



VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

FACULTY OF BUSINESS MANAGEMENT

DEPARTMENT OF MANAGEMENT

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**SUPPLIER LEADERSHIP ASSESSMENT MODEL FOR ELECTRIC
VEHICLE CHARGING INDUSTRY COMPANIES
ELEKTROMOBILIŲ ĮKROVIMO PRAMONĖS ĮMONĖMS SIŪLOMAS
TIEKĖJŲ LYDERYSTĖS VERTINIMO MODELIS**

Master's degree Thesis

Engineering Economics and Management study programme, state code 6211LX086

Business Leadership specialization

Management study field

VILNIUS 2025

Vilnius Gediminas Technical University		ISBN	ISSN
Faculty of Business Management		Copies No.	
Department of Management		Date-.....-.....	

Master Degree Studies Engineering Economics and Management study programme Master Final Thesis	
Title	Supplier Leadership Assessment Model for Electric Vehicle Charging Industry Companies
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Academic supervisor	Rolandas Drejeris

	Thesis language: English
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Annotation

In the context of the rapidly expanding electric vehicle (EV) market, which is transforming the automotive industry towards more sustainable and environmentally friendly transportation solutions, there is an increasing need for efficient and effective EV charging infrastructure. With the European Commission's ambitious goal of establishing 3.5 million charging points by 2030, and projections indicating that EVs will account for 50% of total vehicle sales in the EU by the same year, the demand for leading solutions in the EV charging industry is growing. This thesis addresses the pressing issue of the lack of a standardized model for evaluating supplier leadership within the EV charging industry. The primary objective is to develop a systematic and objective framework for assessing supplier leadership in the European market. The research methodology includes the analysis of scientific literature, comparative analysis, and criteria importance weight analysis. The study focuses on analyzing theoretical frameworks, defining application requirements, and creating a practical model for evaluating supplier leadership. The proposed model aims to improve decision-making processes for EV charging companies by identifying key leadership attributes and performance metrics, facilitating the selection of top-performing suppliers. This structured approach is expected to enhance industry efficiency, reliability, and innovation, providing companies with a competitive edge and contributing to the sustainable growth of the EV charging infrastructure. Therefore, this research offers a valuable tool for the EV charging industry, aiding its development and success in meeting future demands.

Keywords: Electric Vehicle (EV), EV charging stations, Sustainable Transportation, Supplier Leadership, Supplier Evaluation, Research Methodology, Decision-Making Processes, Comparative Analysis, Weight Assessment, Multi-Criteria Decision-Making Methods (MCDM),

Vilniaus Gedimino technikos universitetas	ISBN	ISSN
Verslo vadybos fakultetas	Egz. sk.	
Vadybos katedra	Data~.....~.....	

Antrosios pakopos studijų Inžinerinės ekonomikos ir vadybos programos magistro baigiamasis darbas	
Pavadinimas	Elektromobilių įkrovimo pramonės įmonėms siūlomas tiekėjų lyderystės vertinimo modelis
Autorius	Karolis Bružas
Vadovas	Rolandas Drejeris

	Kalba: anglų
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Anotacija

Sparčiai plečiantis elektromobilių rinkai, kuri keičia automobilių pramonę, kad ji taptų tvaresnė ir draugiškesnė aplinkai, vis labiau reikia veiksmingos ir efektyvios elektromobilių įkrovimo infrastruktūros. Europos Komisijai užsibrėžus ambicingą tikslą iki 2030 m. įrengti 3,5 mln. įkrovimo taškų ir prognozuojant, kad tais pačiais metais EV sudarys 50 proc. visų ES parduodamų transporto priemonių, auga pažangiausių sprendimų EV įkrovimo pramonėje paklausa. Šioje disertacijoje sprendžiama opi problema, kad nėra standartizuoto modelio, pagal kurį būtų galima įvertinti tiekėjų lyderystę elektromobilių įkrovimo pramonėje. Pagrindinis tikslas - sukurti sistemingą ir objektyvią tiekėjų lyderystės Europos rinkoje vertinimo sistemą. Tyrimo metodika apima mokslinės literatūros analizę, lyginamąją analizę ir kriterijų svarbos svorio analizę. Tyrime daugiausia dėmesio skiriama teorinių pagrindų analizei, taikymo reikalavimų apibrėžimui ir praktinio tiekėjų lyderystės vertinimo modelio sukūrimui. Siūlomu modeliu siekiama pagerinti elektromobilių įkrovimo įmonių sprendimų priėmimo procesus, nustatant pagrindinius lyderystės požymius ir veiklos rodiklius, palengvinant lyderiaujančių tiekėjų atranką. Tikimasi, kad šis struktūrizuotas metodas padidins pramonės efektyvumą, patikimumą ir inovacijas, suteiks įmonėms konkurencinį pranašumą ir prisidės prie tvaraus EV įkrovimo infrastruktūros augimo. Todėl šis tyrimas yra vertinga priemonė EV įkrovimo industrijai, padedanti jai vystytis ir sėkmingai tenkinti ateities poreikius.

Prasminiai žodžiai: Elektromobilis (EV), Elektromobilių įkrovimo stotelės, tvarus transportas, tiekėjų lyderystė, tiekėjų vertinimas, tyrimų metodologija, sprendimų priėmimo procesai, lyginamoji analizė, kriterijų svorių nustatymas, daugiakriteriniai sprendimų priėmimo metodai (MCDM),

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INTRODUCTION

Relevance of the topic. In today's world, where the electric vehicle market is reshaping the automotive industry and influencing a rapid shift towards cleaner and more environmentally friendly transportation solutions there is an increasing need of chargers. Because of new policies and plans for promoting EVs in most developed countries, the amount of EVs is expected to reach the bigger portion of market in the next decade. For example, the sales of EVs including PHEVs in EU will reach 50% of total sales of mobile vehicles by 2030, as stated in Europe's strategic targets. (Koman et al., 2024). Furthermore, to meet the European Commission's target of 3.5 million charging points by 2030, approximately 410,000 new charging points must be installed each year (European Alternative Fuels Observatory, 2024). Within this exponentially growing electric vehicle (EV) charging industry there is an increasing demand of leading solutions for businesses and clients

As technologies and transport continues to develop, demand for electric vehicles and its infrastructure keeps growing. It is becoming crucial for EV charging industry to operate effectively and efficiently. A well developed and implemented suppliers leadership evaluation model would ensure that providers and other types of companies can select suppliers that are leading the industry in various aspects. It would be possible to easily choose from suppliers who actively contribute to the industry's expansion and improvement.

Suppliers' leadership evaluation models aim is to provide a systematic and objective approach for evaluating leadership within the industry. This can significantly improve decision-making process for EV charging companies, providing a possibility to make choices by identifying key leadership attributes and performance metrics specific to the EV charging sector. Selecting the right suppliers that fits companies' strategy needs, brings drastic saving in all sectors (Demiralay & Paksoy, 2022). This, as mentioned, can lead to increased efficiency, reliability, and innovation within the industry.

The lack of an appropriate standardized methods for evaluating supplier leadership in the EV charging industry is a current problem. The development of such specific model addresses the lack of systematic decision making, providing a consistent and reliable framework for correct suppliers selection. Companies that can effectively and systematically evaluate leaders - high-performing suppliers, gain a competitive advantage within the industry. The supplier's leadership evaluation model offers a direct tool for EV charging companies.

In summary, the relevance of this subject lies in its potential to contribute to the success and sustainability of the electric vehicle charging industry by offering a systematic and well-developed approach to evaluating the leadership of suppliers.

Problem – There is no standardized model for evaluating suppliers leadership in the industry of electric vehicle (EV) chargers.

Research object – Electric vehicle charging industry companies.

Aim – To develop a model for assessing suppliers leadership in the European industry of electric vehicle (EV) chargers.

Tasks:

1. To analyse a theoretical framework for industry leadership based on key factors identified in the scientific literature review.
2. To establish requirements for the application model of suppliers` leadership in the electric vehicle charger industry.
3. To form a model for assessing suppliers` leadership in the European electric vehicle charger industry market.
4. To try a suggested methodology for the evaluation of supplier leadership in the European market for electric vehicle chargers.

Research Methods.

The methods used for the research are analysis of scientific literature, comparative analysis, criteria importance weight analysis.

1. THEORETICAL BACKGROUND FOR SUPPLIERS LEADERSHIP ASSESSMENT

1.1. Leadership in the industry

Leadership within the industry is a concept that has gained considerable attention from a wide scope of industries and a variety of companies. As industries and markets change and adapt in response to global economical, technological, and dynamic shifts, the role of leadership within the industry becomes increasingly important for the success of the organization (Asghar, 2023). In accordance with that, Globalization has also led to international integration, creating new business opportunities across various sectors, including EV charger industry. Companies now have the chance to enter global markets and access more alternatives. Unfortunately, these opportunities come with increased challenges: business uncertainty, heightened risk, relentless competition, and more complex product development chains. The supply chain's role in global business has become increasingly crucial, shifting the nature of relationships between business entities from tactical to strategic partnerships (Wan et al., 2024; Xian et al., 2024). This shift has significantly raised the standards for supplier selection, increasing more intensive need of leading suppliers within the industries (A & P, 2023). Considering this, the main aim of this part is to provide a theoretical background of the understanding about leadership within specific industries.

