialized. This is a sign for EV manufacturers to focus not only on battery-powered vehicles, but also on innovative models. The potential change of policies regarding new types of vehicles requires EV manufacturers to have both talent and funding to develop technologies. Meanwhile, Gu et al. (2019) explored the effect of government subsidy allocation on the total benefits of the EV supply chain and figured out that in the early EV development stage, subsidies should be allocated to customers; as funds increase, they can be allocated to EV manufacturers. In the late development stage of EV, subsidies are not important because of the consumers' acceptance of EV. Alternatively, China has introduced the 'Dual Credit Policy' to incentivize the prevalence of EV instead of subsidies in 2017 (Li et al. 2025). The policy contains two criteria: China's Corporate Average Fuel Consumption (CAFC) credit and the New Electric Vehicle (NEV) credit, which require automotive manufacturers to produce a certain number of NEVs. Liang et al. (2024) also found that China's automotive manufacturing companies' competitiveness has been enhanced after the implementation of this policy, with traditional automakers improving more greatly than pure NEV automakers. Therefore, the substantial innovation should focus on R&D investment, and policies should be adjusted continuously.

• International Policies

Regulations outside China have also affected the Chinese EV industry. For instance, the United States (US) has enacted the Inflation Reduction Act (IRA), which has become law (Allcott et al. 2025, 1). The IRA states that some subsidies are offered for new energy vehicles to enhance the penetration rate, as well as foreign capital in the US. Subsidies are available only to manufacturers that finish assembly of cars in North America; therefore, companies that do not set up factories there will lose competitiveness. Despite the current limited impact of the IRA on China's battery industry, which supplies EV manufacturers, the long-term effects of the IRA on China's EV industry remain highly uncertain regarding market access. On the other hand, the State of European Union has declared the initiation of an anti-subsidy investigation into EV from China in 2023, and the anti-subsidy tax is imposed on Chinese EV manufacturers, restricting the exports of EV from China into European markets (Bickenbach et al. 2024, 214). This action serves as an example for other countries to take similar action against China, but it also forces some Chinese EV manufacturers to set up factories in Europe to tackle this issue, therefore mapping out new global strategies.

On the other hand, Japan has launched the first national hydrogen strategy worldwide; it included the investment of 15 trillion Japanese yen to form a 'hydrogen society', and this strategy also spurs Japanese automakers to make innovations in fuel cell vehicles (China Daily 2024). Meanwhile, South Korea aims to be a global leader in the production of fuel cell electric vehicles (FCEVs), with the promising production of nearly 3 million by 2040 (Nakano 2021). The situation should be given importance by the Chinese government and automakers; if manufacturers cannot make progress on the next generation of clean energy vehicles, they will lag behind and lose competitiveness.

4.1.3. Risks Identified from Academic Articles

Davidson et al. (2022) analyzed the risks of five leading low-carbon technologies, integrating economic and national security implications in China, and found that batteries can incur high supply chain disruption risks from an economic perspective, especially regarding the supply of critical minerals. Veza et al. (2024, 38) conducted a bibliometric analysis of electric vehicles, including trends and policies. They found that the interplay among EV policies, innovative battery technologies, and charging infrastructure is vital to harnessing the potential of EV and achieving sustainable mobility.

Liang and Li (2023, 237) pointed out that there are difficulties in developing electric vehicles in China, and one of the primary obstacles is the inadequate charging infrastructure, and the limited availability of battery materials contributes to the high cost of EV production. Therefore, it is vital for EV manufacturers to make breakthroughs in battery technology, which may require the use of alternative materials suitable for production. Meanwhile, they also stated that innovations in EV to reduce carbon emissions are also future trends, including sustainable materials, aerodynamic design, and lightweight construction. Some EV manufacturers in China have already equipped solar panels into designs to generate power (Liang & Li 2023, 239). If some EV manufacturers are less competitive in innovation, they will be gradually eliminated due to their failure to meet policies and public expectations.

Capuder et al. (2020) identified the most significant obstacles in achieving a higher presence of EV with a 5-year time scale. In the article, they have used multi-disciplinary approaches to determine the obstacles. First, risks to achieving forecasted goals for large-scale EV integration were identified using PESTEL spectra and SWOT analysis. Then they have used the Delphi method to rank the risks into a risk map based on probability and significance. Lastly, ERM is applied as a framework to map risks and thus form strategies. The most important current risks of the EV market were presented in Table 11.

Table 11. List of risks relevant for the electric vehicle uptake (Capuder et al. 2020, 8)

List of risks relevant for the electric vehicle uptake.

Type of risk	Description/explanation
Technology	The battery technology is not developing according to the expectations and needs for a large EV uptake (energy density, number of charging cycles, battery degradation, and standardization)
Range anxiety	Scepticism/unhappiness of final consumers since the EV range is still not equivalent to the one of CV (social aspect, expectations)
Incentives reduction	Federal and local incentives for buying EVs will be reduced (or recalled entirely) before reaching the critical mass
Promotion	Potential buyers not aware of the incentives and tax reductions. Or the rebates/tax reductions do not adequately compensate for the cost of new technology and do not provide sufficient (initial) cost savings compared to CV
Smart Grid	The investment in smart infrastructure that supports EV charging will be too high, stopping the integration of EV/charging points (grid, sources of flexibility compensating variability and uncertainty of RES and of EV)
Regulation	Regulation for active participation of EVs in electricity markets will take a very long time to set up (local level market is non-existent)
Charging infrastructure	Insufficient development of charging infrastructure: not enough public charging points, slow charging, expensive service
Social aspects	EV potential/market recognized by only higher education and high income buyers, limiting further uptake/integration
Model diversity	Initial demand for model standardization should be substituted with sufficient number of different models serving different needs and demands of potential consumers. This implies developing different "types" of EV – from small city cars, standard middle class cars to caravans, SUVs, larger family cars and sport EVs
Battery cost	Current obstacle for reduction of EV costs and having acceptable costs for final customers is high initial investment cost of batteries. This should be differentiated from the technology risk as technology development is not necessarily followed by reduction in production/sales costs

In the end, the risk map (Figure 12) was drawn based on the experts' opinions in the Delphi study. The experts in his study include scholars in energy sectors, scholars in risk management and strategy fields, and senior industry experts.

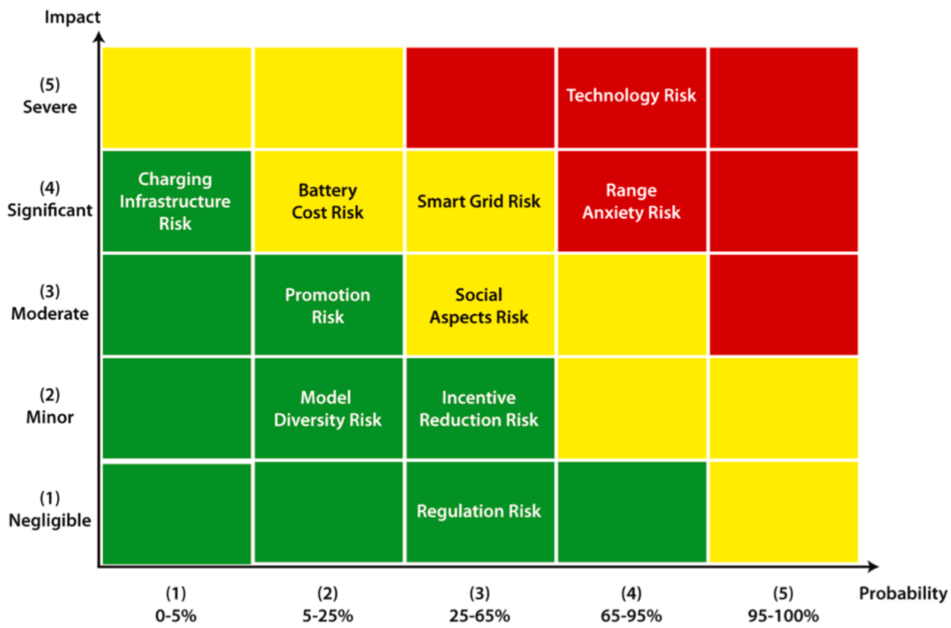

Figure 12. Risk map of factors for electric vehicle uptake (Capuder et al. 2020, 9)

The red colors in the risk map indicate the highest-level risks, which also represent the strongest obstacles to achieving 15% EV integration in 5 years in the article. The most severe risks identified are technology risk and range anxiety risk; these two risks are interconnected. Range anxiety refers to the skepticism of final consumers about EV range, since EV is not equivalent in range to internal combustion vehicles. Consumers are willing to adopt new technology if they expect better experiences from it compared with the current one.

Even though this study is valid, as judged by the multidisciplinary method used, it focused on risks within a 5-year framework; therefore, we can evaluate whether the risks identified still pose continuing threats. Technological risks remain prominent in innovations in batteries, charging infrastructures, etc., while range anxiety risk has been reduced to some extent. For instance, the author alleged that only a few kinds of commercial EV can cover a range of over 250km on driving autonomy (Capuder et al. 2020, 8). However, many commercial car models' ranges exceed this number, with Xiaomi YU7 and LUXEED over 800km in China (China Carhub 2024). As a result, it is unclear whether the range anxiety risk is still strongest among the listed risk categories, although some technological innovations have been made in this area. Therefore, the risk landscape should be renewed.

However, EV manufacturers face risks different from those of traditional vehicle manufacturers due to the rapidly evolving market landscape. The risks exist across the political, economic, social, technical, legislative, and environmental aspects in the EV integration goal (Capuder et al. 2020, 7). For instance, although new EV manufacturers have strong innovation capabilities to develop their products, the requirement for substantial investments in research and development makes them incur high costs in early trials, consuming a large amount of funds, which sometimes requires the supports from the governments. At the same time, many Chinese EV manufacturers have established their business for a very short time (The China Project 2023), and some people remain skeptical about the practicality of those newly developed products. To be accepted as quickly as possible, many manufacturers concentrate on broad acceptance and sales; as a result, they lack the experience and team to manage risks and may even ignore them, increasing the possibility of bankruptcy.

On the other hand, global supply chain risks are also obvious in the EV manufacturing industry. The need for raw materials, such as critical minerals for EV batteries, was heightened during the COVID-19 period when global logistics were affected (Soares et al. 2023, 9). Furthermore, Featherman et al. (2021, 3&12) stated that 'perceived risk' – the uncertainty that consumers face when they don't know the results of their purchases - is a prominent factor for EV purchasers, and the trustworthiness and capability of EV manufacturers can be seen as a risk-reliever and increase consumers' belief that the perceived risks are reduced. Shen et al. (2024, 244) examined the factors restricting the promotion of EV in China, and the technical and infrastructure factors are the main concerns, with prominent factors including security issues, limited driving range, and long charging time. There are three main tasks for the Chinese electric vehicle industry: developing battery technology, reducing vehicle cost, and enhancing charging facilities (Kejun et al. 2021, 7). The first two factors are closely related to EV manufacturers but are contradictory. Developing battery technology is a costly process; therefore, costs should be offset by other activities. This requires manufacturers to balance technological innovation with cost-control strategies, such as enhancing supply chain efficiency. As a result, technology uncertainty poses a major risk, since it is vital for a manufacturer's survival.

4.1.4. Risks identified from the news

Many risks exist for the EV industry in China, according to the news. The first risk is policy changes in terms of international trade. The European Commission has introduced ‘anti-subsidy tariffs’ towards China to minimize the share of EV from China in the European market. In addition, the European market accounts for about 40% of China’s EV exports, and the heavy reliance on a single market could be affected by policy changes (Friedrich Naumann Foundation 2025). Meanwhile, EV manufacturers may face stricter scrutiny over issues such as child labor. Another risk mentioned in the news is the price competition among Chinese EV manufacturers (China Global South Project 2025). Certain leading EV manufacturers’ ambitious expansion in China can pose a risk of elimination for other rivals. Moreover, reputational risks can arise from poor e-waste recycling, especially in developing countries, due to the low cost of EV. Plus, the measures taken by some countries also pose risks to Chinese EV manufacturers. For instance, battery companies in Indonesia are negotiating with Japan and South Korea to reduce the risks from US-China tariff issues, which will weaken the dominant position of Chinese battery companies in this country (RECCESSARY 2025). Chinese EV manufacturers face backlash in the international market. In addition to the tariff on Chinese EV exports from the European Union, other countries, such as Brazil and Thailand, have imposed restrictions to force Chinese EV manufacturers to build factories locally rather than merely exporting cars (Policy Circle 2025). China is also facing challenges with EV supply chains. The saturated battery market in China has led to a decrease in battery prices over the past decades, and the price increase in battery-grade lithium carbonate has pushed up manufacturers’ production costs. The supply chain problem is further hindered by regulatory development. For instance, the IRA issued by the US discourages Chinese EV manufacturers from entering the US market. In addition, the Academician of the Chinese Academy of Engineering indicated that five challenges and risks are prominent in the development of the Chinese EV industry. The risks include technological innovation, such as breakthroughs in batteries and autonomous driving; other risks, such as business disruption and policy lag, can also occur (China National Radio 2024). Other news manifested that the Chinese EV industry faces risks, and corresponding measures were presented (Chinese Social Sciences Net 2024). The first risk is the disruption of supply chain of critical minerals for EV components, and multiple supply chain channels should be established; The second risk the innovations for EV manufacturers, which requires them to increase R&D and investment in core technologies; Another risk is the undermined customers' experiences about EV models, and customized models should be offered to satisfy the needs for different consumers.

4.1.5. Summary of risks identified

Risks are thoroughly identified in the section before based on different sources through horizon scanning, and they are summarized in Table 12. The identified risks can be divided into three categories: global-level, China-specific, and manufacturing-level, and they are indicated as 'G', 'C', and 'M', respectively.