The term “leadership in the industry” or specifically “suppliers' leadership” differently than the traditional leadership within the company or industry does not refer to a particular concept. It is mainly referring to the relationship and evaluation between a company and its suppliers, or where it stands in its industry compared to its competitors. The comparison is made by evaluating various criteria specific to different industries (Kaviani et al., 2020). The search for leading suppliers requires the use of modern information and communication technologies. It is important to remember that evaluating a larger pool of suppliers can lead to more accurate and suitable selection decisions, aligning with current conditions and the needs of commercial participants. To sum up, a company that is leading in the industry is characterized by comparing where it stands on several key attributes and practices.

The first attribute on which leadership can be evaluated is innovation and technology adaptation. This particular concept is crucial in today’s business for all industries. These forward-thinking companies are focusing on staying at the front of technological advancements (Skare et al., 2023). Companies ability to implement innovations and adopt new technologies can significantly enhance efficiency (Danquah, 2018). Throughout their streamline operations,

supply chain and thus reduce costs. No matter the specific innovation, whether it would be integration of Internet of Things (IoT) - devices for real-time monitoring (Mostofa & Islam, 2023), or the adoption of artificial intelligence (AI), companies focus to improve shows an understanding that technological investments are a part of strategic imperatives (Bonham & Green, 2021). Moreover, technology adoption allows companies to stay competitive within its industry, ensuring a competitive edge in an environment where change is constant (Sui et al., 2024). In essence, innovation and technology adaptation are the fundamental tools to transform and improve companies. Such ability is one of the key aspects of an industries leader.

Second characteristic defining a leading supply company is global reach. This shows companies' ability to take position of a valuable player on the international stage. Companies that establish a presence on diverse geographical markets, have a possibility to tap into a wide array of opportunities and adapt to unique demands of different regions (F. Wang et al., 2022). This demonstrates its ability to navigate through complex demands shows companies high level of adaptability that makes a company stand out compared to its rivals (Fernandes et al., 2020). This also shows companies flexibility, because international companies must have the appropriate infrastructure, enough resources and operational agility to deal with faced fluctuations in worldwide market. To conclude, companies global reach combined with its flexibility to thrive in a constantly changing international market positions companies in a superior leading position within the industry (Matricano & Castadi, 2023).

Moving forward, leading supply companies places strong emphasis on quality control on their supply chain (M. Yang et al., 2023). Quality assurance is one of main focuses for a top tier supplier, showing its commitment and ability to deliver exceptional quality production throughout all of production process. Upholding companies reputation and meeting or exceeding clients standards play a huge role in client satisfaction and ratings, which lead to leading position within the industry. Attention to quality is embedded within their operational roots (Kuwornu et al., 2023). This quality can be measured by ISO standards that company has acquired, client satisfaction ratings and ranking within industry. By adhering to strict and complex quality assurance protocols or standards, companies ensure that their products or services consistently meet industry benchmarks. This creates trust among customers (Mofokeng, 2023), enhances brand reputation, and establishes a competitive edge in a marketplace where quality is the main aspect. Briefly, high attention to quality assurance is a compliance requirement for a leading supply company. It's a part of identity that shows companies commitment to customer satisfaction (Iglesias et al., 2019).

Again, adaptability and flexibility, as a separate characteristic, is the essence of a leading supply company. This feature stands as a hallmark of leadership in the supply industry (Schoeck

et al., 2023). It defines companies that thrive in their dynamic operational environment. To be adaptive, company must not only change when it is necessary, they must recognize changing market conditions, customer demands and changing landscapes in an early on stages (Riser et al., 2015). Adaptability is the ability, to adjust strategies and operations without any hesitation and respond to new challenges proactively (Sheel & Nath, 2019). By staying in line with industry's needs, these companies stay relevant in the market. Leading companies can even dictate the pace of innovation within its industry (Bhussar et al., 2022). To sum up, adaptability and flexibility distinguishes leading companies from its competitors and shows its potential to not only to stay relevant within its industry, but also stand out.

In contrast, leading companies in the supply industry integrate sustainability practices into their operations, noting its environmental impact and social responsibility (Romano et al., 2023). These companies align with global sustainability and environmental goals. This commitment to sustainability shows companies that company has responsible vision and goal. A keen look towards awareness of their environmental impact, they implement eco-friendly initiatives, reduce carbon footprints shows adoption of responsible practices (L. Yang et al., 2023). Moreover, integration of non-profitable sustainability practice goals in companies, confirms that the company's economic situation and financial performance are sound (Kohtamäki et al., 2024). By taking part in green business implementation, prioritizing sustainability and social responsibility, companies not only contribute to the well-being of the planet, but also show a long-term success vision (Ficca et al., 2023). In an industrial background, where society increasingly prioritize ethical choices, leading supply companies understand, that sustainability is not only a responsibility, but also a strategic manoeuvre separating it from its competitors. All things considered, integration of sustainable practices for a company is not only a step for a cleaner future, but also an indicator of companies' strength and leadership (Hristov & Chirico, 2019).

On the other hand, a customer – centric approach, where customer satisfaction is of high priority, is another characteristic helping to identify companies leadership. A customer focused approach stands as an identity of a top tier supply company (van Assen, 2018). It shows one's commitment to meeting and exceeding customer expectations. Such companies, alongside adaptation, flexibility, technical evolvement put customer satisfaction ratings as one of their goals and values. Customer satisfaction is key to sustained success (Eklof et al., 2020). These companies invest significant amount of their resources to study the nuances and preferences of their clients. It is not only the ability to satisfy, but also predict what is needed for satisfaction of the clientele. Such features of a company are easily visible throughout its proactive communication, dedication to resolving customer concerns and a provision of personalized

services (Dixon, 2018). Customer satisfaction alongside proactivity in this sector positions the companies as trusted partners for supply. Thus, customer centric approach lies alongside other criteria defining a leading supply company.

Another equally important criterion of a supplier's leadership is its ability to make data – driven decisions. Companies that have identified the need and successfully adopted data analytics and business intelligence principles show high levels (Maroufkhani et al., 2020) of transformative power. Using data analytics - the process of collecting, processing, analysing, and interpreting large volumes of data (Xu et al., 2024), companies are able to extract meaningful insights, patterns, and trends that can inform and guide strategic decisions. This leads companies to an improved operational efficiency, and drive overall business growth (Huynh et al., 2023). This not only allows to make data-based decisions, but also increase the effectiveness of processes across the board. This creates a possibility for companies stay ahead of curve and proactively change their plan of action. Data driven decision making is not only a technological advancement. It is a process allowing companies to manage risks, achieve sustained success and navigate through always changing nature of business (Dodman et al., 2021). To conclude, ability to make data – driven decisions is an indicator of a well-balanced and well controlled business operation, showing companies leadership within its industry.

Diving deeper into companies inside while identifying its leadership, crucial aspect is supply chain management. It is not easy to derive this information, but there are indicators pointing to companies development in this region. A leading supply company excels in supply chain management (Leuschner et al., 2023). Main indicators of an efficient supply chain management are effective logistics, technologically advanced inventory management and distribution (Riaz et al., 2023). This creates a seamless flow of supplies or services to companies' clients. A leading company takes an extra step demonstrating adoption of advancements in all mentioned indicators (Al-Emran & Griffy-Brown, 2023). By optimization and advancements, companies can indicate cost effective utilization of resources and timely delivery of goods. A well balanced and controlled end-to-end supply chain allows companies to stay agile and competitive in a dynamic market, setting such companies as leading apart from their opponents (Prajogo et al., 2016). In a nutshell, well managed supply chain is an indicator of a well-managed company, ensuring clients industries leaders standards meeting quality.

Conversely, compliance with regulations and standards within the industry is a key indicator of a leading supply company (Xie et al., 2023). This underscores companies' dedication to regulations of business practices and accountability. These industry leaders are putting compliance with regulations and standards, ensuring that their operations align seamlessly with the prevailing requirements. Complying with not only local industry standards,

but also international business regulations and certified international standards of a specific industry, show a high level of quality and trust of the products (Adler, 2010). By adhering to regulatory frameworks, leading companies demonstrate their commitment to operating ethically, ensuring integrity of their products or services while maintaining a strong reputation within the industry. In conclusion, compliance with regulations and standards are an indicator of a sustained and trusted leadership within industry.

To sum up, a leadership within an industry is an embodiment of superiority, incorporating a set of attributes. By using innovative technologies and processes, these companies increase efficiency and stay at the front of the industry. Also, through global reach they navigate various markets creating a competitive challenger in the market. Quality assurance and a customer centric approach are integral parts of a suppliers' leadership description. Moreover, market leaders prioritize sustainability, putting themselves in line with global goals and showing their power. Together with compliance with market regulations they appear as a responsible and well operated organization. Also, data driven decision making ensures that all the attributes of a company are well analysed and exhibited. All together, these qualities define a leading company in a supply industry, positioning them at the top compared to their rivals. Briefly industry leadership is characterized by a combination of innovation, global reach, quality assurance, customer-centricity, sustainability, regulatory compliance, and data-driven decision-making. These attributes collectively make a leading supplier company.

1.2. Supplier's leadership in EV industry

Choosing a supplier which is market leader is a crucial part for service providers (Manik, 2023). This is especially important in the industry of Electric Vehicle charging. With the increasing demand for such a service, there is an increasing amount of service providers. As mentioned in the relevance of the topic, due to new policies promoting EVs in developed countries, EVs are expected to dominate the market within the next decade. For instance, EV sales in the US, including PHEVs, are projected to reach 50% of total vehicle sales by 2030, with similar targets in Europe (Abdalrahman and Zhuang 2017). Again, to meet the European Commission's goal of 3.5 million charging points by 2030, around 410,000 new charging points need to be installed annually (European Alternative Fuels Observatory, 2024). This growing EV charging industry is driving demand for advanced solutions for businesses and clients. A visualisation of expansions plans is shown in figure 1 showing charging points growth in EU compared to Green Deal target.

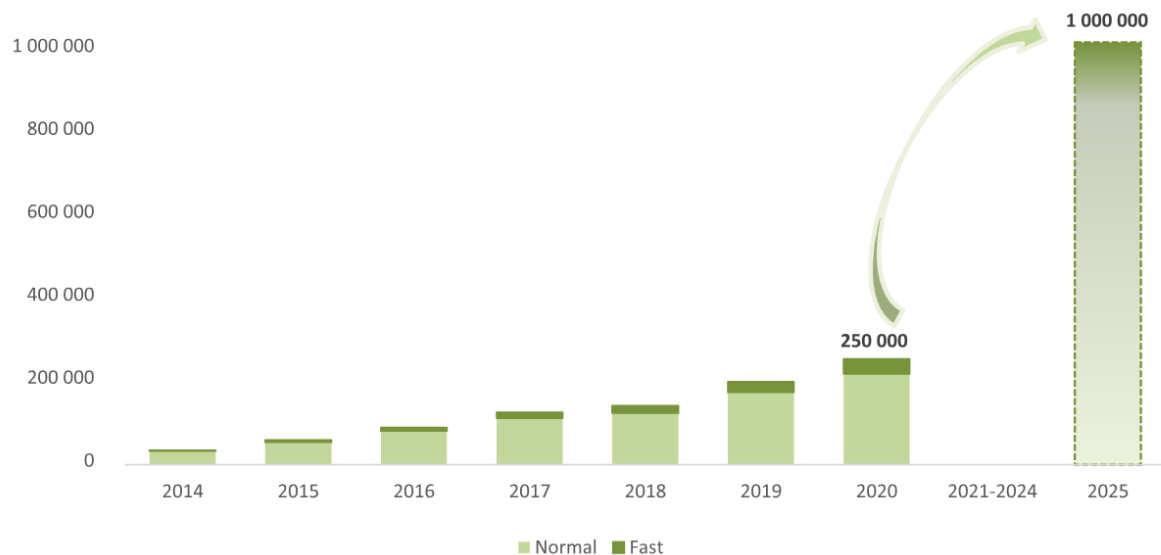


Fig 1. Charging points in EU compared to Green Deal target.

Source: ECA based on EAFO data (2022)

Despite significant advancements in the deployment of electric vehicle (EV) charging infrastructure, Europe holds substantial potential for expanding its electric vehicle charging network, especially in regions that are currently underserved. These areas include less advanced countries and more rural and remote areas such as northern and eastern parts of Europe (Sygic, 2022). This untapped potential offers a significant opportunity for suppliers to exhibit strong leadership by extending their infrastructure into these high-growth zones. Effective leadership in the EV charging industry involves the strategic identification and development of these areas, thereby improving the overall accessibility and reliability of charging services for consumers. Suppliers who can innovate and implement scalable, efficient solutions in these underserved regions will be pivotal in driving the widespread adoption of EVs across the continent (Koman et al., 2024). This growth potential highlights the necessity for a robust evaluation framework to assess supplier performance, ensuring that key leadership attributes such as strategic foresight, operational excellence, and a customer-centric approach are recognized and encouraged (Demiralay & Paksoy, 2022). By cultivating these leadership qualities, Europe's leading EV charging service providers can progress towards European union's ambitious sustainability objectives and create a more comprehensive and equitable EV charging network that benefits all users – service providers, as well as customers.

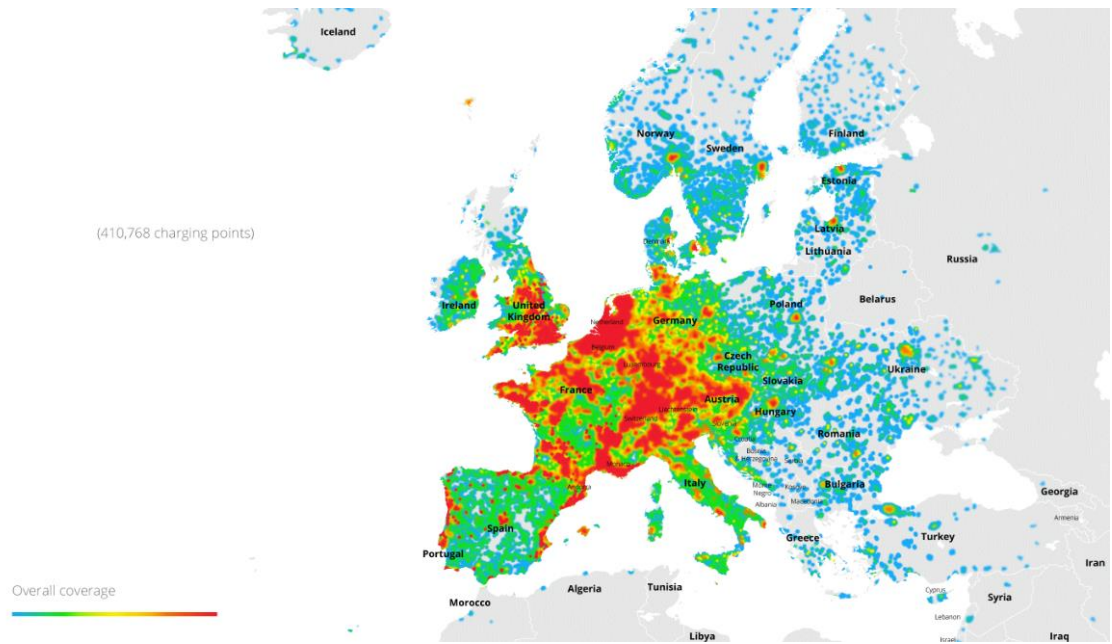


Fig.2 EV charger coverage in Europe.

Source: Sygic (2022).

Numerous researchers dealing with supplier evaluation in high demand industries emphasize the importance of considering a wide range of conditions that vary in their nature (Amiri et al., 2024). Companies face themselves at stage where supplier selection plays a big role as it is one of the most important parts for company to stay competitive within the industry. There are several attributes that need to be considered when choosing a leading supplier for Electric Vehicle service providers.

Diving deeper into the topic, a question arises. What set of criteria can ensure validity and objectivity of the evaluation process? To begin with, the most popular and widely attributed criteria for electric vehicle charging infrastructure is that it must be reliable. Thus, reliability and quality stand as main aspects for leaders within the EV industry. This emphasizes the significance of choosing a leading supplier. Suppliers that emphasize these qualities, have a track record of constantly delivering high quality and reliable products (Franke et al., 2018). Electric vehicle charging industry is a dynamic landscape, where consistent operation is of top priority. Ability to maximize uptime and ensure smooth operation of charging stations is fundamental for companies success (Li, 2020). Whether we look at this aspect from a company's standpoint or from the other side – eyes of EV owners, reliable infrastructure directly influences the overall satisfaction on both ends. To sum up, opting for a supplier that is a leader in terms of reliability and quality is pivoting point that leads companies to trustworthiness and success of electric vehicle charging network.

Secondly, global presence of the company is another characteristic defining a leading supplier within EV charging industry. A supplier with global network, offers support, maintenance, and consistent product availability across different regions. As one of the crucial parts for operating and maintaining a reliable infrastructure, support and service availability within the region is crucial. Market leading supply companies, that are taking part in the international markets can offer services worldwide. This is a crucial part for choosing an electric vehicle charging station supplier. Global presence combined with quality and reliability are key factors minimizing downtime and increasing both operators and its costumer's satisfaction (Zhang, 2021). The benefits of such leading suppliers include geographical reach, support, fast maintenance, and seamless product availability. Additionally, such availability of products in specific regions, improve procurement processes and pivots a standardized experience of both buyer and user. In summary, global presence not only enhances and smoothens operations of the charging network. It also goes in line with reliability of the EV charging network, directly contributing to companies' success.

Additionally, to global presence, diving deeper into customer support and services, as a different aspect of a leading supply company is a must. Well established suppliers have well-developed customer support and service capabilities (Sheth et al., 2023). In the dynamic essence of an electric vehicle charging supplier industry, companies have recognized the crucial part, that support and maintenance availability plays when choosing a supplier. Leading suppliers invest in customer support capabilities, leading to its advantage within the industry. EV chargers are equipment that are always operated, which lead to the need of constant maintenance (Liu et al., 2022). This takes a main role in suppliers' leadership, as it offers clients not only timely maintenance, but also overall satisfaction of EV charger station users. As charging networks keep expanding, importance of responsive and efficient customer support keeps growing. Overall, companies' ability to provide a well-designed customer support and service system, position suppliers as trusty and well-designed companies. Thus, putting suppliers in a market leading position.