Table 12. Summary of identified risks (Created by the author)

Factor	Main Risks	Layer(s)	Implications for Chinese EV manufacturers
Political	1. Tariff and trade barriers (EU has conducted anti-subsidy investigations and US has launched IRA)	1.G+C	- Limit EV exports and meanwhile encourage building plants overseas
Economic	2. Overcapacity in battery production 3. Volatility in prices of raw material 4. Supply chain disruptions of EV raw materials (e.g. nickel and lithium) 5. Domestic price competition	2.C+M 3.G+C+M 4.G+C+M 5.C+M	- Reduce profit margins for small-sized companies - Potentially increase the prices of EV
Social	6. Consumers' lack of confidence in buying ('perceived risks' such as limited range) 7. Talent's shortage in EV industry 8. Limited reputations in global markets	6.C+M 7.C+M 8.C+M	- Require brand building for start-ups - Include recruitments and trainings for talents in R&D - Undermine the image of Chinese EV brands and lose competitiveness
Technological	9. Mismatching infrastructures (e.g. ultra-fast charging)	9.C+M	- Allocate fundings and innovations in R&D - Enhance cross-industry and

	10.Uncertainties about new forms of battery (e.g. solid battery) 11.Uncertainties about new forms of models (e.g. hydrogen-powered cars)	10.G+C+M 11.G+C+M	international cooperations for technological breakthroughs
Environmental	12.Electronic waste and recycling concerns 13.Increasing demand in electricity	12.G+C+M 13.G+C	- Encourage stricter regulations and circular economy - Increase the cost of production
Legal	14.Gradual removal of subsidies in EV purchase 15.Implementation of 'Dual Credit Policy'	14.C+M 15.C+M	- Adjust strategies to fulfill policy compliance - Shift from subsidy-reliance to R&D innovation

It should be noted that some risks identified in this study can be classified into several dimensions of PESTEL analysis. For instance, 'supply chain disruption' was categorized into economic risk because it negatively affects the production and profitability. Meanwhile, this factor can also be categorized into political risk because of influence of trade regulations. Similarly, the factor of innovation requirements is both technological and economic risk, since it involves investments in R&D as well as uncertainties in financial returns. However, in order to increase the clarity of risk categorization, each risk is classified by the main source of uncertainties. Take the 'supply chain disruption' for example again, it is reasonable to put into economic risk category here because of the direct impact of such a risk, such as delivery delays. Although this risk may originally from political intentions, it is still an economic risk in nature. In a word, the risk categorization through PESTEL is systematic, as well as acknowledge the interrelations among different types of risks.

4.2. Risk analysis result

The risk analysis results based on ISO 31000 for each PESTEL factor are listed in Table 13, followed by Figure 13: a risk matrix.

Table 13. Risk analysis result (Created by the author)

Factor	Main Risks	Severity	Likelihood	Uncertainty	Descriptions for the uncertainty
Political	1.Tariff and trade barriers (EU has conducted anti-subsidy investigations and US has launched IRA)	3	3	high	Geopolitics is high uncertain because of the relationships among countries
Economic	2.Overcapacity in battery production	3	3	low	This is obtained from industry report and can be quantified
	3.Volatility in prices of raw material	4	2	medium	The magnitude and timing are influenced by external factors
	4.Supply chain disruptions of EV battery raw materials (e.g. nickel and lithium)	5	4	high	This is affected by many factors, such as geopolitics, etc.
	5.Domestic price competition	3	5	low	It is clear from the development trend
Social	6.Consumers' lack of confidence in buying ('perceived risks' such as limited range)	1	5	medium	Consumers' behavior can be traced
	7.Talent's shortage in EV industry	4	4	low	This can be alleviated by enterprise's actions

	8.Limited reputations in global markets	3	3	medium	It takes time to build reputation, but the global market landscape is observable
Technological	9.Mismatching breakthrough with charging infrastructures (e.g. ultra-fast charging)	4	5	medium	It has a clear direction with unsure pace
	10. Uncertainties about new forms of battery (e.g. solid battery)	3	2	high	It does not show a clear direction for massive business use
	11. Underdeveloped about new forms of models (e.g. hydrogen-powered cars)	3	2	high	It does not show a clear direction for massive business use
Environmental	12. Electronic waste and recycling concerns	1	4	medium	The regulations regarding recycle are in progress
	13. Increasing demand in electricity	1	5	low	This trend development is stable
Legal	14. Gradual removal of subsidies in EV purchase	3	5	medium	This is in action, but the frequency is not stable
	15. Implementation of 'Dual Credit Policy'	3	5	low	It is clear because of written regulations

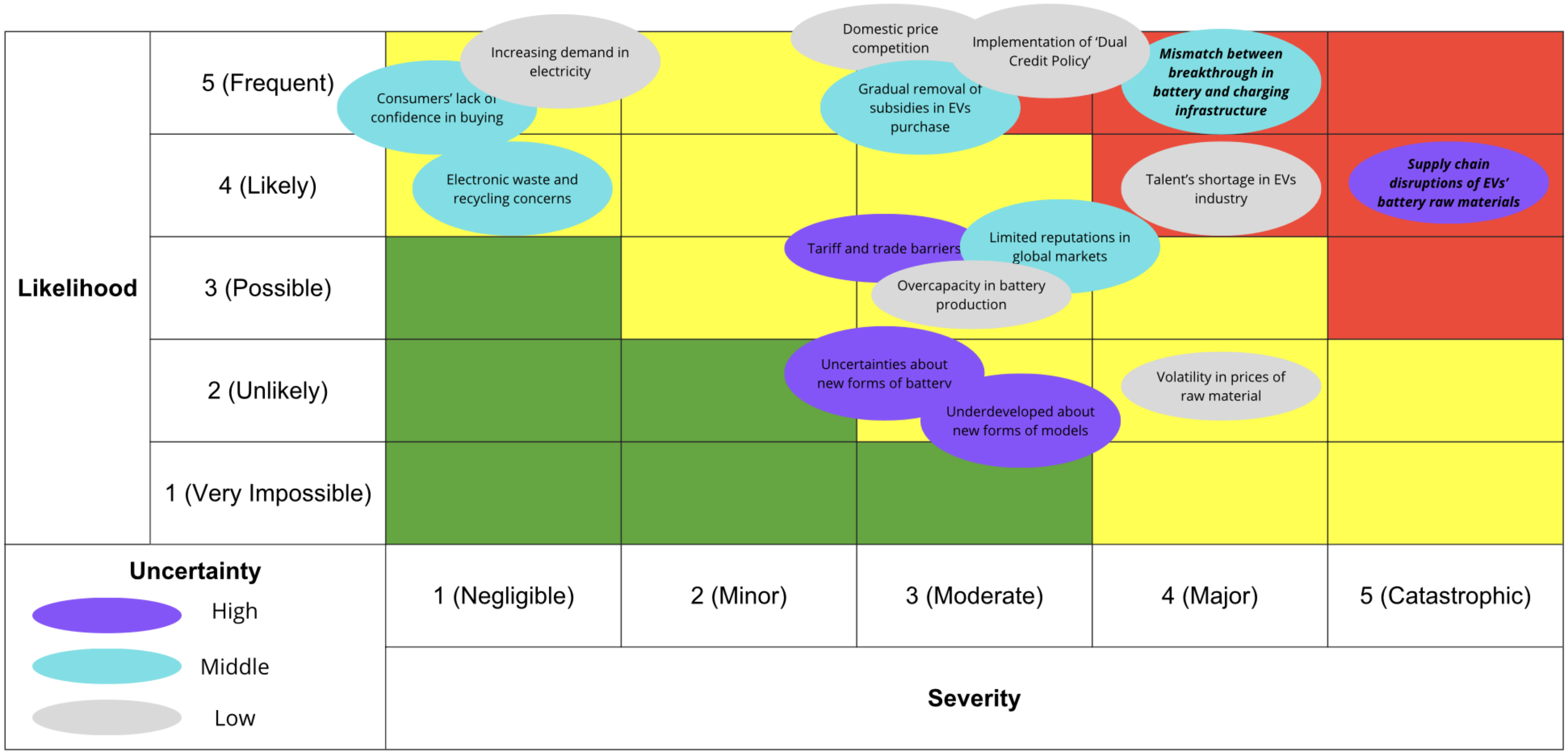

Figure 13. Risk matrix (Created by the author)

In the risk matrix above, detected risk factors are assigned to red, yellow, and green areas, respectively. Red indicates high-level risks, yellow represents medium-level risks, and green represents low-level risks. Meanwhile, the uncertainty is demonstrated in three colors (purple, blue and grey), indicating different levels. The values of severity and likelihood, and the degree of uncertainty, are assessed based on my own knowledge and analysis of the secondary data, and it inevitably involves subjectivity. However, the result remains methodological valid and well-supported. First, the aim of using the quantitative method in the risk analysis process is to identify the most influential risks as driving forces for scenario planning, rather than precisely calculating risk values. Risk analysis serves as an exploratory tool for building scenarios in my study. Second, it is reasonable for me to categorize both severity and likelihood fuzzily into five levels instead of indicating them with concrete values (e.g., the value of likelihood is 4 if the yearly occurrence rate is from 0.1 to 1), since the uncertainty about certain risks makes it rather difficult to decide to value for two factors.

Meanwhile, the values are determined by comparing risks across the same and different PESTEL factors. For instance, regarding the social factor, I assign a consequence value of 1 to consumers' lack of confidence in buying EV, while the talent shortage in the EV industry is assigned a value of 4. The reason is that even though consumers are becoming less confident in buying EV, it will not generate a great influence on the whole industry, since consumers' own wills are not a strong indicator when there already exist clear global goals and policies supporting the transfer to new energy vehicles. In contrast, if the shortage of talent in the EV industry in China persists for a period, the industry can be profoundly affected, including its innovation capabilities, production capacities, and competitiveness, posing a systemic risk. As for likelihood, the former is 5, slightly higher than the latter, which is 4. The reason is that it is clear that some consumers are not choosing EV because of their own concern regarding the range limits, especially in cold weather. Whereas the shortage of talent could be the trend, since many manufacturers are dedicated to developing new models and creating fierce competition for talent, and maintenance for EV also requires massive skilled workers. However, the likelihood value is set to 4 instead of 5 because I do not think this could be the megatrend by 2035, and this problem can be partly addressed through measures such as expanding educational opportunities to foster talents. As a consequence, although the process involves subjectivity, the reasoning is transparent and defensible enough.

By building the risk matrix, I have identified six high-level risks for the Chinese EV manufacturers by 2035, which are: 1) supply chain disruptions of raw material for batteries, 2) domestic price competition, 3) talent's shortage, 4) mismatching breakthrough batteries with charging infrastructures, 5) gradual removal of subsidies in purchasing EV, 6) implementation of 'Dual credit policy'. Among those risks, the top two with the highest numerical values are: supply chain disruptions in raw materials for batteries and mismatches between breakthroughs in batteries and charging infrastructure.

It is noted that even if two risks differ in both severity and likelihood, they can show the same risk level. For instance, the supply chain disruptions in raw materials for batteries have a severity value of 5 and a likelihood value of 4, while mismatches between breakthroughs in batteries and charging infrastructures have a severity value of 4 and a likelihood value of 5. Both in the red area.

Supply chain disruptions in raw materials for batteries have a greater potential impact on the development of Chinese EV manufacturers, as they directly affect production processes and are highly unpredictable, influenced by many factors, such as geopolitics. As the IEA mentioned (2025c, 8), a persisted supply shock in battery minerals could increase the price of battery pack by 40-50%. It is noted that even if China refines the majority of certain critical minerals (IEA 2025b, 146), they are mainly imported from other countries upstream; for example, China extremely relies on the Democratic Republic of Congo for cobalt (IEA 2025c, 271). this situation creates the risk that the supply chain for these critical minerals can be fragile if turbulence occurs. This risk is shaped by several factors, one of which is the uncertainty about the production of new battery types. If one type of battery is widely commercialized, it will change the structure of critical mineral demand, thereby generating volatility in the existing supply-demand structure. This poses threats, especially for small Chinese EV manufacturers, since they often lack the capacity to respond with agility to such risks and often bear the cost of potential price increases driven by the volatility. The risk can also intensify industry differentiation between giant leaders and marginal manufacturers, widening the cost disadvantages for some manufacturers. Large EV manufacturers can change their operational structures by merging with battery manufacturers or expanding investments in in-house battery production, while marginal manufacturers become increasingly disadvantaged due to actions from their powerful competitors.

On the other hand, mismatches between breakthroughs in batteries and charging infrastructure could hinder the technological development of certain manufacturers, leaving them unable to compete and survive. Although this is a clear development path, the extent of coordination between the technology and infrastructure systems remains uncertain. China remains strong in deploying fast charging, accounting for 80% of global growth in 2024 (IEA 2025b, 102), and it is promising that certain manufacturers have already made breakthroughs regarding charging infrastructures. For instance, BYD has designed its own ‘Super-e platform’ to deliver around 400 km of range in 5 minutes for its own batteries (IEA 2025b, 105), and many other manufacturers do not allocate the same resources to developing this technology, especially those small-sized manufacturers with limited funds. While the government has launched ultra-fast charging projects in big cities like Beijing and Chongqing (IEA 2025b, 103), if manufacturers take action behind the upgrading of charging infrastructure, they are merely followers rather than pioneers in the industry, which undermines their competitiveness. Meanwhile, those manufacturers will remain passive if consumers become more demanding of models that function well and are innovative, since they do not keep up with the speed of charging infrastructure upgrading initiated by their competitors. The risk is also reflected in the charging solutions. For example, one Chinese EV manufacturer, NIO, is a leader in battery swap for EV, with over 3000 swap stations across China (IEA 2025b, 129), and it also aims to coordinate battery standards with other Chinese EV manufacturers like Geely Group, JAC Group, and Chery Automotive. If charging infrastructure like swap stations is a trend in China, the ultra-fast charging technology will be at a disadvantage, and as a result, manufacturers are increasingly dedicated to developing it to survive. Therefore, mismatches between breakthroughs in batteries and charging infrastructure stem from the lack of a uniform standard and different development strategies among manufacturers. It is still uncertain which charging solution will be more widely adopted and become mainstream over the next 10 years.

Therefore, based on the risk analysis results, these two factors will be selected as driving forces for developing a 2*2 scenario matrix in the next step, which refers to the risk evaluation in the ISO 31000.