Moving forward, companies' flexibility is another criteria defining a leading supply company. It is a key attribute of supply companies putting them in line with dynamic landscape of evolving Electric Vehicle (EV) charging industry. In today's world, where EV industry is constantly evolving, service providers need to adapt to different regulations (Khalkhali & Hosseinian, 2020), vehicles, payment methods, operational software and other parts of EV charging network. Charging networks are a comparably new object in the market, so new regulations in different countries are being used and developed, which requires flexibility. Ability of a supplier to provide flexible solutions means that charging infrastructure can be

easily upgraded or improved, offering an immeasurable advantage for long term planning. This puts companies that choose such flexible suppliers in a position, where they can easily and strategically navigate through constant developments and changes in the EV charging industry. As the industry continues to evolve, the role of flexibility for charging solutions become increasingly important. This leads to companies that offer future proof solutions becoming the first and logical choice (Ulpiani & Sailor, 2023), putting suppliers in a leader position.

In contrast, we cannot forget about suppliers' financial stability. To choose a leading supplier, often means choosing a financially stable and well-established company (Jena et al., 2023). Financial stability is a significant value of a company, as it fulfils goals of a long-term partner within the EV charging industry. A financially powerful supply company can withstand economic swings, uncertainties and find resources for needed development when needed (Pisicoli, 2023). In an industry that is rapidly changing and evolving, stability plays a crucial role for the longevity of the products. Whether it is maintenance, innovation implementations, scaling and continues product development – financially stable companies have the resources to shift their focus where it is needed. Such supplier can invest in research and development (RnD) ensuring their production stays at the forefronts of innovation. To conclude, financial stability stands as roots of reliability, innovation and support – points that are crucial for a market leading company. Supplier companies' financial stability is directly linked with to reliability and longevity of electric vehicle charging network, which makes them an obvious choice for companies seeking to choose a leader.

Similarly, leading supplier companies invest in research and development (RnD) (Q. Wang & Zhang, 2020) offering newest solutions for its customers. Similarly to suppliers financial stability, it is necessary to look deeper into companies activities. A leading company must not only be financially stable but also dedicate a part of that budget to renewing its production and manufacturing. This directly influences companies' competitiveness within the industry. Such leading companies can meet evolving needs of electric vehicle users – thus also the needs of such service providers. Development can include faster charging times, easier installation and integration, enhanced user interfaces and smart charging possibilities. Staying at the forefront of technological development, ensures companies remain competitive in its industry. If a company is not investing in research and development – it is simply far from a leader of an industry (Gupta et al., 2013). As electric vehicles keep evolving, charging station suppliers need to keep up with the pace, dictating future development. As demand of electric vehicles increases, charging networks will keep expanding and new solutions will need to be implemented. To wrap up, innovation is a pivotal attribute of a supplier's leadership in European EV industry.

To sum up the attributes of a supplier's leadership in the European EV industry and suppliers leadership within the industry in general have similarities. Both focus on global presence, reliability, customer centric approach. But also has attributes specific to the industry – for example customer support, maintenance services, finances. Because of these differences, there is a need to look at a wide range of criteria. The choice of such a leading supplier for EV charging providers is crucial, for ensuring reliability and quality. Supplier must be global present and have abilities to provide reliable customer support and maintenance services. Furthermore, financial stability – which directly resonates with flexibility and research and development attributes, is one of the main aspects defining supplier's leadership for electric vehicle industry. Summing up, the leadership of a supplier in the EV industry incorporates a wide set of criteria, emphasizing the importance of reliability, quality, global presence, robust customer support, maintenance services, financial stability, flexibility, and a commitment to research and development. Choosing a supplier for EV charging providers with such criteria, is a must if companies want to choose leaders.

1.3. Analysis of existing suppliers selection models

In the context of the electric vehicle (EV) charging industry, the effective evaluation and selection of suppliers are critical to achieving operational excellence and sustainability targets. This cannot be done without choosing suitable, preferable and adaptable method for assessing suppliers. This chapter explores the analysis of existing supplier selection methods, focusing on the significance of their methodological attributes and their potential application to develop a Supplier Leadership Assessment Model specifically for assessment of leadership in EV Charging station manufacturing Companies. The industry's dynamic nature and the urgency to expand reliable and accessible charging infrastructure necessitate a thorough understanding of various decision-making frameworks. By investigating diverse models such as multi-criteria decision-making approaches, data envelopment analysis, and advanced selection techniques, this chapter seeks to identify the strengths and weaknesses that are present in each method. This comprehensive analysis will shed light on how and whether these models can be tailored or integrated to address the specific challenges and opportunities within the EV charging sector, ultimately aiding in the creation of a robust framework for supplier leadership assessment.

To begin with, most commonly used approaches need to be overlooked. Table 1 presents various approaches that researchers have used for the assessment and selection of suppliers. For a successful and data-based analysis to take place, not only criteria must be chosen appropriately, but also the method that these criteria will be applied to, as Supplier selection is a decision-making process based on multi-criteria analysis (Tirkolaee, E.B. 2021).

Table 1. Overview of methodologies

No.	Method	Abbreviation for	Description
1	AHP	Analytic hierarchy process	A systematic approach for evaluating MCDM (Multiple Criteria Decision Making) issues based on a scale of pairwise comparisons.
2	ANP	Analytic network process	Extension of the AHP (Analytic Hierarchy Process) technique that allows for the consideration of interdependencies among criteria.
3	COPRAS	Complex proportional assessment	A systematic approach designed to prioritize a group of alternatives based on their level of importance and utility.
4	DEA	Data envelopment analysis	A non-parametric system designed to assess the effectiveness of a group of multiple decision-making units.
5	DEMATEL	Decision-making trial and evaluation laboratory	An expanded approach for constructing a structural model and examining the relationship of influence.
6	EDAS	Evaluation based on distance from average solution	A Multiple Attribute Decision Making (MADM) approach that assesses alternatives by considering positive and negative distances from the average solution.
7	ELECTRE	Elimination and choice reflecting the reality	A collection of methods designed to rank a set of alternatives by evaluating their concordance and discordance indexes.
8	MOORA	Multi-objective optimization by ratio analysis	A method for outranking employing a ratio system, enhanced in robustness with the incorporation of the full multiplicative form known as MULTIMOORA (MOORA plus the complete multiplicative form).
9	PROMETHEE	Preference ranking organization method for enrichment of evaluations	A set of outranking techniques centered on choosing a preference function for each criterion in the context of a Multiple Criteria Decision Making (MCDM) problem.
10	TOPSIS	Technique for order of preference by similarity to ideal solution	A method grounded in the notion that the optimal solution to a Multiple Criteria Decision Making (MCDM) problem is the one closest to its ideal state.
11	SAW	Simple Additive Weighting	A Multiple Attribute Decision Making (MADM) method that calculates a weighted sum of performance ratings for each alternative, providing a straightforward approach to ranking alternatives.
12	VIKOR	Multicriteria Optimization and compromise solution	Method for determining the compromise ranking-list of a set of alternatives according to the measure of closeness to the ideal solution.

Source: Ghorabae (2017)

The evaluation and selection of suppliers encompass multiple factors, which need criteria for correct approach. (Keshavarz Ghorabae, M. 2016). For example, mathematical programming (MP) models aim to identify the optimal solution to a problem. Whereas multi-criteria decision-making and choice (MCDM) models seek to assess available options, offering informed recommendations from various perspectives (Chai, J. 2013). In multi-criteria

decision-making (MCMD), human decision-making becomes essential part of assessing and assigning weight to the most crucial criteria. In a literature review conducted by Ghorabae, M. K. in 2017, methods for selection of a leading supplier were examined from January of the year 2001 to May five years later. A comprehensive analysis encompassed a total of 339 scientific articles published in reputable journals and notable conferences. The table includes acronyms and concise descriptions for each approach.

Focussing on mostly used supplier assessment models overviewed by Ghorabae M. K. in 2017, first method for assessment is the Analytic Hierarchy Process (AHP). It was developed by Thomas L. Saaty in the 1970s, provides a comprehensive framework for decomposing a decision problem into a hierarchy of more manageable sub-problems. This method is particularly effective in multi-criteria decision-making contexts, where diverse and often conflicting criteria must be considered (Kebeba et al., 2024). The Analytic hierarchy process methodology involves four main steps: Construction of hierarchy, pairwise comparison, priority synthesis, aggregation of priorities. This is a systematic and structured approach extensively employed for addressing Multiple Criteria Decision Making (MCDM) challenges. AHP simplifies complex decision-making problems by breaking them down into a hierarchy of more manageable sub-problems (Kebeba et al., 2024). This method involves making pairwise comparisons among criteria and alternatives, which allows decision-makers to express their preferences on a scale, usually from 1 to 9. These comparisons are used to ascertain the relative importance of each criterion and to evaluate how well each alternative performs against these criteria. The outcome is a set of priority weights that rank the alternatives. The Analytic Hierarchy Process (AHP) is a powerful decision-making tool that can effectively address the complexities involved in decision making. When evaluating an EV charger supplier as a leader within the industry, determining the criteria that reflect leadership within the industry are crucial. By breaking down the decision problem into a structured hierarchy, performing pairwise comparisons, and synthesizing priorities, Analytic Hierarchy Process facilitates a comprehensive and rational evaluation of alternatives (Ballo et al., 2024). This method not only aids in identifying the most suitable supplier but also ensures that the decision is based on a balanced consideration of all relevant criteria. AHP is particularly advantageous in supplier selection processes, where it is essential to consider a variety of factors such as cost, quality, delivery performance, and sustainability. By converting subjective judgments into numerical values, AHP method provides a transparent and rational foundation for decision-making. Its structured approach and focus on maintaining consistency in judgments make it a dependable tool for creating a Supplier Leadership Assessment Model in the EV charging industry, ensuring that all pertinent criteria are thoroughly assessed and weighted appropriately. Although AHP

has been widely used for supplier assessment, it is mostly significant and practical to use for priority weights assessment (Kebeba et al., 2024) and not for ranking the alternatives. Additionally, AHP's dependence on consistent and precise judgments may lead to inconsistent results, which can undermine the reliability of the evaluation process. This method also struggles to account for qualitative aspects and the strategic influence that are crucial for assessing supplier leadership effectively, thus, is not the best option for suppliers leadership assessment.

Moving on to the Analytic Network Process (ANP). This method extends the Analytic Hierarchy Process (AHP) by incorporating the interdependencies among decision criteria, allowing for a network structure where criteria and alternatives can influence each other reciprocally (Jones & Smith, 2023). This makes ANP well-suited for capturing the complex relationships and feedback loops present in real-world decision-making. By organizing criteria and alternatives into clusters and nodes, ANP accounts for both direct and indirect influences, providing a more comprehensive analysis. Pairwise comparisons within this network are used to derive priority weights, processed through a super matrix that reflects these interdependencies (Smith & Brown, 2024). While ANP's thorough approach is beneficial for evaluating factors like technological innovation, regulatory compliance, and environmental impact in the EV charging industry, it may not be the most suitable for a Supplier Leadership Assessment Model in this sector. The complexity involved in constructing and analysing the network structure can be resource-intensive and time-consuming, which is impractical for an industry that evolves rapidly. The extensive pairwise comparisons required can lead to inconsistencies and decision fatigue, particularly with numerous criteria and suppliers (Garcia & Lee, 2019). Given the fast-paced advancements and changing regulatory landscapes in the EV charging industry, a more agile and straightforward evaluation method might be necessary. Thus, despite ANP's ability to capture interdependencies effectively, its complexity and potential for subjective bias may limit its practicality and timeliness in assessing supplier leadership within this context.

Next method indicated by analysis of by Ghorabae M. K. is COPRAS method, or in full abbreviation - The Complex Proportional Assessment method. This is a structured approach designed to prioritize a set of alternatives by evaluating their significance and overall utility. It begins by normalizing the decision matrix to enable the comparison of different criteria on a common scale, followed by calculating a weighted normalized decision matrix using predefined criteria weights. The utility degree of each alternative is determined by assessing positive and negative ideal solutions, representing the best and worst possible values for each criterion. COPRAS is particularly effective in multi-criteria decision-making scenarios, such as supplier

selection, where various factors like cost, quality, delivery time, and sustainability must be considered (Kumar et al., 2024). Its ability to produce a clear ranking of alternatives based on their overall performance offers decision-makers a transparent and straightforward tool for selection. However, COPRAS may not be the most suitable method for developing a Supplier Leadership Assessment Model in the electric vehicle (EV) charging industry. This sector's rapidly changing market conditions and technological advancements can make it difficult to accurately determine criteria weights and obtain reliable data. Additionally, COPRAS does not account for the complex interdependencies and dynamic interactions between criteria that are often present in this industry, potentially leading to an inconsistent evaluation (Yang et al., 2023). Thus, while COPRAS provides a systematic and clear evaluation process, its applicability to the nuanced and fast-paced EV charging industry may be limited, highlighting the need for a more flexible and adaptive approach for effective supplier leadership assessment.

Next approach that has also been referenced in various research in topic of suppliers evaluation is Data Envelopment Analysis, or DEA for short. This non-parametric method is mostly utilized to assess the efficiency of multiple decision-making units such as organizations, departments, or suppliers (Zhao et al., 2024). Unlike traditional parametric methods, DEA does not assume a specific functional form to describe the relationship between inputs and outputs. Instead, it constructs a piecewise linear frontier from observed data to measure the relative efficiency of each DMU by comparing them to the most efficient units in the dataset. This approach is especially useful for evaluating suppliers, as it allows for a comprehensive assessment of multiple performance metrics like cost, quality, delivery time, and innovation. However, DEA may not be the best fit for a Supplier Leadership Assessment Model in the electric vehicle (EV) charging industry. As research shows, the method's dependence on historical data can be restrictive in this fast-paced sector, where technological advancements and market dynamics are constantly evolving. Additionally, DEA does not naturally incorporate qualitative factors or the strategic significance of certain criteria, which are essential for a thorough evaluation of supplier leadership in the EV industry (Georgantzinos et al., 2024). Given the complex and rapidly changing nature of the EV charging sector, an evaluation framework that can adapt to new developments and include qualitative insights is necessary. In the light of these factors mentioned by researchers, while DEA provides a robust framework for efficiency analysis, its application in this context may require complementary methods to fully capture the diverse aspects of supplier performance and leadership. Because of that, Data Envelopment Analysis is not best suitable.

Focusing on more advanced and not as widely used methods on the list, next is DEMATEL. As abbreviation stands, this is a Decision-Making Trial and Evaluation Laboratory

method. This advanced method was designed to create a structural model that analyses and visualizes the complex relationships and influences among various criteria. This approach starts by gathering expert assessments to form a direct-relation matrix, quantifying the direct impact one criterion has on another. This matrix is then converted into a total-relation matrix, which captures both direct and indirect influences. The resulting structural model offers a clear visualization of the cause-and-effect relationships, identifying the most influential criteria and their interactions. DEMATEL is particularly useful in scenarios where understanding the interdependencies and feedback loops among criteria is crucial. However, despite its strengths in mapping intricate relationships, Decision-Making Trial and Evaluation Laboratory method may not be ideally suited for developing a Supplier Leadership Assessment Model for the electric vehicle (EV) charging industry. The method's complexity and the extensive expert input required can be resource-intensive and time-consuming, posing challenges in a rapidly evolving sector (Runtuk et al., 2024). The goal of suppliers leadership evaluation model in this research particular case is for it to be easily applicable and foster beneficial use in day to day task of a company. Additionally, DEMATEL might not effectively capture the qualitative nuances and swiftly changing technological advancements characteristic of the EV charging industry (Gao & Zhou, 2024). Therefore, while DEMATEL provides a robust framework for analysing influence relationships, its use in this specific context may necessitate complementary methods to ensure a more agile and comprehensive evaluation of supplier leadership.

Next approach on the list for analysis is Evaluation Based on Distance from Average Solution (EDAS). A relatively new and efficient MCDM method. In a nutshell, it is a Multiple Attribute Decision Making approach that evaluates alternatives by analysing their positive and negative distances from an average solution. In a way, it is similar to COPRAS method. This method starts by calculating the average performance of all alternatives for each criterion. It then determines the positive distance, which shows how much better an alternative is compared to the average, and the negative distance, indicating how much worse it is. These distances are aggregated to produce a comprehensive assessment score for each alternative, ensuring a balanced evaluation by considering both positive and negative deviations from the average. Although EDAS is useful for scenarios where equilibrium among various performance metrics is crucial (Zhang et al., 2024), it may not be ideally suited for developing a Supplier Leadership Assessment Model for the electric vehicle (EV) charging industry. The method's dependence on an average solution can oversimplify the complexities and dynamic interactions within the EV sector, which is marked by rapid technological advancements and changing market dynamics. Additionally, EDAS might not fully account for qualitative factors and strategic priorities essential for assessing supplier leadership in this rapidly evolving industry (Tiwari &

Soni, 2024). Therefore, while EDAS provides a systematic and balanced evaluation framework, its application in the EV charging industry may require integration with other methods to effectively address the sector's unique challenges and opportunities.

Moving on with the analysis of suppliers selection models, seventh one in the list is ELECTRE (Elimination and Choice Expressing Reality). This is a set of decision-making methods designed to rank alternatives by evaluating their concordance and discordance indexes - statistical measures used to evaluate the agreement or disagreement. These methods compare pairs of alternatives across multiple criteria, determining the extent to which one option is superior to another (Akram & Deveci, 2023). The concordance index indicates how well an alternative meet or exceeds the criteria compared to others, while the discordance index highlights where an alternative falls short. By balancing these indexes, ELECTRE systematically eliminates less favourable options, refining the selection of viable alternatives. Although ELECTRE is highly effective in complex decision-making scenarios involving multiple conflicting criteria, it may not be the best fit for developing a Supplier Leadership Assessment Model for the electric vehicle (EV) charging industry. The method's intricate and time-consuming pairwise comparisons can be challenging in a rapidly evolving, innovation-driven sector (Liang et al., 2023). Moreover, ELECTRE may struggle to fully capture the qualitative nuances and swiftly changing technological advancements essential for assessing supplier leadership in the EV charging industry. Therefore, while ELECTRE provides a thorough and structured evaluation framework, its application in this context might require integration with other methods to achieve a more agile and comprehensive assessment of supplier performance and leadership which is unnecessarily overcomplicating.

Moving on to the less popular approach, Multi-Objective Optimization by Ratio Analysis (MOORA) is analysed. This decision-making method focuses on ranking alternatives based on multiple criteria through a ratio system, involving the normalization of performance data and calculation of ratios to derive overall scores. This approach combines the ratio system, reference point method, and full multiplicative form to offer a comprehensive and balanced evaluation by considering both the advantages and disadvantages of each alternative. However, despite its thoroughness, MOORA approach is not ideally suited for developing a Supplier Leadership Assessment Model for the electric vehicle (EV) charging industry. The methods' emphasis on quantitative data might overlook essential qualitative aspects such as financial records, capabilities and strategic alignment with industry trends (Başaran & Tarhan, 2022). Furthermore, the dynamic and rapidly evolving nature of the EV charging sector requires an evaluation framework that can swiftly adapt to new technological advancements and changing market conditions (Chate et al., 2021). Therefore, while MOORA provide robust and systematic

evaluation frameworks, their application in this context may necessitate integration with other methods to ensure a more holistic and adaptive assessment of supplier performance and leadership.