5. Form Scenarios

The logic for forming scenarios is shown in Figure 14, and each scenario is built from a combination of two driving forces. Each scenario is assigned a descriptive title to help readers understand and compare them later. Each scenario is also presented with an AI-generated image to provide vivid descriptions. Moreover, each scenario is elaborated through storylines that show the dynamics between two driving forces and the possible outcomes they produce together. Lastly, narratives are written around these storylines. That is, I will select one virtual person for each scenario from the perspective of Chinese EV manufacturers, since this helps translate complex scenario descriptions into concrete human behaviors in different situations, enhancing stakeholders' understanding with relatable descriptions to initiate changes of in present (Rasmussen 2005, 247), it also makes us realize what might happen in futures with pre-determined trends (Rasmussen 2005, 248). Meanwhile, scenarios are different from forecasts. Forecasting is about predicting the future, and its value is determined by the accuracy of the prediction, while the value of scenarios is largely decided by people's understanding and flexibility (Ralston & Wilson 2007, 125). Narratives, therefore, provide a way for organizations to develop and test strategies for different futures with scenario logics rather than predicting a single future.

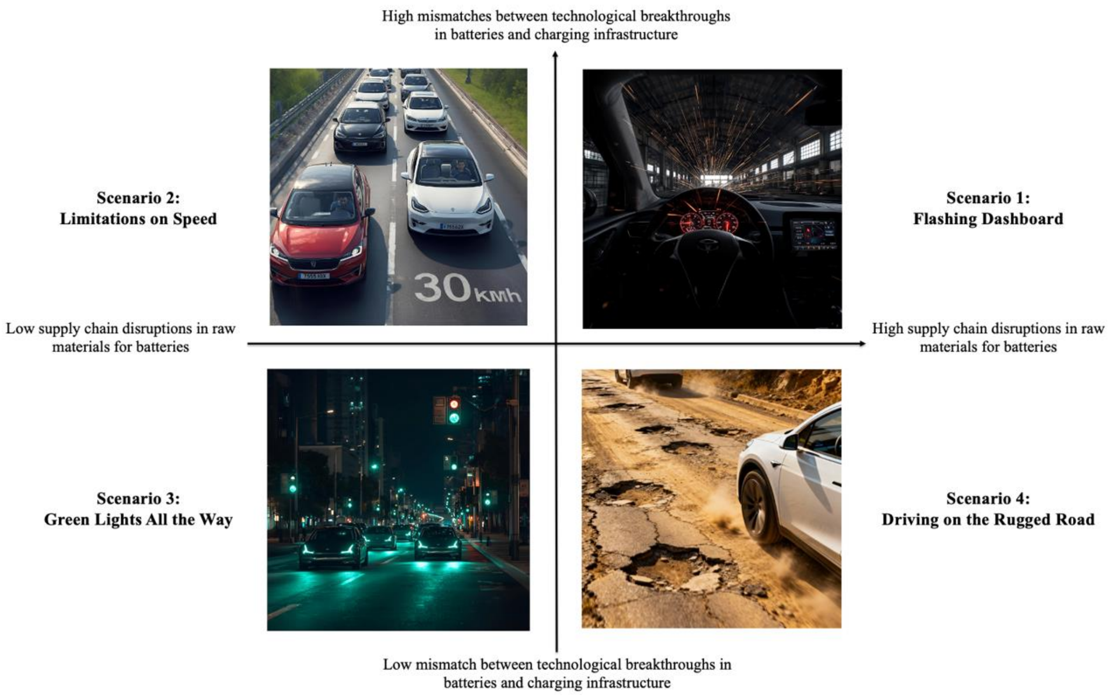

Figure 14. Scenario logics (Created by the author)

5.1. Scenario 1: "The Flashing Dashboard"

5.1.1. Scenario storylines

This scenario represents high supply chain disruptions in raw materials for batteries and high mismatches between technological breakthroughs in batteries and charging infrastructure. In the storylines, a car resembles the Chinese EV manufacturers, and dashboard indicators flash constantly because of functional failures in the car, just as the two negative factors mentioned above are combined. As a result, the car often breaks down, mirroring the gloomy Chinese EV manufacturers.

Supply chain disruptions are becoming increasingly serious over the next ten years, driven by both geopolitical tensions and policy monopolies. As a result, China has lost its leading position in EV battery manufacturing because of an insufficient material supply. This will subsequently negatively influence Chinese EV manufacturers, since they are highly dependent on those domestic batteries for production. Manufacturers have to seek other ways to survive in such conditions. For instance, some manufacturers strive to be innovative with other types of batteries that depend much less on imported critical minerals, while others still heavily rely on the same material but with a much higher cost than before. Both situations require substantial financial support. At the same time, the incoordination between technological breakthroughs in batteries and charging infrastructure worsens further across different manufacturers. This mismatch makes it hard to develop uniform national regulations; therefore, some excellent performers in technological innovation can serve as advocates in drafting regulations, further consolidating their positions in the whole industry. Consequently, large manufacturers survive by vertically integrating, such as with companies that are more powerful in procuring foreign critical minerals. On the contrary, the less competitive manufacturers are gradually exiting the market due to insufficient resources. In short, the entire Chinese EV manufacturing industry becomes chaotic, given the different technological development paths and the lack of agreed-upon standards.

5.1.2 Narrative story

Ming, an officer in the organization for drawing regulations for the EV industry. In 2033, he walks into the office in the morning as usual. He becomes increasingly stressed these days, because he is 'welcomed' with an overwhelming number of files on his table. The lack of uniform regulations and standards creates a situation in which several standards are drafted within 3 months and are waiting for audit by Ming. For instance, city X has adopted standard A for swapping batteries, while city Y has adopted standard B for ultra-fast charging. Meanwhile, he has received many complaints recently, as EV manufacturers argue that it is unfair to be subjected to regulations that are solely targeted at them, and they advocate that the standard applied to them should be applicable to all manufacturers. Ming is therefore bothered by such a message from calls nearly every day. Ming has also received information that many EV manufacturers have ceased business operations. The cost of sourcing critical minerals for batteries has risen tenfold in a year because many countries have limited their exports to China. Consequently, the costs for battery manufacturers have sharply risen, leading EV manufacturers to compete for batteries. The result is that some EV manufacturers can neither afford the rising costs of sourcing other battery-critical minerals for their own production nor allocate sufficient funds to develop new types of batteries. Ming has realized that the existing situation is not merely about technological innovation, but about chaos across the whole industry, reflected in some manufacturers' expansion without considering the whole industry, as well as in the uncoordinated policy-making. As a policymaker, Ming definitely wants to establish unified regulations for management, but he can just balance the benefits by selecting the decision that do least harm to the industry and stakeholders, which is picking the best from a bad bunch.

5.2. Scenario 2: "Limitations on Speed"

5.2.1. Scenario storylines

This scenario represents high mismatches between technological breakthroughs in batteries and charging infrastructure, and low supply chain disruptions in raw materials for batteries. The production proceeds smoothly with sufficient material supplies, resembling a car in good condition. However, the car's speed is not high due to the slowdown in innovation. The speed is also negatively influenced by the remaining giants.

The supply chain for battery raw materials remains stable with no restrictions, as reflected in both quantity and timeliness. This stability does not cause fluctuations in production costs. However, the main concern is the lack of coordination between technological breakthroughs in batteries and charging infrastructure. Some EV manufacturers cannot update their products to meet new prevalent types of charging infrastructure developed and supported by manufacturer S. Those manufacturers also want to be pioneers in changing standards based on their own preferences, but they have little impact on both policymakers and customers compared with S. As a result, despite the supply chain ensuring stable production, the technological monopoly by the giant hinders innovations that could be the major breakthroughs in the whole industry. Therefore, some EV manufacturers have to maintain the status quo and fall into 'innovation fatigue'. Viewed across the entire EV manufacturing industry, the giant gradually dominates the market by marginalizing less competitive manufacturers, leading to product homogenization with massive volume. Customers have also grown tired of seeing similar car models and have increasingly shown reluctance to buy them. This situation has left Chinese EV manufacturers in stagnation with a dramatic fall in sales. Gradually, Chinese EV brands have lost their reputation and competitiveness in the global market.

5.2.2 Narrative story

Hua is an R&D engineer at a small EV manufacturing company. It is a typical working day in 2032. Hua sits at his desk with little work, always worried about being dismissed by the company, given that his company has already become less profitable than ever before due to the phase-out risk posed by some giants. Even though Hua's company can ensure stable production without concern for battery materials, it lacks the discourse power to advocate for industrial standards grounded in its own innovations. Therefore, Hua and his colleagues lose the impetus to make breakthroughs and are forced to stay in the status quo. His situation is also influenced by his company's strategy, which aims to be acquired by one of the giants to minimize losses. Some images have flashed through Hua's mind: he worked until midnight in the laboratory 10 years ago, and their products are always popular with customers; he enjoyed being absorbed in his work despite occasional hard times. Hua realizes that the time when each manufacturer had its own specialty is long gone, and it will not return. Hua now prays to be acquired by a company in the industry instead of being laid off, and he knows that this is an era when mistakes in pursuing new models are less, and innovations are becoming fewer as well.

5.3. Scenario 3: "Green Traffic Lights All the Way"

5.3.1. Scenario storylines

This scenario represents low mismatches between technological breakthroughs in batteries and charging infrastructure, and low supply chain disruptions in battery raw materials. The car moves smoothly on the road with green traffic lights all the way, as Chinese EV manufacturers prosper.

In this scenario, Chinese EV manufacturers are developing more rapidly than those in other countries. On one hand, China has established stable cooperation with countries that provide sufficient critical minerals through investments and multiple supply channels. Meanwhile, China has also increased domestic production of critical minerals, thereby decreasing its reliance on foreign materials. Reliance has also dropped, given the fact that the recycling technology for used batteries has greatly improved. The outcome is that EV manufacturers have abundant resources for stable production, which, in turn, stimulates technological innovation by reducing trial costs. On the other hand, China has issued national regulations and standards for EV charging, indicating that the charging infrastructure is developing, aligning with technological innovations. For instance, the new standard allows for interchangeable charging methods across different brands (e.g., it requires that an electric model be swapped with a battery and be equipped with ultra-fast charging equipment at the same time). As a consequence, charging capacities and efficiencies are positively influenced by the enhanced coordination between charging infrastructure and charging technology innovations. In summary, Chinese EV manufacturers benefit not only from unified national-level regulation but also from the high certainties in supply chains. Therefore, China is becoming the world leader in the industry by setting global industrial standards and by developing a competitive, sustainable industrial structure.

5.3.2 Narrative story

Shan, an office worker in a small city in China in 2035. She has bought a new electric model from the brand S. It was not a tough decision for her because she knows that charging concerns no longer exist compared with the situation 10 years ago. Meanwhile, she can still remember the problems with charging facilities in 2025. She bought her first electric model that year, motivated by a desire to choose eco-friendly products. However, problems have arisen while she was driving the vehicle. One day on the road, her car was nearly out of power with very limited range, and then she saw a charging station where she could charge it. Arriving at the station, she was disappointed to find that the charging facility was not compatible with her model, so she had to call emergency rescue for her car. The situation has changed totally today. Shan can open the program on her phone to check charging point availability, and she can also get her car fully charged within 5 minutes from 0 state of charging. Uniform technological standards have eliminated incompatibility among different brands, boosting customer confidence in buying the domestic EV. She also realized that China has already become the world leader in this charging technology, and it is gradually becoming prevalent globally. The convenience of her life and boom of the EV manufacturing industry lies in the synergy of effective policies and stable innovation.

5.4. Scenario 4: "Driving on the Rugged Road"

5.4.1. Scenario storylines

This scenario represents low mismatches between technological breakthroughs and charging infrastructure, and high supply chain disruptions in battery raw materials. The car is in good condition, as the low mismatches between technological breakthroughs in batteries and charging infrastructure, and the rugged road indicate the high supply chain disruptions in battery raw materials. The car can move on the road, and its functions can be damaged by the road conditions. Chinese EV manufacturers, therefore, need to find solutions to evade the 'pitfalls' on the road.

In this scenario, China has already demonstrated coordination between EV manufacturers' technological innovations and charging infrastructure, creating user-friendly car models. When choosing models, customers are no longer concerned with charging functions. However, the problem of disruptions in certain critical minerals used in batteries is becoming more prominent than 10 years ago. For instance, the proportion of imported nickel from country A has decreased by 80% due to a policy issued by country A that strictly restricts exports. In addition, the geopolitical situation is worsening, partly blocking the logistical routes of the critical minerals. As a result, EV manufacturers have to halt production due to a shortage in battery supplies. The disruption is also magnified by the fact that ESG (environment, society, and governance) standards are implemented further, greatly increasing compliance costs and forcing some mining organizations to stop their business. Although

Chinese EV manufacturers face disruptions, the influences vary for companies of different sizes. Large manufacturers minimize the effects through overseas investments, such as by setting up critical minerals processing facilities in locations with fewer restrictions. In contrast, small companies and start-ups are struggling to survive due to a lack of resource integration. As a consequence, the overall structure of Chinese EV manufacturers becomes increasingly concentrated, with the big giants becoming even more dominant. As a consequence, it is even easier to coordinate between technology innovations and charging infrastructures, since fewer manufacturers require less communication cost for policies regarding both time and finance. In summary, although innovations can proceed smoothly with the aid of national unified policies, the industry remains unstable owing to its dependence on external resources.

5.4.2 Narrative story

Ye, the senior executive vice president of a giant EV manufacturing company, M. She is now planning to start her business trip to country B. The reality is that the price of cobalt (a critical mineral for EV batteries) has soared recently, as the main producer (Country A) has faced severe scrutiny from international organizations over the problem of child labor. Therefore, country A is required to close some mining sites. It is strategic for Ye and her company to make a shift from country A to country B, which is also a strong cobalt supplier. Ye also realizes that they must take concrete actions to minimize supply chain risks; thus, she aims to negotiate with some small cobalt suppliers in search for the merge opportunities. Her company is lucky, because some of its disadvantaged competitors have already gone bankrupt because of a shortage of battery supply. At the same time, her company has gained brand advantages, because it has become the advocate in drawing charging standards. Ye knows that the charging infrastructure is merely 'beautiful wastes' if there are not so many vehicles on the road. Another concern for her is that those 'beautiful wastes' can possibly be removed or substituted if more new imported models dominate the domestic market. Moreover, to reduce reliance on certain critical minerals, a new battery technology that relies on other minerals is under development at Ye's company, but no one knows whether the innovative products will withstand future supply turbulence. Ye understands that even though her company is taking action in the face of supply chain risk, the entire industry in China remains very passive.