Following less popular approaches, PROMETHEE - The Preference Ranking Organization Method for Enrichment of Evaluations is analysed for adaptation of suppliers leadership evaluation in EV charger industry. This complex method is a set of outranking techniques used in Multiple Criteria Decision-Making process that focuses on selecting specific preference functions for each criterion to evaluate and rank alternatives through pairwise comparisons. Each preference function reflects the decision-maker's preferences and the relative superiority of one alternative over another for a given criterion. By aggregating these preference values across all criteria, PROMETHEE produces a comprehensive ranking of alternatives, emphasizing the most preferred choices while considering the relative importance of each criterion (Liu & Liu, 2024). The method's flexibility in selecting preference functions makes it adaptable to various decision-making contexts, which is particularly useful for complex evaluations involving multiple, often conflicting, criteria. However, despite its advantages, the method may not be the most suitable for developing a Supplier Leadership Assessment Model in the electric vehicle charging industry. The method's reliance on detailed pairwise comparisons can be time-consuming and challenging to manage, particularly in a sector characterized by rapid technological advancements and shifting market conditions (Alves et al., 2024). Additionally, this approach may not adequately capture the qualitative aspects and strategic priorities essential for evaluating supplier leadership in the dynamic EV charging industry. Therefore, while PROMETHEE provides a robust and flexible evaluation framework, its application in this context may require integration with other methods to ensure a more comprehensive and adaptive assessment of supplier performance and leadership. This additional time consumption makes methods application not suitable for specific requirements of EV charging industry.

Next on the list is widely used and one of the most referenced methods – TOPSIS. The abbreviation stands for Technique for Order of Preference by Similarity to Ideal Solution. This is a commonly used decision-making approach based on the concept that the optimal solution to a Multiple Criteria Decision Making (MCDM) problem is the one nearest to the ideal solution and farthest from the worst-case scenario. Method developed by Hwang and Yoon a decade later than the AHP method in 1981. TOPSIS is created on the concept that the most preferred alternative should have the shortest geometric distance from the ideal solution and the longest distance from the negative-ideal solution (Stević et al., 2020).

TOPSIS entails identifying the ideal and negative-ideal solutions by evaluating the best and worst values for each criterion, then assessing alternatives based on their distances from these reference points (Gökler & Boran, 2023). The alternative that is closest to the ideal solution and farthest from the negative-ideal solution is deemed the most favourable. This method offers a logical framework for ranking alternatives, making it particularly useful for complex decision-making situations involving multiple conflicting criteria. TOPSIS may be particularly well-suited for creating a Supplier Leadership Assessment Model in the electric vehicle (EV) charging industry because it allows for straightforward comparisons between alternatives based on their proximity to an ideal state. This makes it effective for evaluating suppliers across a variety of criteria, such as cost, quality, delivery performance, and sustainability. Its structured methodology ensures that all relevant factors are considered and balanced, which is critical in an industry characterized by rapid technological progress and shifting market conditions. Additionally, TOPSIS's ability to handle both quantitative and qualitative data enables a more comprehensive assessment of supplier capabilities, including innovation and strategic alignment with industry trends. In the context of determining EV charger supplier as a leading one, TOPSIS provides a systematic approach. To evaluate and rank suppliers based on critical criteria determining a supplier as a leader by considering both the proximity to the ideal solution, which in this case is a leader, and the distance from the negative-ideal solution (Jiang et al., 2024). Because further factors, the TOPSIS method is not suitable for supplier leadership evaluation as this approach may not fully capture selected qualitative and strategic aspects of leadership, which are crucial for evaluating supplier leadership in the European industry of EV chargers. In a nutshell, TOPSIS relies on the geometric distance from an ideal point, which may not always align with the decision-maker's intuitive understanding of supplier performance, especially when subjective judgments are involved. Together with complication of data interpretation and more challenging calculations, TOPSIS can introduce biases and fail to account for the complex, multi-faceted nature of leadership performance.

Moving on to next popular and widely referenced approach, The Simple Additive Weighting or SAW for short is analysed. It is also known as weighted linear combination or scoring method and provides a clear understanding of multi-criteria assessment by enabling the evaluation of indicators across various dimensions (Vafaei et al., 2022). This method is a popular approach in Multiple Attribute Decision Making processes due to its straightforwardness and efficiency in ranking various alternatives. The Simple Additive Weighting method, in a nutshell, involves assigning weights to each criterion, normalizing the performance scores of alternatives, and summing the weighted scores to determine the best

option (Y. J. Wang, 2019). The process typically involves six main steps. When applied to supplier leadership assessment in the electric vehicle charging industry, SAW provides a structured methodology by assigning weights to multiple performance criteria essential for evaluating suppliers. Each supplier is rated based on these criteria, and a weighted sum is computed for each one, resulting in an overall score. Its simplicity and transparency facilitate a clear decision-making process, allowing decision-makers to systematically evaluate and rank suppliers based on specific, selected criteria (Shekhovtsov, 2023). By assigning appropriate weights and normalizing performance scores, the SAW method provides a comprehensive evaluation that identifies industry leaders best meeting criteria, that are crucial for leading EV charger suppliers. The SAW method's capability to manage multiple criteria effectively and transparently makes it particularly suitable for developing a Supplier Leadership Assessment Model in the electric vehicle charging sector. It offers a balanced and clear evaluation process, which is crucial for making informed decisions in an industry marked by fast-paced technological changes and shifting market conditions.

Ant the last method on the agenda for the analysis of existing suppliers selection models is The VIKOR method. Compared to other methods, this one does not have a clear abbreviation stating the fundamentals of the approach. In a nutshell, this is a prominent multicriteria optimization and compromise solution technique used in decision-making processes. This method is particularly effective in situations where decision-makers need to rank and select from a set of alternatives based on their proximity to an ideal solution, just like TOPSIS method (Opricovic & Tzeng, 2024). VIKOR operates by evaluating each alternative against a set of criteria, identifying both the best and worst performance values among all alternatives. It then calculates a compromise solution by balancing the maximum group utility and the minimum individual regret of the opponent. This is achieved through the computation of a Q index, which synthesizes the various criteria into a single value for each alternative. The alternatives are subsequently ranked according to this index, providing a clear and rational ranking list that highlights the most preferred options. However, despite its strengths, the VIKOR method may not be the most suitable choice for a Supplier Leadership Assessment Model in the electric vehicle charging industry. This sector often requires a more straightforward and transparent evaluation process due to its fast-paced nature and the need for quick decision-making (Yazdani et al., 2019). The complexity and the compromise-focused nature of VIKOR might not align well with the industry's requirement for clear, decisive rankings based on multiple performance attributes.

In Ghorabae's method summary, various methodologies for supplier assessment and selection are outlined. Regarding the description of main multi-criteria decision-making

methods, it is possible to derive each one and choose which one suits the requirements the most. For example, COPRAS method, pioneered by Zavadskas in 1994, addresses limitations by separately assessing the impact of maximized and minimized indicators (Zavadskas et al. 1994). On the other hand, SAW method pioneers clear and straight forward approach. Comparing these two to TOPSIS method, it stands out, as it establishes alternatives by measuring the distances between the best and worst indicator values. TOPSIS was developed with the objective that subjective weight may not be always feasible, and the attribute weight is applied. Also, for example EDAS method, where solution is determined based on distances of them from an average solution. (Keshavarz Ghorabae et al., 2017). Using this information, researchers can choose the most suitable methodology for assessing.

In addition to multi-criteria decision methods, many researchers around the world have also compared several methods pros and cons with each other. M.R. Mahmoud and L.A. Garcia compared five multicriteria estimation methods: weighted average (WA), PROMETHEE II, compromise programming (CP), ELECTRE II, and the analytic hierarchy process (AHP) (Jiang et al., 2024). The stability of the results obtained, the clarity of the methods and the amount of additional information needed for the method were assessed. It was concluded that analytic hierarchy process (AHP) along with The Simple Additive Weighting (SAW) were similarly most appropriate for the problem they formulated. Zanakis in his research chose eight methods for their mathematical experiments: ELECTRE, TOPSIS, exponential weighting (MEW), simple addition of weights (SAW), and four versions of the analytic hierarchy process (Zanakis et al. 2020). The simple weighting (SAW) and exponential weighting methods were found to be the most appropriate. These are followed by COPRAS, the analytical hierarchy process and finally ELECTRE. Other researchers have also carried out a comparative analysis of the VIKOR and TOPSIS methods, evaluating the alternatives according to their distance to the ideal solution.