5.5. Differences among scenarios

The differences among scenarios are summarized in Table 14.

Table 14. Differences among scenarios (Created by the author)

	Scenario 1 The Flashing Dashboard	**Scenario 2** Limitations on Speed	**Scenario 3** Green Traffic Lights All the Way	**Scenario 4** Driving on the Rugged Road
Mismatches between Technological Breakthroughs in Batteries and Charging Infrastructure	High	High	Low	Low
Supply Chain Disruptions in battery raw materials	High	Low	Low	High
Industrial Integration	High (Unstable)	High (Monopoly)	Low	High (Giants Remain)
International Competitiveness	Low	Middle	High	Middle
Innovation Speed	*uncertain*	Low	High	Middle
Narrative Character	An Officer	An R&D engineer	A Consumer	A management personnel
Character's Attitude	Contradictory	Worried	Satisfied	Unsecure

It is noted that the innovation speed in scenario 1 'Flashing Dashboard' is uncertain, because the speed can be either high or low. On one hand, the innovation speed can be high if fierce competition continues among EV manufacturers, and it is necessary to develop products with new features to obtain their leading positions and to be competitive; this can possibly be further aided by the high disruptions in critical minerals for batteries, since the shortage can incite some manufacturers to explore substitutes for the existing products. This means that manufacturers that already include battery production would upgrade their battery production lines, while manufacturers that use batteries from a supplier would develop new types of batteries. On the other hand, innovation speed can be low if the high disruptions in battery critical minerals persist for a long period. If the next-generation battery still relies on the same main critical minerals, the disruptions would definitely extend the domestic R&D cycle. Thus, the innovation speed cannot be evaluated given the high uncertainties of the two factors. In contrast, in scenario 2 'Limitations on Speed', the innovation speed can be hindered by the fact that products are homogeneous. In fact, it is also possible that giant companies accelerate their innovation pace with limited existing competitors, since they can focus more on developing their own products. But, as mentioned before, 'innovation fatigue' will set in if the company does not understand the industry's innovation landscape. Therefore, the innovation speed slows down with the technological monopoly of giant companies. The innovation speed in scenario 3 'Green Traffic Lights All the Way' is high, supported by two factors, creating a healthy competition environment. The innovation speed in scenario 4 'Driving on the Rugged Road' falls in the middle between 'Limitations on Speed' and 'Green Traffic Lights All the Way'. Although the supply of battery critical minerals is sufficient, providing R&D resources, the new technologies will not be used efficiently without corresponding infrastructure. Therefore, innovation speed is mainly limited by the lack of coordination with charging infrastructures.

In addition, although industrial integration also shows a high level in scenarios 1, 2, and 4, the situation varies slightly. It means that the giant manufacturers hold the majority of market shares, marginalizing the living spaces of small businesses. In scenario 2, 'Limitations on Speed', a monopoly forms over technological innovation (mainstream technology is controlled by the giants), making it hard for small manufacturers to compete due to the industrial standards set by the giants. So, the monopoly manifests in technical barriers and the lack of standards appeal. Then, in scenario 4, 'Driving on the Rugged Road', industrial integration is affected by competition for resources rather than technology. The company that is active in resource acquisition can demonstrate powerful production ability, while the company that cannot ensure normal production hardly survives. Therefore, there is a high chance that giants remain because of their strong ability to compete for resources. Last, scenario 1 'Flashing Dashboard' combines two shocks from scenarios 2 and 4, but with instability, and this is engendered by both unclear directions of policy and the heterogeneous influences of supply chain disruptions on manufactures. This scenario is also not helpful in enhancing international competitiveness, given the chaotic industrial landscape. In contrast, scenario 3 'Green Traffic Lights All the Way' exhibits low industrial integration given the presence of multiple manufacturers with a beneficial competition environment, enhancing the international competitiveness for Chinese EV manufacturers.

I also chose four different characters, both within the EV manufacturing company and in related fields, because I am eager to examine how scenarios influence industry stakeholders. Those characters' lives and behaviors are closely related to Chinese EV manufacturers, and they exist throughout the whole EV industry, ranging from upstream (material suppliers) to downstream (customers). Meanwhile, it is also noted that the character in one scenario may show a different attitude in another scenario. For example, the customer in scenario 3, 'Green Traffic Lights All the Way', may feel unsatisfied in scenario 2 because of the fewer selection options for new models. However, my selections remain reasonable, as the suitable character is selected by considering their relevance to each scenario's storyline, rather than exploring the impacts of one scenario on all people. Additionally, as Bell (1997, 93) mentioned, one of the purposes of futures studies is to increase democratic participation in imagining and designing the future. Therefore, I believe that futures are not built solely for a specific group but are inclusive for all, and this relies on the interplay and mutual influences among individuals with different perspectives for democratic participation. This point is also supported by Tuomi (2019, 8), who claimed that the future is shaped by people's actions, agency, and interactions, and the dialogue with various voices helps participants to make sense of their realities in innovative ways. As a result, if people from different sectors learn about the impacts of different possible futures, it will generate broader perspectives for strategy development than if everyone supports the same scenario.

5.6. The Wild Card Scenario: 'The Broken Tire'

One wild card scenario is constructed based on Figure 13： risk matrix. As depicted in the matrix, one risk with high severity and low likelihood is the volatility in prices of raw materials for batteries (severity value is 4, while likelihood value is 2). Although this risk is not the most significant for Chinese EV manufacturers, it well shows the characteristics of the wild card. The volatility in the prices of raw materials for batteries suggests that prices of certain critical minerals (e.g., lithium, nickel, copper) can rise or drop in a given period. An increase in the prices of battery raw materials will raise production costs, while a decrease in prices will create overcapacity. As a result, both situations manifest adverse impacts on the industry landscape.

The suitable wild card scenario is built with the consideration of global risks from the report of the World Economic Forum (2025). The global risk report 2025 released by the World Economic Forum (2025) has listed the top ten global risks ranked by severity both in 2 years and over a 10-year period, and the EV industry is affected by many of the listed risks, such as geopolitical conflicts, the scarcity of natural resources, and economic downturn. In Figure 15, natural resource shortages have a relatively higher severity level in both the short- and the long-term. This risk can cause a sharp surge in the price of battery raw materials because of scarcity. On the other hand, the risk of concentration of strategic resources is comparatively higher in both dimensions. This risk refers to the firm control of certain critical inputs or technologies by a few countries or organizations, disproportioning the resources obtained. In the Chinese EV manufacturing industry, critical minerals are mainly mined in several countries, highlighting the risk mentioned.

As mentioned, the wild card scenario is built not only on the risk matrix I created but also on the global risk landscape. Therefore, the wild card is the extreme surge in the price of battery raw materials. Similarly, the scenario storylines and the narrative story are drafted with the risks identified by the World Economic Forum.

Selecting the extreme surge in the price of battery raw materials as the wild card can be justified based on several reasons. I also consider choosing another wild card, such as technology transitions. However, the selected wild card event can have a significant impact on the entire industry rather than on specific manufacturers. For example, technology transitions can happen gradually rather than suddenly, giving manufacturers time to develop innovation strategies. Meanwhile, wild cards can lead to both positive and negative outcomes; as Mendonca et al. (2004, 207) suggested, they can result in a dead end or push the trend path forward. From the risk management perspective in my study, a negative wild card is appropriate, since risk can lead to harm, and I want to explore how manufacturers can act in adversity, rather than how to become more prosperous from existing situations. Therefore, my selection scope of wild cards focuses on factors that would generate undesirable effects on the whole industry. Since my study concentrates on the Chinese EV manufacturers, the wild card should be context-specific. The scope of the effect of wild cards varies; some wild cards generate global impacts (e.g., COVID-19), while some only affect part of the world. The extreme surge in the prices of battery raw materials particularly affects Chinese EV manufacturers, as they are sensitive to price turbulence, given the vast production scale. Meanwhile, the heavy dependence on imported critical minerals is largely influenced by geopolitics and international regulations. Lastly, "price competition" in China makes it difficult to pass the soaring costs from manufacturers to customers downstream, intensifying the side effects of surging materials prices. In short, the wild card is unique, given both the operational environment of Chinese EV manufacturers and the aim of this study.

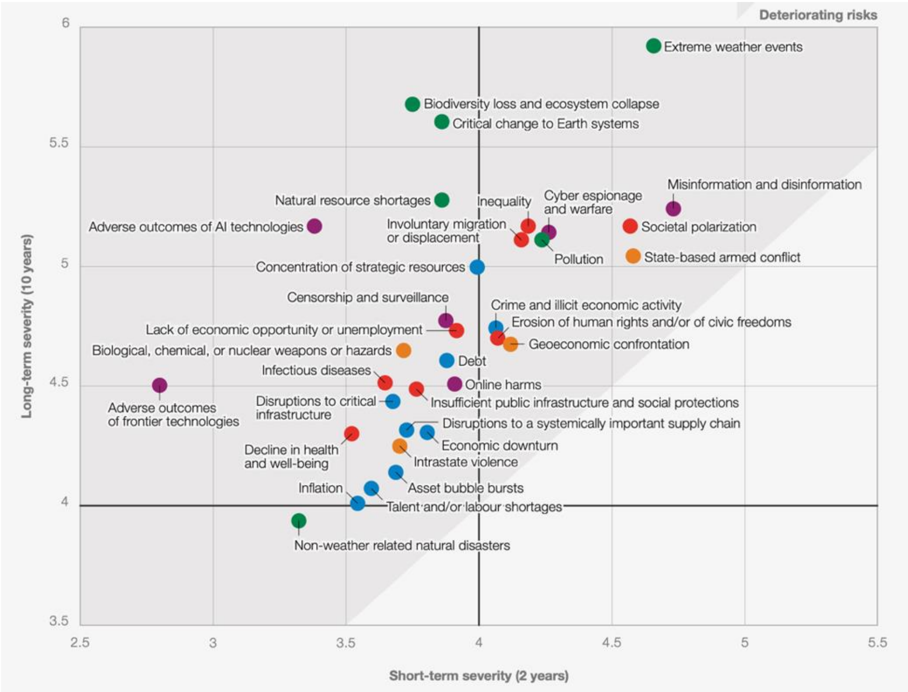

Figure 15. World risk map (the World Economic Forum 2025)

Scenario storylines

This scenario represents the continuous surge in the price of battery raw materials and resembles the abrupt breaking of a car tire on the road. The driver has limited control over the broken tire, and more dangerously, it is deadly under such conditions. Just as manufacturers can suffer from sudden disruptions that deteriorate their performance.

Figure 16. The illustrative image for the wild card (Generated by AI)

It should be noted that high supply chain disruptions occur in scenario 1‘Flashing Dashboard’ and scenario 4 ‘Driving on the Rugged Road’, and it means that the logistic issues appear, resulting in the temporary shortage of the material. In a word, Chinese EV manufacturers cannot acquire sufficient critical minerals for production in a timely manner due to supply chain disruptions. Meanwhile, although the risk is considered prominent over the next 10 years, it is hard to discern the duration because of many uncertainties (policies, international relations, etc.), and manufacturers can make short-term adjustments to address the issue and survive. On the other hand, the risk differs from a continuous surge in the price of battery raw materials. In the latter situation, the supply of battery raw materials is negatively affected for several years, and the problem is manifested in both the ‘scarcity’ and the ‘affordability’. Even though the issue of rising manufacturing costs can be alleviated by some powerful manufacturers in scenario 1, the measure is ineffective when the sustained surge in the price of battery raw materials is maintained, creating ‘unaffordability’ for all manufacturers. As a result, the scenario is depicted as price-driven rather than supply-driven risk.

The continuous surge in the prices of battery raw materials is triggered by several factors over the next decade. First, a high concentration of several critical minerals exists in country X (geographically), and it abruptly strengthens its pricing power by extremely increasing the prices. Despite increasing concern about the shortage of natural resources, country X has decided to continue mining stably, by raising prices to limit the usage of such materials. The materials remain physically available with harder efforts. In addition, geoeconomic confrontations are becoming apparent, and country X is exporting materials to China at stunningly high prices to curb the development of the

EV industry there. As a result, the price soars beyond expectations, and the problem cannot be addressed with short-term strategies like diversifying supply channels. The shock sweeps the whole industry, and even manufacturers with strong resources cannot offset the rising cost. Chinese EV manufacturers face compressed profit margins, and they have to raise finished vehicle prices, which damages their price competitiveness in the global market. The industry landscape is wholly reshaped by the shock, ceasing most of the production. Although such an extreme price escalation is unlikely, its impact would be striking and profound if it occurs.

Narrative story

Bai, the Chief Executive Officer of an EV manufacturing company M, and his company also produce their own batteries. He is checking the production and sales data about the company's products in his office. The data show that both vehicle production and sales are declining month by month. Even though he recognizes that the supply of critical battery materials is sufficient, his company can no longer afford to purchase such materials. They must now pay 50 times as much for the same amount of material compared with just one year ago. To operate within the budget, the company has to lower its production. On the other hand, the company tries to compensate for the condition by drawing on other sources. For example, it uses inferior-quality materials for the vehicle body than before, which results in many customers leaving because of the much lower cost-effectiveness (more money for worse products). In the past year, Bai organized hundreds of meetings with procurement teams, and the team has put forward many solutions, such as diversifying supply channels and renegotiating contracts, but none have been effective enough to stop the rising prices. Bai also realizes that such a situation is faced not only by his company but all manufacturers in the industry. He witnessed manufacturers' bankruptcy over the past year, and his company will also go bankrupt in the near future if the situation persists. Bai believes that the entire industry will be devastated rapidly.

6. Risk Management Strategies

6.1. General risk management strategies

The world is full of uncertainties and complexities; thus, we can find solutions while avoiding dead ends. Scenarios, therefore, help generate clearer images of the future, and it is a success to find paths for actions and to evade dead-end results (Tuomi 2019, 11). At the same time, scenarios are plausible futures, and we are not sure which one is most possible, so organizations need to develop multiple strategies in the face of changing environments. The scenarios in this thesis are based on the risk analysis results, so I aim to explore how Chinese EV manufacturers can achieve sustainable growth amid major risks across different situations.

According to ISO 31000 (Flaus 2013, 48), risk assessment results in the formulation of risk treatment strategies. Risk treatment is an indispensable part of the risk management process, as it converts analytical results into concrete actions that help organizations prepare for different situations. Risk management remains descriptive instead of practical without a risk treatment process.