In summary, the methods examined the analysis of existing suppliers' selection models for assessing supplier leadership in the electric vehicle charging sector each offer distinct advantages and characteristics. Nevertheless, the Analytic Hierarchy Process (AHP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and Simple Additive Weighting (SAW) emerge as the most appropriate choices for this context. AHP is particularly useful due to its hierarchical structure, which facilitates detailed comparisons of criteria and sub-criteria. TOPSIS stands out for its ability to rank alternatives based on their proximity to an ideal solution, offering a clear and straightforward ranking system. SAW is valued for its simplicity and ease of implementation, making it ideal for swift decision-making in a rapidly evolving industry. Conversely, methods like DEA, DEMATEL, EDAS, ELECTRE

and others fall short in this application. Unclear and unnecessary complexity may not deliver the clear and direct evaluations required for quick and transparent supplier assessments (S.H. Zanakakis et al. 2020). Other methods may also struggle to meet the industry's demands for decisive rankings implementing quantitative and qualitative measures, as well as the ability to quickly adapt to changing market conditions. Thus, AHP, TOPSIS, and SAW are preferred due to their efficiency in handling multiple criteria, their transparent and easily interpretable results, and their support for the dynamic decision-making needed in the electric vehicle charging industry.

As the study problem suggests, evaluating suppliers' leadership in the electric vehicle (EV) charger industry requires adaptable and effective decision-making methodologies due to this industry's dynamic and complex nature. Methods such as Analytic Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and Simple Additive Weighting (SAW) are known for their capability to handle multiple criteria efficiently, and for producing transparent and easily interpretable results. However, for a model to be most suitable, it is crucial to customize these models to fit the specific context of supplier leadership evaluation in the EV charger industry. This customization involves selection of the criteria that reflect the industry's unique needs, assessing the importance of these criteria to create a balanced evaluation framework, and choosing a reliable assessment method that shows insights and judgments that are essential for ensuring the assessment's validity and reliability. These structured methodologies allow for breaking down complex decision problems into more manageable parts, making it suitable for tailored applications (Ishizaka & Labib, 2020). Additionally, emphasize that TOPSIS and SAW are highly adaptable to different decision-making scenarios, highlighting the importance of precise criteria selection and expert involvement to maintain the models' relevance and effectiveness (Behzadian et al., 2021). By adapting these decision-making models, a robust and contextually appropriate framework that supports strategic decisions in the evolving EV charging sector can be developed.

1.4. Suppliers leadership justification criteria

Regardless of the choice of method, supplier selection is a process involving various tasks and methods. Supplier evaluation is one standing out as the most essential aspects. Various sources of literature have been dedicated covering the topic of supplier's leadership evaluation and selection process. To conduct a valuable selection process, correct establishment of a set of criteria, needed for specific application, forms a base for supplier evaluation model. Many businesses recognize the significance of employing supplier selection criteria in their overall supplier selection process (Stevic, Ž. 2016). In recent years, rapid developments in multi-

criteria analysis, addressing numerous selection models, have been tested. Multi-criteria analysis approach is widely accepted and applied in supplier selection, where decisions often rely on the precision offered by various criteria methods. The complex selection of necessary aspects and the determination of the weights that they resemble are crucial for supplier selection decisions with the strategic objectives of companies' performance objectives of the buying organizations (Lima-Junior, F. R. 2016). While most suppliers' assessments revolve around quality, costs, and delivery. (Urbaniak, M. 2021), a more in-depth analysis is needed. Because of evolving industries specific demands, there is a growing need for additional studies in supplier evaluation (Gaikwad, L. 2019). Because of increasing demand, there is a numerous amount of different evaluation models that can be adopted for specific industries. By overlooking most used models, we can derive suitable methods and criteria most suitable for suppliers' leadership evaluation model in European electric vehicle charging industry.

Moving on, as it stated in the overview of existing methods, for a methodology to be applied, correct criteria must be chosen. For this reason, an analysis of various literature sources and studies is conducted in the first part. Additionally, existing supplier evaluation models criteria are analysed. Using existing practices, most suitable criteria fulfilling the need of a supplier's leadership evaluation model for European EV industry can be adapted.

To begin with, the first suppliers' evaluation model with criteria to be analysed is Carter's 10 Cs of Supplier Evaluation. Supplier evaluation is difficult to comprehend and is equally referred to as the 7Cs, 9Cs or 10C based on the number of criteria. The mostly referred model, 10Cs, was created by an American academic, named Dr. Ray Carter in 1995. Dr. Carter, the director of DPSS consultants, initially introduced his 7Cs supplier evaluation model. Later, after few alterations, model was expanded by incorporating three additional criteria. These ten criteria are derived for evaluating suitability of a supplier. The main criterion for evaluation goes as follows.

1. Competency.
2. Capacity.
3. Commitment.
4. Control.
5. Cash.
6. Cost.
7. Consistency.
8. Culture.
9. Clean.
10. Communication.

To apply the 10Cs model, first suppliers' competence is evaluated. This evaluation is conducted based on assessment of supplier's capabilities measured against company's needs. Next, capacity is assessed. The supplier needs to have enough capacity to withstand companies' requirements. A suitable company must have ability to meet fluctuating orders. Next up is commitment. A well-suited supplier must not only be committed to a customer, but also to high quality standards. A good example is ISO standards, such as ISO 9001 - internationally accepted standard as a basis for the continuous improvement of all company processes (Hillnhagen et al., 2023). Further, control within the company is evaluated. The main focus here, is control over production. A company that has more control over supply and production can be more flexible when it is needed. Next criteria is cash, which is an indicator of financial strength. A financial superior company can withstand market fluctuations and invest more time in research and development. One of the most important criteria – cost. Companies need to compare cost to its resources and how it compares with other options. Consistency is up next. Consistency is indicated by companies' ability to ensure high quality production and its ability to use procedures or methods ensuring it. Moving on to culture aspect. Supplier's values should meet your companies' vision. Culture should be as closely matched as possible, leading to matching expectations. Next, a supplier company must be clean. This means that it should invest in sustainability, showing their commitment to environmental laws and practices. And last but not least, is communication. This criteria describes how quickly communication takes place, is it easy to reach seniors or specific workers within the company. All things considered, 10Cs model focuses on main aspects necessary for smooth operation and relationship between suppliers and companies. In context of application of the CARTES 10C method criteria in analysing leading companies in the EV charging supplier industry reveals several critical success factors. These include cost, consistency and commitment of suppliers. By prioritizing these factors, EV charging suppliers can be addressed as taking competitive edge and leadership in the rapidly evolving market.

Secondly, Criteria for selection and assessment of a supplier by Dalvi M. and Patil M. (2020) is studied. A study conducted by these two researchers involved the analysis of 94 international scientific studies published between a period of 51 years. (From 1966 to 2017), obtained from academic databases. The goal of this study was identifying factors influencing supplier selection based on the level of relevance to today's market. The findings consist of 25 essential supplier selection and assessment criteria, are presented in Table 2. Criteria are presented with their reference quantity, accordingly, indicating their importance compared to each other. In conclusion, the analysis of Dalvi M. and Patil M. conducted criteria resonate with indication of leading EV charging station manufacturers indicated in earlier part. For leadership

among EV charging station suppliers reveals several critical factors that drive industry success. Foremost is the ability to maintain timely delivery performance, which is vital for ensuring supply chain efficiency and customer satisfaction. Attention to high-quality standards is also essential, as it guarantees product reliability and builds trust. Cost efficiency is important for competitiveness and providing value to customers. Operational flexibility is crucial for adapting swiftly to market changes and customer needs. Additionally, having robust production facilities and sufficient capacity allows suppliers to meet increasing demand without sacrificing quality. High service quality and strong technical capabilities further set leading suppliers apart in competition by offering exceptional support and innovative solutions for customers. Strategic geographical location and strong environmental performance are also significant, as they facilitate market access and align with global sustainability objectives.

Table 2. Criteria for selection and assessment of a supplier

No.	Criteria	Reference quantity
1	Timely delivery performance	17
2	Quality standards	15
3	Cost efficiency	13
4	Flexibility	12
5	Production facilities and capacity	11
6	Performance and reputation	11
7	Service quality	11
8	Technical capability	10
9	Geographical location	9
10	Environmental performance	9
11	Attitude	7
12	Labor relations records	7
13	Warranties and claim policies	6
14	Responsiveness	6
15	Financial position	5
16	Order processing efficiency	5
17	Packaging standards	4
18	Cultural similarity	4
19	Ethical standards	4
20	Communication effectiveness	4
21	Legal claims handling	3
22	Political stability	3
23	Business interest alignment	3
24	Competitive environment	2
25	Currency stability	2

Source: Dalvi and Patil (2020)

Moving forward with another review of criteria, a study of researcher Chen Y is examined and analysed. In the study, essential criteria for identifying most valuable criteria for supplier evaluation were identified. Chen Y conducted information from previous scholars in supplier assessment, including Weber et al. (1991), Weber & Current (1993), Weber & Desai (1996), and Dickson (1996). After conducting an extensive examination of vendor evaluation methods, its Chen Y concluded, that price ranked as the most significant factor, with delivery and quality following closely. These empirical studies indicated a comparable level of importance among various selection criteria, including price, quality, and delivery performance (Chen, 2011). Results of the research are presented in table 3. Using the criteria, reference quantity and importance an assessment of suppliers can be conducted.

Table 3. Evaluation criteria for supplier assessment.