Two risks (supply chain disruptions in battery raw materials and mismatches between breakthroughs in batteries and charging infrastructure) are identified as high risks for Chinese EV manufacturers because of both high likelihood and severity, showing that they both locate in the upper right area of the curve. However, the wild card (an extreme surge in the prices of battery raw materials) is in the 'tolerable area' based on the chart because of low likelihood but high severity (upper left corner). Additionally, organizations can only accept the risk with awareness if impacts are beyond control. It is hard to treat the risk, since there is neither the space to lower the likelihood further nor the ability to control the severity. Transferring the risk is also impossible, since the influence of the wild card is systematic and long-lasting; how can organizations wish to transfer to other parties that also suffer from the event? Lastly, it is hard to terminate the risk, because it means that the organization will retreat from the industry and stop doing business as an individual. Although it can also be seen as a measure, the risk management strategies in my study are developed on the premise of ensuring the integrity of the organization. Therefore, terminating the risk is not suitable in this context.

Two high-level risks are selected to build four logical scenarios, along with an additional wild card scenario. I will first develop risk treatment strategies for the two high-level risks separately, and then concrete measures that account for their mutual influences.

The high risk ‘mismatches between breakthroughs in batteries and charging infrastructure’ is difficult to treat by the manufacturers alone. On one hand, although some manufacturers have the power to advocate for the drafting of charging infrastructure standards and even build them for their own products, they are still supervised at the national level. One uncertainty about building charging infrastructure is its social acceptance and its nationwide prevalence. As mentioned, consumers remain concerned about the range of models, and it would be better if the changing standards were unified across locations. On the other hand, competition for new electrical model innovations is becoming increasingly fierce in China, squeezing out some companies. The reason for being excluded from the market is that some companies are going the wrong way in research and innovation. They care more about being unique and fancy in the model’s appearance than about utility, including charging capacity. As a result, consumers are reluctant to purchase such models, which offer limited practical improvements.

As a result, the optimal risk management method is to treat the risk. This does not mean that manufacturers will withdraw completely from technological development (e.g., by stopping the development of super-fast charging). Manufacturers that incorporate battery production should not rely on a single battery technology with full confidence, but should diversify their solutions. Once the technology that benefits them is threatened by other potential mainstream schemes, they will not be attacked wholly and will have alternatives to provide positive feedback. Furthermore, the new technology can be deployed in phases. It is ideal to test such a technology on a small scale, such as in a specific area of a city, and then expand the application as the infrastructure develops. However, this process entails the coordination between national legislative departments and manufacturers. National legislative departments often take compatibility into account, because the status quo is that EV distribution across the country is unbalanced, with more EV in wealthier and warmer regions, such as Shanghai and Shenzhen, while fewer in less developed and colder regions, such as Heilongjiang and Ningxia (Xing et al. 2023, 151). The policies for developing Es in the early stage are favorable for big cities, including the provision of charging infrastructure. Meanwhile, building charging infrastructure is profitable for manufacturers, as it helps them gain market share and enhance the acceptance of their products. Better coordination can be achieved by introducing more policies in unfavorable areas; after all, construction is led by the government. Drawing charging standards should not be set by powerful manufacturers, but by multiple manufacturers to promote technological interoperability and ensure that common charging technology is available across as many models as possible.

The risk cannot be terminated, given that some manufacturers hope to advocate charging standards compatible with their production and to find a charging solution that can become mainstream in futures. For example, several leading Chinese EV manufacturers form a ‘supercharge alliance’ to allow standardization of EV charging (GULF NEWS 2024). Even though GB/T 20234 (National Public Service Platform for Standards Information 2024) has standardized the charging port, which most brands in China use, charging power and communication protocols vary across models, so they do not match well with charging infrastructures, and specific charging ports are still needed for some models. The standard needs to be reviewed and updated in a timely manner as charging technology advances, especially given the emergence of innovative technologies such as wireless charging and battery swapping in recent years. The applicability of the current charging infrastructure is challenged, therefore intensifying the risk of mismatches between battery technology and charging infrastructure. It is advisable for manufacturers to actively collaborate with local government and energy sector agencies to build charging infrastructure and, importantly, update it as technologies develop. This indicates that technology should not be developed with the mere aim of profitability and competitiveness, but should also incorporate factors across the entire EV industry.

On the other hand, although it seems that manufacturers that do not start battery manufacturing business can avoid such a risk by not including the link, they are more likely to be exposed to another high-level risk, ‘supply chain disruptions.’ The risk of supply chain disruptions is high in the likelihood, and it poses negative impacts on normal production in the short term. Therefore, it is an operational risk that can be mitigated with suitable management processes and procedures. Even though EV manufacturers that include battery production can also face supply chain disruption risks, the mechanisms are different. For manufacturers that vertically integrate battery production, supply chain disruptions directly affect battery and vehicle production capacities, whereas manufacturers that rely on purchasing batteries can suffer from reduced procurement channels, uncertain supply sources, and limited bargaining powers. Both mechanisms will restrict production and profitability for EV manufacturers.

Supply disruptions for batteries depend on upstream mines and materials, and reliance on a single battery technology (e.g., liquid lithium battery) is largely constrained by the availability of the resource. Manufacturers that incorporate battery production can collaborate with mining enterprises, such as by investing directly or signing long-term supply contracts to ensure the supply stability. Meanwhile, those that acquire critical resources can have competition advantages than its competitors. It is also advisable to relocate part of the production capacity to countries with better advantages in acquiring the materials and in opening potential markets. In fact, some of the brands have already put this into practice. For instance, BYD has established its factories in Hungary (BYD 2025b). This can be seen as a desirable example of diversifying supply chain patterns and may be considered by some manufacturers. The action also illustrates that diversifying markets by reaching global customers is a risk mitigation strategy. The overreliance on the single market can lead to lower customer acceptance if the policy is unfavorable to the manufacturer, and multiple market strategies can alleviate this by mapping out alternatives. For manufacturers not engaged in battery production, it is recommended to work with several battery suppliers. EV manufacturers should actively seek cooperation with multiple battery suppliers to ensure supply continuity and should not focus on a single model, but rather on multiple models that are compatible with various batteries. Then they can still develop their products if one of the batteries is phased out gradually.

Lastly, it seems that a wild card falls into the ‘tolerate’ area due to its high severity and low likelihood; however, tolerating does not imply that organizations have no measures to address the risk; tolerance may only work when the risk is within organizations’ ability. Instead, it suggests that traditional risk management strategies are often insufficient due to the scale and duration of impacts. Hence, it is vital for organizations to be resilience-oriented. In a word, being tolerant of the wild card makes sense if organizations rationalize their possible bankruptcy and disappearance. Otherwise, organizations should insist on a complete transformation.

When suffering the effects of the wild card, the foremost consideration for manufacturers is survival, since such an event exerts systemic influence, and most strategies for high-level risks are invalid.

Many Chinese EV manufacturers are engaged in 'the price competition', indicating that some brands try to attract consumers by lowering prices of their models or providing favorable payment schemes. So, it is rather unwise for manufacturers transfer the soaring costs from production to customers, since this action goes against the trend of providing high-cost-effectiveness products. Plus, searching for alternative suppliers is very limited; the structurally high prices of raw materials will force them to raise prices of their products; otherwise, they will be the first and foremost victims, and therefore, diversification of supply channels becomes ineffective.

Manufacturers are thus forced to follow some strategies. For instance, technological innovations have been evident in the EV industry, such as improvements in the energy density of lithium-ion batteries. Such a route is advisable, as it reduces the dependence on the quantity of battery raw material for the same energy generated. However, this strategy can be seen as an alternative that emphasizes technology substitutions. Instead of relying on existing materials at high prices, searching for new types of batteries that require different materials is viable, especially by using materials that are abundant in China, thereby reducing the risk of a shortage of foreign materials. In addition, manufacturers can focus on battery recycling by reusing the battery pack or extracting materials. The availability of recycling materials remains limited; therefore, it is hard to see its impact in the short term; In addition, the majority of companies engaging in the battery reuse at the end of first life locate in Europe (IEA 2025b, 144). Therefore, manufacturers should actively engage with the government to develop policies on battery recycling and to map out efficient recycling networks to enhance the resource utilization rate. Lastly, it is imperative that manufacturers restructure their business. Although this strategy also addresses the risk of high supply chain disruptions, the latter underscores the need for a complete reconfiguration of the business. For example, manufacturers can form a contract with mining corporations vertically in the upstream in the long term (e.g., 20 years) to ensure the supply of materials at an affordable price, and the integration can also be horizontal by cooperating with other EV manufacturers to procure materials in a joint manner, lowering the cost.

6.2. Scenario-specific risk management strategies

Although risk management strategies are formulated separately for two high-level risks, they should differ in concrete actions by following the general strategies, since it is wise to manage risk with adequate resource allocation and avoid waste to help manufacturers operate optimally in both procedures and funding. The summary of strategies for each scenario is shown in Table 15.

Table 15. Comparison of risk management strategies among scenarios (Created by the author)

	Scenario 1 The Flashing Dashboard	**Scenario 2** Limitations on Speed	**Scenario 3** Green Traffic Lights All the Way	**Scenario 4** Driving on the Rugged Road	**Wild Card Scenario** The Broken Tire
Mismatches between Breakthroughs in Batteries and Charging Infrastructure	High	High	Low	Low	/
Supply Chain Disruptions in Battery Materials	High	Low	Low	High	Available but unaffordable
Risk Characteristics	Unsustainable business	Difficult to be implemented technology	Increased competitions among manufacturers	Disrupted productions	Influenced survival chance
Risk Management Goal	Consider Transformation	Diversify technologies	Increase efficiency	Ensure productions	Start Transformation
Risk Management Logic	Terminate + Treat	Treat + Terminate	Tolerate + Treat	Treat + Transfer	*Limited Treat*
Tailored Risk Management Strategies	- Postpone enlarging production scale - Decrease bet size on a single technology - Resort to industrial alliance	- Multiply technology routes - Enhance conversations with policymakers - Concentrate on phased application	- Refine supply chain management - Gradual technology upgrade - Increase consumers' satisfaction	- Engage in upstream - Multiply supply channels - Establish long-term cooperations with suppliers	- Commercialize new technology - Secure a solid place in the upstream - Make breakthrough in battery recycles

The tailored risk management strategies for each scenario are explained as follows:

6.2.1. For Scenario 1 – The Flashing Dashboard

• Postpone expanding production scale. The combined effect of two risks makes it difficult for manufacturers to maintain existing production, let alone expand production scale. Manufacturers should first consider how to ensure normal production and terminate irreversible further investments in expanding production scale. Since the scale expansion is advisable if production is profitable.

• Decrease bet size on a single technology. It is advisable for manufacturers not to over-rely on a single technology, since high reliance on a single technology is vulnerable to the constraints of upstream materials. Manufacturers can reduce the severity of both risks. On one hand, developing parallel technologies allows manufacturers to innovate products compatible with charging infrastructure; on the other hand, it helps reduce the adverse impact of material supply shocks if manufacturers diversify their material needs.

• Resort to an industrial alliance. Manufacturers can share risks by forming alliances with peers in the same industry. For example, they can reduce pressure on costs through joint procurement and R&D, enhancing the negotiation power with upstream suppliers. This allows manufacturers to be resilient if the shock cannot be absorbed by a single company-level capacity.

6.2.2. For Scenario 2 - Limitations on the Speed

• Multiply technology routes. Manufacturers can reduce the likelihood of risks by developing multiple battery technologies simultaneously. Technologies, such as super-fast charging and innovative batteries with high energy density, help manufacturers avoid prematurely focusing on a technology that lacks infrastructure support. The practice creates adaptability for manufacturers if 'technology lock-in' occurs.

• Enhance conversations with policymakers. The mismatch is sometimes shaped by regulatory frameworks and governmental policies. The aligned technology route set by policymakers provides manufacturers with a clear goal to follow, and therefore, manufacturers can influence policy uniformity and support policy initiation.

• Concentrate on phased application. Introducing new technology with limited application in a specific area aids manufacturers in testing its compatibility with existing infrastructure. The slow process not only allows adjustments but also reduces wide-scale rejection, enabling smooth integration of new technology into the system.

6.2.3. For Scenario 3 – Green Traffic Lights All the Way

• Refine supply chain management. Instead of reconstructing supply chain structures, manufacturers can enhance supply chain efficiency and reliability through process optimization to increase speed and reduce costs. For example, establishing a stable partnership with suppliers can ensure a stable supply. AI tools can be used to monitor logistics and to manage inventory.

• Gradual technology upgrade. Since manufacturers do not face so many pressures from both risks, they can concentrate on gradually upgrading technology. Manufacturers can improve product performance while simultaneously maintaining stable operation. Gradual technology upgrades can reduce the risk of technological innovations outpacing infrastructure development and enable better compatibility of new features into charging networks.

• Increase consumers' satisfaction. Manufacturers can achieve this by optimizing user experience and focusing on product quality. In a stable situation when risks pose limited threats, consumers' perception and brand trust play a crucial role. Active responsiveness helps manufacturers to consolidate their position in the industry and facilitate sustainability.

6.2.4. For Scenario 4 – Driving on the Rugged Road

• Enlarge the business into the upstream. This can be realized through vertical integration with upstream businesses such as critical minerals and battery processing. The practice increases control over production inputs and reduces reliance on external suppliers, helping manufacturers partially mitigate market volatility by ensuring supply security.

• Multiply supply channels. Establishing partnerships with suppliers in different geographic locations can reduce the overreliance on a single supplier. When the supply of critical minerals in one region is severely disrupted, manufacturers can minimize the impact by implementing supply redundancy through a network, increasing manufacturers' flexibility.

• Establish long-term and cooperative relationships with suppliers. Manufacturers can form strategic partnerships with suppliers, such as by entering into a long-term contract. This arrangement creates shared information with aligned interests. When risk becomes increasingly obvious, manufacturers can respond jointly with suppliers rather than bear it solely.

6.2.5. For Scenario 5 – The Broken Tire

• Commercialize new technology. Manufacturers should accelerate the commercialization of new battery technologies to reduce reliance on certain critical minerals, including developing batteries with extremely high energy density and inventing batteries that use alternative minerals that are different from affected minerals. The practice does not indicate incremental upgrades but a fundamental transformation to maintain competitiveness.

• Secure a solid place in the upstream. Manufacturers must hold an absolutely powerful position in the upstream of the business. It can be achieved by increasingly controlling critical minerals mining through joint ventures and equity investments. It should be noted that this differs from the action of enlarging business into upstream in scenario 4, the aim of the former is to lock resources and to be involved in the pricing mechanism to reduce the market's instability, while the purpose of the latter is to increase operational control for stable supplies.

• Make breakthroughs in battery recycling. If the same materials can be extracted from end-of-life batteries, the dependence on resource extraction is reduced. The challenge lies in the high costs, including logistics, battery check and evaluation, automated disassembly, and other related costs. This requires manufacturers to allocate resources to such fields beyond commercializing new technology.

As summarized in the table, detailed risk strategies are developed for scenarios based on risk management logic. The basic four logics - treat, terminate, transfer, and tolerate - are effective for scenarios built on two high-level risks identified. When the supply chain is stable and highly compatible between battery technology and charging infrastructure, it is reasonable to be tolerant by refining processes and upgrading gradually. When both risks are significant, manufacturers need to temporarily terminate some businesses by halting further expansion and negotiating with other stakeholders jointly. In contrast, although manufacturers can see the wild card scenario as tolerable, transformative actions are still needed to survive. Also, the traditional four logics might be ineffective in the wild card scenario, with only limited treatment measures. Such a situation forces manufacturers to transform urgently and fundamentally, unlike the risk controls, without breaking the operating environment for the four scenarios.

In principle, two risks are at a high level due to high severity and high likelihood, and three risk treatment logics are applicable for high risks in theory. However, it is worth noting that uncertainty also plays a role, as we are not sure about the frequency or the duration of the risk in the next decade. In other words, the conventional risk matrix is not persuasive enough to form risk management strategies, and scenarios can be seen as a supplementary, effective method beyond probabilistic calculation. Meanwhile, the essence of uncertainty shows that even risks at high levels can be managed within an acceptable threshold. Therefore, it is reasonable to take into consideration the effects of high risks with different degrees, using four logical scenarios. As a result, the risk management strategies are adjusted accordingly, and the tolerance strategy is effective in scenario 3 when both risks evolve in a direction that is less serious. In conclusion, while four risk management logics are valid in principle, the applications should be adaptive as risks are not fixed but evolving.

7. Discussion

7.1. Managerial Implications

Although five scenarios present different implications for strategy development, several general risk management strategies are applicable to Chinese EV manufacturers. Regardless of the size or production activities of those manufacturers, these strategies are developed based on an analysis of industry-wide risks, which generally exist across the industry rather than in a specific manufacturer. Meanwhile, the measures are formed based on strategic management principles, not concrete actions. Therefore, the strategies can be generally applied to the manufacturers within the industry. It should also be noted that manufacturers differ in financial status, resource allocation, and strategy focus, so strategies can be adjusted in accordance with each manufacturer's features and circumstances. In short, the proposed strategies are flexible and can be broadly applied to Chinese EV manufacturers to support long-term development.

7.1.1. Keep strategic flexibility

It is wise for manufacturers to develop several possible development routes simultaneously rather than insisting on a single one. Although clear goals often lead to concrete actions towards them, the risk is that some of them cannot respond promptly, and their survival ability is undermined. By identifying risks that threaten operations, manufacturers can develop different strategies for several situations in advance. Once the risk is intolerable based on assessments, effective strategies can then be put into practice to minimize its negative effects. This requires manufacturers to create 'resilience'. The concept of resilience is "*the intrinsic capacity of a system to adapt its operations before, during, and or following variations or disturbances in order to continue to operate, in both planned and unexpected circumstances*" (Flaus 2013, 23). Scenarios in my study, therefore, help identify both planned and unexpected potential interruptions, and the strategy formulations enable manufacturers to continue to operate.

Organizations can therefore enhance their 'strategic flexibility' when applying the combined method. Strategic flexibility refers to an organization's ability to adapt to substantial, uncertain, and rapid environmental changes that significantly impact its performance (Aaker 1984, 74). Roberts and

Stockport (2009, 29) also noted that strategic flexibility reflects an organization's ability to use its resources both proactively and reactively. Although definitions vary, strategic flexibility is triggered by uncertainty in both internal and external operational environments, such as technological advances and regulatory changes (Brozovic 2018, 8). Organizations can achieve strategic flexibility through strategic variety, meaning that appropriate strategic options should be applied to a given situation (Brozovic 2018, 9). Raynor and Leroux (2004) used scenario planning as a concrete tool for achieving strategic flexibility, since they believe it enables organizations to prepare for unpredictable futures. Continuous adaptation helps organizations maintain a competitive advantage; therefore, developing different scenarios provides adaptation pathways. Meanwhile, strategic flexibility reduces risk (Brozovic 2018, 13). Organizations can respond quickly to environmental changes and mitigate the impact of risks through actions, such as modifying strategy directions identified through scenario planning. On the other hand, organizations achieve strategic flexibility by taking in new information, updating expectations, and allocating resources to make a high-quality decision. The process is included in the risk management process as communication and consultation, monitoring and review. Communication and consultation are effective in reducing information asymmetry by incorporating views from different stakeholders to assess risks comprehensively; it also helps promote awareness and understandings of risk, building a sense of inclusiveness among those affected by risks (ISO 2018). Monitoring and review support the continuous tracking of risk evolution and effectiveness of risk treatment measures (ISO 2018), and it should be incorporated through the whole risk management process. In addition, recording and reporting is also necessary, as they convey risk management activities and results across organizations and different stakeholders (ISO 2018), collecting ideas from different perspectives to generate insights for the development of strategy.

7.1.2. Diversify battery technology routes

This means manufacturers can diversify battery technologies. Although this is ideal for some manufacturers with abundant financial resources, small manufacturers can be followers without obtrusive testing to avoid the high cost of potential failure. The practice represents the diversification of vehicles at the design level rather than in application level. Therefore, the charging standard is not diversified as a result. The purpose of diversification is not to build new charging infrastructure but to make the products compatible with it. For example, the model can be charged both via super-fast and battery swapping, without burdening the charging infrastructure. Given the unevenly distributed charging infrastructure in China, such an approach helps to alleviate the system mismatch. Diversifying battery technologies provides adaptability and reduces lock-in risks, while unified charging standards ensure stability without compromising charging infrastructure. In fact, there are examples indicating the implementation of the notion. One Chinese EV manufacturer, Li Auto, has already cooperated with the giant Chinese battery producer for EV CATL by producing sodium ion batteries for future models to reduce the reliance on critical minerals (Reuters 2026). It highlights that the technology is promising especially in the times of geopolitical instability.

7.1.3. Create stable supply chains through upstream involvement

Although China processes the majority of critical minerals for EV batteries, the resources are mainly imported from other countries. Some critical minerals are easily disrupted by external risks. For example, DRC accounts for 90% of China's cobalt supply, and geopolitical risks will cause fluctuations in cobalt prices (Liu et al. 2023, 14). Therefore, diversifying the supply sources of critical minerals by collaborating with other export countries can alleviate the supply chain disruptions. In addition, promoting the recycling of critical minerals can ensure supply security to some extent, which requires both national regulatory support and standards within the manufacturers. Manufacturers can be involved in upstream activities in several ways. They can establish a strategic alliance with critical minerals suppliers, requiring manufacturers to make a shift from a pure purchaser to a participant in pricing and supply coordination. For Chinese EV manufacturers, supplier integration is crucial in enhancing operation efficiency (Zhang et al. 2024, 8546). One example is that the leading EV manufacturer, BYD, has already engaged in vertical integration through actions. It puts stakes in sourcing critical minerals across China, Africa and South America and battery cell production with battery producers (Supply Chain Community 2025), which requires both resources and adaptability.

7.1.4. Establish institutional collaborations

Investments in R&D and the production of new models are necessary in the early stages of EV development. Some manufacturers went bankrupt because of broken cash flow caused by factors such as unsatisfactory product acceptance and low confidence from benefactors. Establishing national-level institutional collaborations enables manufacturers to cope with risks beyond organizational boundaries. For instance, forming an industrial alliance with peers can help manufacturers enhance negotiation power in purchasing. Meanwhile, manufacturers' orientation should align with and be guided by national schemes, such as the creation of strategic critical mineral reserves and the joint exploration of alternative resources overseas. Lastly, regulations (e.g., battery recycling) can be developed and coordinated through dialogues between manufacturers and policymakers to allocate resources and reduce structural vulnerability, as the government plays a key role in advocating interoperability, vehicle integration and standardization about charging infrastructure for the transition of EV prevalence (IEA 2025b, 14).

Although the general strategies are presented, it must be noted that not every strategy is equally crucial in every scenario, and manufacturers should consider the compatibility between the advised strategies and their resources and capabilities for implementation. Meanwhile, it is still not clear which scenario is the most possible over the next 10 years, and they have equal strategy implications; Chinese EV manufacturers should stay alert and create alternative plans for all scenarios for resilience.

7.2. The coupling effect of scenario planning and risk management

As explored in the study, scenario techniques are applied alongside a standard risk management procedure, ISO 31000, in ERM process for Chinese EV manufacturers. Such an application manifests several general advantages beyond the industry.

In the traditional risk evaluation process, a risk matrix is built on likelihood and severity by assigning concrete numbers. However, the assignments for the parameters are largely based on the evaluators' knowledge and experience. The determination of high risks can vary among experts, leading to uncertainty in the evaluation. In addition, the factor of uncertainty in scenario planning is the degree to which future developments and outcomes are not predictable; if it is too ambiguous to bet on a single outcome, then high uncertainty applies (Ralston & Wilson 2007, 108). Therefore, the uncertainty in risk management depends on the difficulty of assessing likelihood and severity, and the understanding of risk evolution. If the gathered information is convincing enough to make us give an exact evaluation, we are confident enough to draw a clear conclusion; otherwise, the directions remain ambiguous. In essence, risks are detected within the existing operational environment, and one uncertainty is the magnitude and the duration of the outcome. For example, the halt in production caused by supply disruptions may vary depending on an organization's resources and responses; risk management should be adaptable to business contexts and risk evolution by being dynamic (Flaus 2013, 45). The scenario development logic in my study considers the magnitude of risks, indicating that risks can evolve either towards a positive or a negative direction. By considering the combined effects of high-level risks on manufacturers, I develop different strategies for them. However, since risk evolves, the specific strategies are not static; they should also be updated by monitoring the external operational environment as described in ISO 31000 (ISO 2018). In the context of scenario planning, monitoring and review involve the continuous observation of driving forces, weak signals, and corresponding uncertainties, ensuring that scenarios are still relevant and formed strategies can be adjusted as the environment evolves. The notion aligns well with the monitoring and reviewing process in ISO 31000, as it identifies emergent risks and changes in the context are considered to formulate new alternatives for risks (Flaus 2013 51; Hamir & Md Sum 2021, 20). In this sense, scenarios offer flexible strategies through continuous monitoring of risks. After all, scenarios help explore organizations' possible futures and form agile plans rather than producing a predetermined outcome and corresponding sole strategy, thereby strengthening the validity of risk management.

Moreover, risks are typically analyzed based on people's experience and past data (Beer et al. 2000, 11), resulting in the repeated occurrence of known risks. The traditional risk management practice applies at the operational level, indicating that organizations incorporate known risks into daily operational processes and management practices, such as through process optimization. Those risks help enhance efficiency and avoid loss. By considering risk management at the strategic level through scenario planning, organizations pay attention to possible risks that could negatively affect their business in the long run, whereas conventional management tools work only to a limited extent for emerging risks. Therefore, scenarios are effective at transforming the uncertainty at the strategic level into operable management schemes by envisioning different possible outcomes and being prepared in advance.

Traditional risk management strategies in ISO 31000 emphasize a linear logic. For example, risk is acceptable if the product of likelihood and severity is below a certain level (Flaus 2013, 73). While the application is effective for managing known risks, it is partly valid for wild card scenarios. On one hand, when the wild card exerts an irreversible impact, organizations can barely take options but tolerate it through actions of limited utility. In this situation, organizations tend to be passive and reactive. On the other hand, organizations can develop transformative strategies with undetermined outcomes to fundamentally alter their exposure to risk. However, such an action is uncertain, and the paths and practices need to be explored. Therefore, the strategic response to the wild card is not normative yet still explorative, since no clear guidelines are presented for the outcome, only directions. Although strategies can be explored within an existing risk management framework, the paths and results remain open. In a word, scenarios help organizations consider strategic planning beyond traditional risk management frameworks and encourage proactive action rather than passive tolerance.

Last, the relationships among uncertainty, likelihood, and severity are shown in Figure 17, the traditional risk management practice is complemented by scenario planning in the futures studies field.

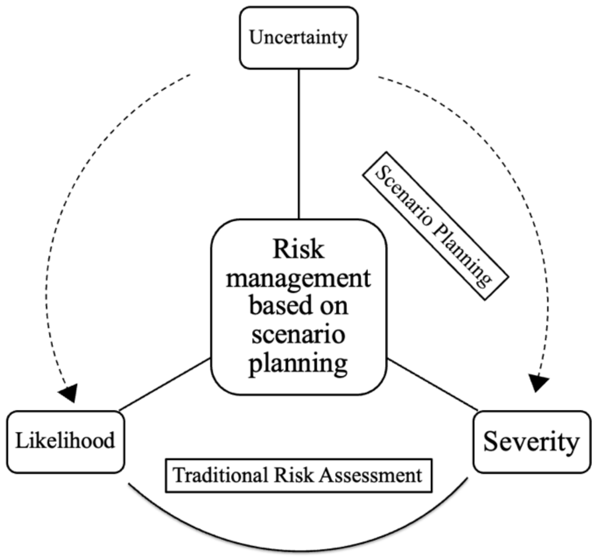

Figure 17. Risk management based on scenario planning (Created by the author)

The scenario planning-based risk management process, three factors -uncertainty, likelihood and severity are all taken into consideration. It should be noted that risks with high uncertainty do not indicate a high numerical value solely; they should be considered with uncertainty because of their unpredictable nature. As a result, uncertainty is a crucial factor for semi-quantitative risk analysis. In a nutshell, the uncertainty about risks lies in our knowledge of assessing the likelihood and severity, given the evolution of risks. When applying the risk management process from ISO 31000, flexible strategies should be developed by envisioning possible futures of scenarios rather than relying on a single management method. Therefore, risk management based on scenarios can be utilized as a strategic tool beyond operational planning for organizations, thereby contributing to the implementation of ERM.

In a word, risk management is a systematic process for organizations' risk assessment and treatment, and it is effective in reducing predetermined risks that adversely affect the organization's operational environment. Scenario planning extends the time frame for risk management and accounts for the uncertainty of our evaluations. Strategic flexibility demonstrates that organizations can develop different strategies and correct the direction of decision-making by envisioning several possible futures through scenario planning. Scenario planning identifies possible evolution pathways for risks and their interconnectedness, thereby transforming risk management from a static approach to a dynamic one through strategic flexibility.

8. Conclusion

8.1. General Findings

The aim of this study is to explore the interplay between scenarios and a traditional risk management framework (ISO 31000) for ERM in the context of Chinese EV manufacturers. First, external risks for Chinese EV manufacturers by 2035 were identified through horizon scanning using the PESTEL method. Then, two high-level risks were identified through risk assessment in ISO 31000, considering three risk factors: likelihood, severity, and uncertainty. Subsequently, four scenarios were developed based on two high-level risks, along with one additional wild card scenario, to envision possible futures for Chinese EV manufacturers by 2035. Different risk management strategies were then developed for each scenario, allowing for the summary of general strategies for all scenarios.

At the practical level, the study helps Chinese EV manufacturers identify high-level risks that may negatively affect their operations over the next decade, including disruptions in supply chains in battery critical minerals and mismatches between breakthroughs in batteries and charging infrastructure. Different scenarios were then generated based on the risk characteristics. Therefore, manufacturers should keep strategic flexibility to develop risk management strategies, including diversifying battery technology routes, creating stable supply chains through upstream involvement, and establishing institutional collaborations. It should be noted that the specific strategy varies, depending on their resources and implementation capabilities.

At the theoretical level, it was found that the scenario planning techniques I chose can be well integrated with the traditional risk management practice outlined in ISO 31000 for ERM for Chinese EV manufacturers, since scenarios were developed based on the risk evaluation results. The combination allows scenario planning to extend traditional risk management beyond the operational level, thereby enhancing the company's long-term strategic planning. In this way, scenarios support risk management in developing proactive strategies for the company's sustainability in the uncertain environment. Meanwhile, the combination is valuable for further exploration across industries and different cultural contexts.

Although the measures inevitably generate new risks, it transforms the abrupt shocks into manageable trade-offs with strategies. It should also be noted that the proposed measures are not about risk elimination but about enhancing manufacturers' resilience under uncertainties. After all, risk management should be monitor and review to continuously update the risk landscape, indicating a loop process instead of a one-way process.

8.2. Future research directions

Several limitations in this study allow for further research. First, scenarios are built on subjective grounds based on the developer's judgment and experience. Therefore, other methods from future studies can be applied. For instance, the Delphi method can be used in the risk identification stage to collect perspectives from experts in the EV manufacturing industry, enabling exploration of the coupling between risk management and scenarios in a wider context (e.g., in Europe), meaning that comparative studies across countries may help the assessment of the framework with broader applicability. Another limitation is that all future development paths of Chinese EV manufacturers cannot be captured, especially those with a low likelihood and high severity. Thus, scenarios can be constructed by combining several wild cards in futures. Meanwhile, it is also valuable to apply other scenario planning methods, such as the futures table, to examine the interconnectedness of risks more broadly.

Despite the limitations, the study is valid, as by being flexible in strategies for all scenarios developed through risk analysis, Chinese EV manufacturers can not only sustain their leading position in production but also be the all-round pioneer in strategic adaptability, technology innovation, and long-term competitiveness.

8.3. Ethical Considerations

There are also several ethical considerations to acknowledge. First, the risk assessment data in this study were collected from secondary sources. To prevent bias, the data were diversified, meaning they were gathered from various sources and written by authors from different cultural backgrounds. Furthermore, the data were cross-checked and analyzed without favoring any particular view. The data were also collected openly for transparency, excluding those from covert sources, such as unpublished articles. Meanwhile, it should be noted that the scenarios in this study describe possible futures for EV manufacturers in China rather than predictions. Therefore, the strategic suggestions in Chapter 7 do not advocate concrete solutions for any specific manufacturer or the government but provide a strategic framework in an environment of uncertainty. It should be avoided that study results are misused or overinterpreted by policymakers or managers in organizations; instead, they should be considered in context. Lastly, the images generated by AI tools in Chapter 5, Form Scenarios, are used solely for the illustration of written texts; the car models in the images are not involved in privacy or represent any brand or manufacturer. The images were generated based on my research design and analytical logic, so they are applicable only in my study and cannot be used for other purposes.

Reference

Aaker, D. A. – Mascarenhas, B. (1984) THE NEED FOR STRATEGIC FLEXIBILITY. *The Journal of Business Strategy*, Vol. 5(2), 74–82.

Aguilar-Millan, S. (2013) Playing the Wild Card. *World Futures Review*, Vol. *5*(2), 144-152.

Ahmad, S. A. – Teo, P.C. (2024) The Implementation of Enterprise Risk Management (ERM) Frameworks in Small and Medium Enterprises (SMES): A Literature Review. *International Journal of Academic Research in Business and Social Sciences*, Vol. 14(9), 290-307.

Allcott, H. – Kane, R. – Maydanchik, M. S. – Shapiro, J. S. – Tintelnot, F. (2025) The Effects of "Buy American": Electric Vehicles and the Inflation Reduction Act. *National Bureau of Economic Research Working Papesr*, article 33032.

Amer, M. – Daim, T. U. – Jetter, A. (2013). A review of scenario planning. *Futures : The Journal of Policy, Planning and Futures Studies*, Vol. 46, 23–40.

Aven, T. (2011) Quantitative risk assessment: the scientific platform (1st ed.). Cambridge University Press. Cambridge.

Beer, T. – Foran, B. (2000) *Management for the future: risk management, future options and scenario analysis in Beer (ed.) Risk Management and the Future*. Australian Minerals and Energy Environment Foundation, Melbourne, Australia.

Bickenbach, F. – Dohse, D. – Langhammer, R. J. – Liu, W.-H. (2024) EU Concerns About Chinese Subsidies: What the Evidence Suggests. *Inter Economics*, Vol. 59(4), 214–221.

Bloomberg NEF (2025) *Electric Vehicle Outlook 2025*. Bloomberg NEF. < https://about.bnef.com/insights/clean-transport/electric-vehicle-outlook/>, retrieved 9.11.2025

Börjeson, L. – Höjer, M. – Dreborg, K.-H. – Ekvall, T. – Finnveden, G. (2006) Scenario types and techniques: Towards a user's guide. *Futures : The Journal of Policy, Planning and Futures Studies*, Vol. 38(7), 723–739.

Bromiley, P. – McShane, M. – Nair, A. – Rustambekov, E. (2015) Enterprise Risk Management: Review, Critique, and Research Directions. *Long Range Planning*, Vol. 48(4), 265–276.

Brozovic, D. (2018) Strategic Flexibility: A Review of the Literature. *International Journal of Management Reviews : IJMR*, Vol. 20(1), 3–31.

Bruaset, S – Sægrov, S. (2018) Using the multiple scenario approach for envisioning plausible futures in long-term planning and management of the urban water pipe systems. *European Journal of Futures Research*, Vol. 6(1), Article 7.

BYD (2025a) *Search Results for: blade batteri*. <https://en.byd.com/search/blade%20batteri?utm>. retrieved 10.9.2025

BYD (2025b) *比亚迪欧洲总部落户匈牙利，全球化布局又一里程碑*. BYD. < https://www.byd.com/cn/news/2025/detail583>. retrieved 18.2.2026 (in Chinese)

Cairns, G. – Wright, G. (2017) Scenario thinking: Preparing your organization for the future in an unpredictable world. Palgrave Macmillan, London.

Capuder, T. – Miloš Sprčić, D. – Zoričić, D. – Pandžić, H. (2020). Review of challenges and assessment of electric vehicles integration policy goals: Integrated risk analysis approach. *International Journal of Electrical Power & Energy Systems*, Vol. 119, Article 105894.

Chen, A. – You, S. – Liu, H. – Zhu, J. – Peng, X. (2023) A Sustainable Road Transport Decarbonisation: The Scenario Analysis of New Energy Vehicle in China. *International Journal of Environmental Research and Public Health*, Vol. 20(4), 3406.

China Carhub (2024) *The 2024 China's Long-Range Pure Electric Vehicle Rankings*. China Carhub. <https://chinacarhub.com/the-2024-chinas-long-range-pure-electric-vehicle-rankings/?utm>, retrieved 14.11.2025.

China Daily (2024) *Probing into Japan's slow adoption of fuel cell vehicles*. China Daily. <https://global.chinadaily.com.cn/a/202405/28/WS6655ae68a31082fc043c99f3.html?utm>, retrieved, 13.11.2025.

China Global South Project (2025) *China's EV Price War Could Offer Short-term Gains But Long-term Risks for Global South Consumers*. China Global South Project. <https://chinaglobalsouth.com/analysis/byd-ev-price-war-global-impact/>, retrieved, 22.11.2025.

China Industrial News Network（2025）*缺口将达 103 万人 新能源汽车人才断层凸显*. China Industrial News Network. <https://www.cinn.cn/p/429636.html>, retrieved 22.11.2025. (in Chinese)

China International Public Relations Association (2026) *新能源车行业营销趋势洞察及展望：2024-2028深度报告*. China International Public Relations Association. < https://www.chinapr.com.cn/259/202601/3657.html?utm >, retrieved 17.1.2026 (in Chinese)

China National Radio (2024) *欧阳高明：新能源汽车产业面临五大风险*. China National Radio. <http://auto.cnr.cn/2015xc/20240229/t20240229_526612447.shtml>, retrieved, 22.11.2025. (in Chinese)

Chinese Social Sciences Net（2024）*中国新能源汽车产业链安全风险防范应对策略*. Chinese Social Sciences Net. <https://cssn.cn/zkzg/zkzg_gxzkdzyx/zkzg_gxdzyx_xskx/202412/t20241219_5825189.shtml>, retrieved, 22.11.2025. (in Chinese)

Das, K. – Behera, R. L. – Paital, B. (2022) *COVID-19 in the Environment*. Elsevier.

Davidson, M. R. – Karplus, V. J. – Lewis, J. I. – Nahm, J. – Wang, A. (2022) Risks of decoupling from China on low-carbon technologies. *Science (American Association for the Advancement of Science)*, Vol. 377(6612), 1266–1269.

de Oliveira, U. R. – Marins, F. A. S. – Rocha, H. M. – Salomon, V. A. P. (2017) The ISO 31000 standard in supply chain risk management. *Journal of Cleaner Production*, Vol. 151, 616–633.

Dewi, D. – Bastori, I. – Tris Yuliyanto, A. – Stankevica, K. – Soetrisnanto, A. (2020) Manufacturing Risk Identification in the Steel Industry. *E3S Web of Conferences*, Vol. 190, 6.

Efe, A. (2023) A comparison of key risk management frameworks: COSO-ERM, NIST RMF, ISO 31.000, COBIT. *Denetim Ve Güvence Hizmetleri Dergisi*, Vol. 3(2), 185-205.

Fan, C. – Montewka, J. – Zhang, D. – Han, Z. (2024) A framework for risk matrix design: A case of MASS navigation risk. *Accident Analysis and Prevention*, Vol. 199, Article 107515.

Fan, H. – Li, Z. – Duan, Y. – Wang, B. (2025) Incentive policy formulation for China's electric vehicle market: Navigating pathways to sustainable mobility with a green premium analytical model. *Energy Policy*, Vol. 202, Article 114610.

Featherman, M. – Jia, S. (Jasper) – Califf, C. B. – Hajli, N. (2021) The impact of new technologies on consumers beliefs: Reducing the perceived risks of electric vehicle adoption. *Technological Forecasting & Social Change*, Vol. 169, Article 120847.

Flaus, J.-M. (2013) *Risk analysis : socio-technical and industrial systems (1st ed.)*. ISTE, London.

Fotr, J. – Špaček, M. – Souček, I. – Vacík, E. (2015) Scenarios, their concept, elaboration and application. *Baltic Journal of Management*, Vol. 10(1), 73–97.

Friedrich Naumann Foundation (2025) EU's Risky Business: *The challenge of Chinese Electric Vehicles in Europe*. Friedrich Naumann Foundation. <https://www.freiheit.org/europe/eus-risky-business>, retrieved, 22.11.2025.

Gu, X. – Ieromonachou, P. – Zhou, L. (2019) Subsidizing an electric vehicle supply chain with imperfect information. *International Journal of Production Economics*, Vol. 211, 82–97.

GULF NEWS (2024) *12 Chinese carmakers form 'supercharge alliance': EV race to go on overdrive?* GULF NEWS <https://gulfnews.com/business/12-chinese-carmakers-form-supercharge-alliance-ev-race-to-go-on-overdrive-1.1714064061436?utm> . retrieved 18.2.2026

Hamir, H. – Md Sum, R. (2021) An analysis of risk management processes and comparison with ISO31000: 2018. *Asian Journal of Research in Business and Management*, Vol. 3 (4): 16-30.

Hiltunen, E. (2006) Was it a wild card or just our blindness to gradual change. *Journal of Futures studies*, Vol. 11(2), 61-74.

Hutchins, G. (2018) *ISO 31000: 2018 enterprise risk management*. *Greg Hutchins*.

Institute of Risk Management (2018) *Horizon Scanning: A Practitioner's Guide 2018*. Institute of Risk Management. <https://www.theirm.org/media/7423/horizon-scanning_final2-1.pdf#page25>, retrieved 26.1.2026.

International Organization for Standardization (ISO) (2018). *ISO31000: 2018 risk management-guidelines*. International Organization for Standardization. <https://www.iso.org/standard/65694.html>, retrieved 2.2.2026.

Jonek-Kowalska, I. (2022) *Effectiveness of Enterprise Risk Management*. Springer International Publishing, Cham, Switzerland.

Karasan, A. – Erdogan, M. (2021). Creating proactive behavior for the risk assessment by considering expert evaluation: a case of textile manufacturing plant. *Complex & Intelligent Systems*, Vol. 7(2), 941–959.

Kejun, J. – Chenmin, H. – Songli, Z. – Pianpian, X. – Sha, C. (2021) Transport scenarios for China and the role of electric vehicles under global 2 °C/1.5 °C targets. *Energy Economics*, Vol. 103, Article 105172.

Li, Y. – Li, Q. – Shi, J. (2025) Effects of dual-credit policy on electric vehicle diffusion under subsidy transfer: a multi-stakeholder perspective. *Environment, Development and Sustainability*. 1–30.

Liang, L. – Mei, Q. – Li, C. (2024) Does “Dual Credit Policy” Really Matter in Corporate Competitiveness? *Sustainability*, Vol. 16(16), 6991.

Liang, Y. – Li, Y. (2023) Exploring the future of electric vehicles in China: market trends, government policies, carbon emissions and technology development. *Highlights Bus. Econ. Manag*, Vol. 6, 236-242.

Liu, W. – Li, X. – Liu, C. – Wang, M. – Liu, L. (2023) Resilience assessment of the cobalt supply chain in China under the impact of electric vehicles and geopolitical supply risks. *Resources Policy*, Vol. 80, Article 103183.

Luís, A. – Garnett, K. – Pollard, S. J. T. – Lickorish, F. – Jude, S. – Leinster, P. (2021) Fusing strategic risk and futures methods to inform long-term strategic planning: case of water utilities. *Environment Systems & Decisions*, Vol. 41(4), 523–540.

McKinsey & Company (2024) Global Energy Perspective 2024. McKinsey & Company. <https://www.mckinsey.com/~/media/mckinsey/industries/energy%20and%20materials/our%20insights/global%20energy%20perspective%202024/global-energy-perspective-2024.pdf>, retrieved 3.10.2025

Masini, E. (1993) *Why futures studies?* Grey Seal.

Mazhar, S. A. – Anjum, R. – Anwar, A. I. – Khan, A. A. (2021) Methods of data collection: A fundamental tool of research. *Journal of Integrated Community Health*, Vol. 10(1), 6-10.

Mehrabanfar, E. (2014) Wild cards applications in futures studies. *International Journal of Modern Management & Foresight*, Vol. 1(8), 212-218.

Mendonça, S. – Pina e Cunha, M. – Kaivo-oja, J. – Ruff, F. (2004) Wild cards, weak signals and organisational improvisation. *Futures : The Journal of Policy, Planning and Futures Studies*, Vol. 36(2), 201–218.

Miller, K. D. – Waller, H. G. (2003) Scenarios, Real Options and Integrated Risk Management. *Long Range Planning*, Vol. 36(1), 93–107.

Minkkinen, M. – Auffermann, B. – Ahokas, I. (2019) Six foresight frames: Classifying policy foresight processes in foresight systems according to perceived unpredictability and pursued change. *Technological Forecasting & Social Change*, Vol. 149, Article 119753.

Molarius, R. – Keränen, J. – Poussa, L. (2015) Combining Climate Scenarios and Risk Management Approach—A Finnish Case Study. *Climate (Basel)*, Vol. 3(4), 1018–1034.

Nakano, J. (2021) *South Korea's Hydrogen Industrial Strategy*. The Center for Strategic and International Studies. <https://www.csis.org/analysis/south-koreas-hydrogen-industrial-strategy?utm>, retrieved, 13.11.2025.

National Public Service Platform for Standards Information (2024) *Electric vehicle conductive charging system—Part 5: DC charging system for GB/T 20234.3*. National Public Service Platform for Standards Information. <https://std.samr.gov.cn/gb/search/gbDetailed?id=2ACFF0F7662AFCD5E06397BE0A0AC644>, retrieved, 7.2.2026

Nicola, M. – Alsafi, Z. – Sohrabi, C. – Kerwan, A. – Al-Jabir, A. – Iosifidis, C. – Agha, R. (2020). The socio-economic implications of the coronavirus pandemic (COVID-19): A review. *International journal of surgery*, Vol. 78, 185-193.

Nocco, B. W. – Stulz, R.M. (2022) Enterprise risk management: Theory and practice. *Journal of applied corporate finance*, Vol. 34(1), 81-94.

Oduoza, C. F. (2020) Framework for sustainable risk management in the manufacturing sector. *Procedia Manufacturing*, Vol. 51, 1290-1297.

Olson, D. L. – Wu, D. D. (2008) *Enterprise Risk Management*. World Scientific Publishing, Singapore.

Palomino, M. A. – Bardsley, S. – Bown, K. – De Lurio, J. – Ellwood, P. – Holland-Smith, D. – Huggins, B. – Vincenti, A. – Woodroof, H. – Owen, R. (2012) Web-based horizon scanning: concepts and practice. *Foresight (Cambridge)*, Vol. 14(5), 355–373.

Panyukov, D. I. – Kozlovskii, V. N. – Aidarov, D. V. – Shakurskii, M. V. (2022) FMEA Risk Analysis on the Basis of Action Priorities. *Russian Engineering Research*, Vol. 42(10), 1077–1080.

Peterson, G. D. – Cumming, G. S. – Carpenter, S. R. (2003) Scenario Planning: a Tool for Conservation in an Uncertain World. *Conservation Biology*, Vol. 17(2), 358–366.

Policy Circle (2025) *China's EV industry risks collapse from ruthless price wars*. Policy Circle. <https://www.policycircle.org/industry/chinas-ev-industry-price-wars/>, retrieved, 22.11.2025.

Raimi, D. – Zhu, Y. – Newell, R. G. – Prest, B. C. (2024). Global energy outlook 2024: Peaks or plateaus. <https://www.rff.org/publications/reports/global-energy-outlook-2024/>, retrieved, 11.11.2025

Ralston, B. – Wilson, I. (2007) *The scenario-planning handbook : a practitioner's guide to developing and using scenarios to direct strategy in today's uncertain times*. Thomson South-Western, Mason, Ohio.

Rasmussen, L. B. (2005) The narrative aspect of scenario building - How story telling may give people a memory of the future. *AI & Society*, Vol. 19(3), 229–249.

Raynor, M. E. – Leroux, X. (2004) Strategic Flexibility in R&D. *Research Technology Management*, Vol. 47(3), 27–32.

RECCESSARY (2025) *Indonesia bolster EV battery with Japan, South Korea amid U.S. -China tariff risks*. RECCESSARY. <https://www.reccessary.com/en/news/indonesia-ev-battery-firm-japan-korea>, retrieved, 22.11.2025.

Reuters (2025) *China's cutthroat EV revolution leaves little margin for profit*. Reuters. < https://www.reuters.com/business/autos-transportation/chinas-cutthroat-ev-revolution-leaves-little-margin-profit-2025-04-22/?utm>, retrieved 29.10.2025.

Reuters (2026) *In China, battery makers bet big on sodium in moving away from critical minerals*. Reuters. <https://www.reuters.com/sustainability/climate-energy/china-battery-makers-bet-big-sodium-move-away-critical-minerals--ecmii-2026-03-16/?utm>, retrieved 23.3.2026.

Roberts, N. – Stockport, G. J. (2009) Defining Strategic Flexibility. *Global Journal of Flexible Systems Management*, Vol. 10(1), 27–32.

Rockfellow, J. D. (1994) Wild cards: preparing for "the big one." *The Futurist*, Vol. 28(1), 14.

S&P Global Mobility (2025) *Automotive Suppliers Outlook for 2025: Key Trends and Challenges*. S&P Global Mobility. <https://cdn.ihsmarkit.com/www/prot/pdf/0125/Auto-Suppliers-Outlook-2025.pdf>, retrieved 12.11.2025.

Safón, V. – Iborra, M. – Escribá-Esteve, A. (2024) Outcomes of firm resilience in wild card crises—Country, industry, and firm effects in the Covid-19 crisis. *International Journal of Disaster Risk Reduction*, Vol. 100, Article 104177.

Saunders, M. N. K. – Lewis, P. – Thornhill, A. (2019). *Research methods for business students (Eighth edition.)*. Pearson.

Shen, L. – Chen, Z. – Dou, X. – Xu, X. – Cao, Z. – Liao, S. (2024) Restricting factors for promoting electric vehicles: Evidence from China. *Transport Policy*, Vol. 148, 234–245.

Soares, L. O. – Reis, A. da C. – Vieira, P. S. – Hernández-Callejo, L. – Boloy, R. A. M. (2023) Electric Vehicle Supply Chain Management: A Bibliometric and Systematic Review. *Energies (Basel)*, Vol. 16(4), 1563.

Supply Chain Community (2025) *How BYD's Vertical Integration Is Shaping the Future of Supply Chains.* Supply Chain Community. <https://supplychaincommunity.org/how-byds-vertical-integration-is-shaping-the-future-of-supply-chains/?utm>, retrieved 23.3.2026.

The China Project (2023) *China's top 15 electric vehicle companies*. The China Project. <https://thechinaproject.com/2023/05/18/chinas-top-15-electric-vehicle-companies/?utm>, retrieved 7.2.2026

The International Council on Clean Transportation (2023) *Nine trends in the development of China's electric passenger car market*. The International Council on Clean Transportation. <https://theicct.org/wp-content/uploads/2023/03/China-EV-trends_brief_EN_final2.pdf>, retrieved 12.11.2025.

The International Energy Agency (IEA) (2023) *New Energy Vehicle Industry Development Plan (2021-2035)*. IEA <https://www.iea.org/policies/15529-new-energy-vehicle-industry-development-plan-2021-2035>. retrieved 10.9.2025

The International Energy Agency (IEA) (2024) *World Energy Outlook 2024*. IEA. <https://www.iea.org/reports/world-energy-outlook-2024>, retrieved 9.9.2025

The International Energy Agency (IEA) (2025a) *Greenhouse Gas Emissions from Energy Data Explorer*. IEA. <https://www.iea.org/data-and-statistics/data-tools/greenhouse-gas-emissions-from-energy-data-explorer>, retrieved 9.9.2025

The International Energy Agency (IEA) (2025b) *Global EV Outlook 2025.* IEA. <https://www.iea.org/reports/global-ev-outlook-2025>, retrieved 9.9.2025

The International Energy Agency (IEA) (2025c) *Global Critical Minerals Outlook 2025.* IEA. <https://www.iea.org/reports/global-critical-minerals-outlook-2025>, retrieved 17.12.2025

The State Council of the People's republic of China (2020) *国务院办公厅关于印发新能源汽车产业发展规划（2021–2035 年）的通知.* The State Council of the People's republic of China.

<https://www.gov.cn/zhengce/zhengceku/2020-11/02/content_5556716.htm>, retrieved, 23.1.2026

The State Council of the People's Republic of China (2025) China plans new energy transport guide by 2035. <https://english.www.gov.cn/news/202504/27/content_WS680d6ce5c6d0868f4e8f2187.html>. retrieved 10.9.2025

The World Economic Forum (2025) Global Risks Report 2025. The World Economic Forum <https://www.weforum.org/publications/global-risks-report-2025/>, retrieved 19.1.2026

Tuomi, I. (2019) Chronotopes of foresight: Models of time-space in probabilistic, possibilistic and constructivist futures. *Futures & Foresight Science*, Vol. 1(2). ffo2.11.

Veza, I. – Syaifuddin, M. – Idris, M. – Herawan, S. G. – Yusuf, A. A. – Fattah, I. M. R. (2024) Electric Vehicle (EV) Review: Bibliometric Analysis of Electric Vehicle Trend, Policy, Lithium-Ion Battery, Battery Management, Charging Infrastructure, Smart Charging, and Electric Vehicle-to-Everything (V2X). *Energies (Basel)*, Vol. 17(15), 3786.

Wang, Y. – Guo, C. – Du, C. – Chen, X. – Jia, L. – Guo, X. – Chen, R. – Zhang, M. – Chen, Z., – Wang, H. (2021) Carbon peak and carbon neutrality in China: goals, implementation path and prospects. *China Geology*, Vol. 4(4), 1–27.

Xiao, Y. B. – Yuan, X. G. – Zhang, X. Q – Wu, T. (2025) *我国新能源汽车：优势产业如何持续发力*. <https://www.sem.tsinghua.edu.cn/info/1171/37311.htm?utm>. retrieved 10.9.2025 (in Chinese)

Xing, J. – Liu, X. – Zhang, Y. (2023) Development of the electric vehicle industry in China. *China Economic Journal*, Vol. 16(2), 139–184.

Zhang, P. (2025) *Automakers' share of China NEV market in 2024: BYD tops with 34.1%, Tesla 3rd with 6.0%.* <https://cnevpost.com/2025/01/10/automakers-share-china-nev-market-2024/>, retrieved 10.9.2025

Zhang, Q. – Feng, Y. – You, L. (2024) Research on the Impact of Supply Chain Integration on Supply Chain Resilience in NEV Manufacturing Enterprises. *Sustainability*, Vol. 16(19), 8546.

Zhao, X. – Li, X. – Jiao, D. – Mao, Y. – Sun, J. – Liu, G. (2024) Policy incentives and electric vehicle adoption in China: From a perspective of policy mixes. *Transportation Research. Part A, Policy and Practice*, Vol. 190, Article 104235.

Zio, E. (2018) The future of risk assessment. *Reliability Engineering & System Safety*, Vol. 177 (2018): 176-190.

Appendices

Appendix 1 Explanation of the use of AI

First, I used an AI tool which is called “Canvas” to generate images for the scenarios in Chapter 5 (Figure 14 and Figure 16). I use these images to provide visualization for scenarios in this study, conveying meanings straightforwardly for the readers of this work. By typing into key words into the AI tool, the corresponding images are generated. For example, for Figure 16, I typed the words “an electric vehicle with a broken tire on the road”, then several images were generated automatically. Subsequently, I chose the image that best fits with the written texts and the context in the study. To avoid biases, I did not type any brand name or products from certain countries into the AI tool; therefore, vehicles in images do not indicate the existing models.

In a word, I use this image-generated AI tool to make my writings comprehensible and add vividity, and it does not affect my analytical processes and results.

The author holds the full responsibilities for the content.