No.	Criteria for evaluation	Reference quantity	Importance
1	Price	61	Extremely important
2	Deliver on time	44	Extremely important
3	Quality	40	Extremely important
4	Equipment and capability	23	Very important
5	Technical capability	15	Important
6	Geographic location	13	Important
7	Management and Organization	10	Important
8	Industrial reputation	8	Important
9	Maintenance service	7	Important
10	Financial situation	7	Important
11	Historical performance	7	Important
12	Service attitude	6	Important
13	Production control ability	3	Important
14	Packing ability	3	Important
15	Previous image	2	Important
16	Communication system	2	Important
17	Training ability	2	Important
18	Employment relations	2	Important
19	Mutual negotiation	2	Important
20	Procedure legality	2	Important
21	Previous sales	1	Important
22	Business relations	1	Important
23	Guarantee	0	Important

Source: Chen Y (2014)

After analysing supplier assessment criteria by Chen Y, main criteria that can be applied for suppliers leadership in EV charging industry are outlined. Ensuring product quality and robust technical capability are essential, as they guarantee the delivery of reliable and cutting-edge charging solutions. Competitive pricing strategies are also as crucial. Reliability, strong historical performance are vital for maintaining an efficient supply chain and building customer trust. Financial performance provides a clear picture of a supplier's stability and ability to sustain operations. Effective supply chain management, which includes production control and timely delivery, is necessary for seamless operations and customer satisfaction. Regulatory compliance ensures adherence to legal standards, reducing the risk of legal issues. Additionally, comprehensive warranty/guarantee policies and outstanding customer support services, such as maintenance and effective communication systems, are key to fostering long-term customer relationships and satisfaction.

As it is clear from comparison of different studies, exhibiting evaluation criteria, there is diversity between each one of the models, but also some similarities when dividing criteria into specific groups. It is necessary to conduct and adapt these criteria for electric vehicle charging industry, choosing a systematic approach. After analysing different approaches, similarities of the majority of criteria fall under specific groups. Identified specific groups are named bellow.

1. Reliability
2. Finances
3. Assets and infrastructure
4. Flexibility
5. Responsiveness
6. Safety
7. Sustainability

For example, all three methods include some form of cost and financial criteria. Chen Y. (2010) study outlines price, financial situation, previous sales and compensations. Similarly, study conducted by Dalvi M. & Patil M. (2020) focus on cost and financial position. Another example is reliability. Different approaches show different qualities. The first method concentrates on consistency and control, while others include quality of production, service. Using this information, it is easy to derive necessary criteria, that similarly fall into different categories in all reviewed evaluation criteria models.

As mentioned previously, it is clear from the comparison of different writers, that they all share common criteria when assessing suppliers' that also fall in the category of their leadership. The recurrence of specific criteria being mentioned and implemented by multiple

authors suggests that it is useful throughout all scopes of industries. This similarities of opinions among various authors serves as an indicative guide for creation of decision-making processes. Consequently, the developed model will focus on and prioritize the incorporation of these commonly cited criteria, fostering a robust approach to supplier leadership evaluation. Using this data and points mentioned about necessary attributes of a supplier's leadership for EV industry we can choose most common criteria that include all different groups from the assessment and go in line with European EV industry. The selected criteria go as follows. The crafted model will highlight and give a possibility to the incorporation of these most often referenced criteria. Recognized vital characteristics of supplier leadership in the European EV industry, identify a set of shared criteria that include a variety of perspectives gathered during the assessment. These chosen criteria seamlessly align with the distinctive requirements of the electric vehicle sector.

1. Product Quality
2. Cost/Pricing
3. Reliability
4. Financial Performance
5. Market Presence
6. Technological Innovation
7. Supply Chain Management
8. Regulatory Compliance
9. Flexibility
10. Warranty/Guarantee
11. customer support services
12. Sustainability

Using these 12 criteria, formulated during the theoretical phase of this research, allows the identification of the leading supplier for electric vehicle charging industry companies. It focuses on main aspects necessary for EV charging station network while incorporating all the necessary parts of standard leading supplier evaluation models used throughout the years. These criteria will be incorporated in the design of suppliers' leadership evaluation model for electric vehicle charging industry companies. By integrating these criteria, there is a background to create a robust framework that not only mirrors the best practices of traditional supplier evaluation models but also addresses the unique demands of the EV charging industry. This comprehensive model will be instrumental in evaluating suppliers' leadership, ensuring that all necessary components are considered. For instance, product quality and technical capability are crucial for delivering advanced and reliable charging solutions, while cost and pricing strategies

determine market competitiveness. Reliability and financial performance ensure operational stability, and industrial reputation and past performance build stakeholder confidence. Supply chain management ensures efficiency, regulatory compliance mitigates legal risks, and flexibility allows for adaptation to market changes.

2. METHODOLOGY FOR DECISION MAKING OF LEADING EV CHARGER SUPPLIER EVALUATION

The methodologies and criteria of data collection and analysis that are used in the research of assessing suppliers as leaders within the industry were presented in the first section of this chapter. It also analyses the problems with the study's structure. The presentation of the appropriate research instruments is the focus of the chapter's second section.

In the first part of this study, the main points and aspects to implement in this research were identified. Moreover, most frequently used multi-criteria evaluations or multi-criteria analysis methods for such assessments were identified and brought up. Therefore, the focus of the second part is mainly to establish requirements for selecting methodologies giving deeper and more informative insights on it and adapt selected method for the assessment of leading EV charger suppliers.

2.1 Requirements for decision-making method and application

The purpose of this research is to develop an evaluation model for suppliers' leadership evaluation in the electric vehicle charger's industry. After the theoretical part of the research of scientific literature, main aspects of necessary research methodology have been identified. In brief - this method must measure the importance of the chosen criteria from the first part and provide us with quantifiable weights for measuring it.

The context of selecting an optimal supplier for electric vehicle chargers requires to use complex decision-making processes that account for various criteria specific to this industry. This section evaluates various attributes of methodologies that can be systematically applied to approach the problem (Keshavarz Ghorabae, M. 2016). The focus is on identifying after analysing and comparing different decision-making methods to select the most suitable for leading EV charger supplier. The methodologies analysed in the first part include Multi-Criteria Decision-Making techniques, mathematical modelling, and qualitative analysis methods.

Numerous multi-criteria approaches were analysed in the first part, but selecting and adapting the most suitable for a specific problem is challenging. Despite the extensive range of multi-criteria methods proposed in the scientific literature for supplier evaluation, each varying in complexity, it is not always clear which methods are best suited for specific applications (Kebeba et al., 2024). The applicability of multi-criteria methods to a given scenario is evaluated based on following attributes:

- The number of problems that needs to be solved by the method.
- The total number of alternatives that can be evaluated.

- The number of indicators used to describe the alternatives.
- The level of information on the views of decision-makers that is pertinent to the method's application.
- The possibility of analysing the reliability of the results.
- The time needed to perform the multi-criteria assessment.
- The resources necessary to resolve a multi-criteria problem using the particular method.

Because the nature of evaluating suppliers in the electric vehicle charger industry is a complex task that requires consideration of multiple factors three main methodologies were identified as suitable after adaptation regarding their comparison. The Analytic Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and Simple Additive Weighting (SAW). All three methods are well-suited for this purpose due to their effective multi-criteria decision-making frameworks based on their comparison. Analytic Hierarchy Process provides a structured approach by breaking down the decision problem into smaller, more manageable sub-problems and deriving priority weights through pairwise comparisons, ensuring a thorough and detailed evaluation of each (Tirkolaee, E.B. 2021). TOPSIS excels in ranking suppliers by calculating their proximity to an ideal solution, helping to identify suppliers that not only meet desirable criteria but also avoid undesirable characteristics. Its emphasis on distance measurement and offers a clear and quantitative basis for comparison. SAW is valued for its simplicity, adding weighted performance scores for each criterion, which makes it a practical choice for quick and straightforward assessments.

2.2 Selection and design of research method application

After reviewing the most widely used methodologies, the challenge of selecting the appropriate methodology for decision support arises. From the absence of a robust systems, such as AHP, TOPSIS and SAW, a method that can address ever-increasing demands in this area needs to be selected. Numerous suggestions for supplier evaluation using various methods are extensively documented in the scientific literature. (Thamagasorn & Pharino, 2019). Based on methodological part, specific barriers that currently impede practical implementation have been identified in AHP and TOPSIS research methods. Many researchers addressing the issue of supplier or suppliers leadership evaluation emphasize the need to take into account a relatively wide range of conditions that differ in their content (Marzouk & Sabbah, 2021). The research method must be flexible, which increases challenges. Selected system must be possible to adapt the assessment to specific situations, which in this case, can be determined by different characteristics of suppliers and buyers, and most importantly - priorities of decision makers. In

contrast to AHP, which requires complex pairwise comparisons and consistency checks, SAW simplifies the decision-making process and reduces the risk of inconsistent judgments which are often seen in recent research (Stević et al., 2016). Furthermore, while TOPSIS involves calculating distances from ideal and negative-ideal solutions, SAW does not involve this concept as it simply sums the weighted normalized scores. This is more straightforward and more applicable for evaluation of suppliers. Also, it has proven increased study reliability while evaluating qualitative and subjective criteria. And finally, when interpreting results of SAW method it emphasizes the aggregate performance across all criteria, making it easier to see which suppliers perform best overall according to the weighted criteria.

Based on the aim of the research and lack of existing suppliers leadership evaluation model in EV charging industry, a model is developed. This is done by using background developed from literature analysis. The analysis incorporates aspects like attributes of leadership, analysis of methods existing, specified justification criteria, background for method was equipped. Regarding the requirements for the study mentioned earlier and adaptation of saw method, following approach displayed in figure 3 is created to tackle the task of assessing the aim of the research.

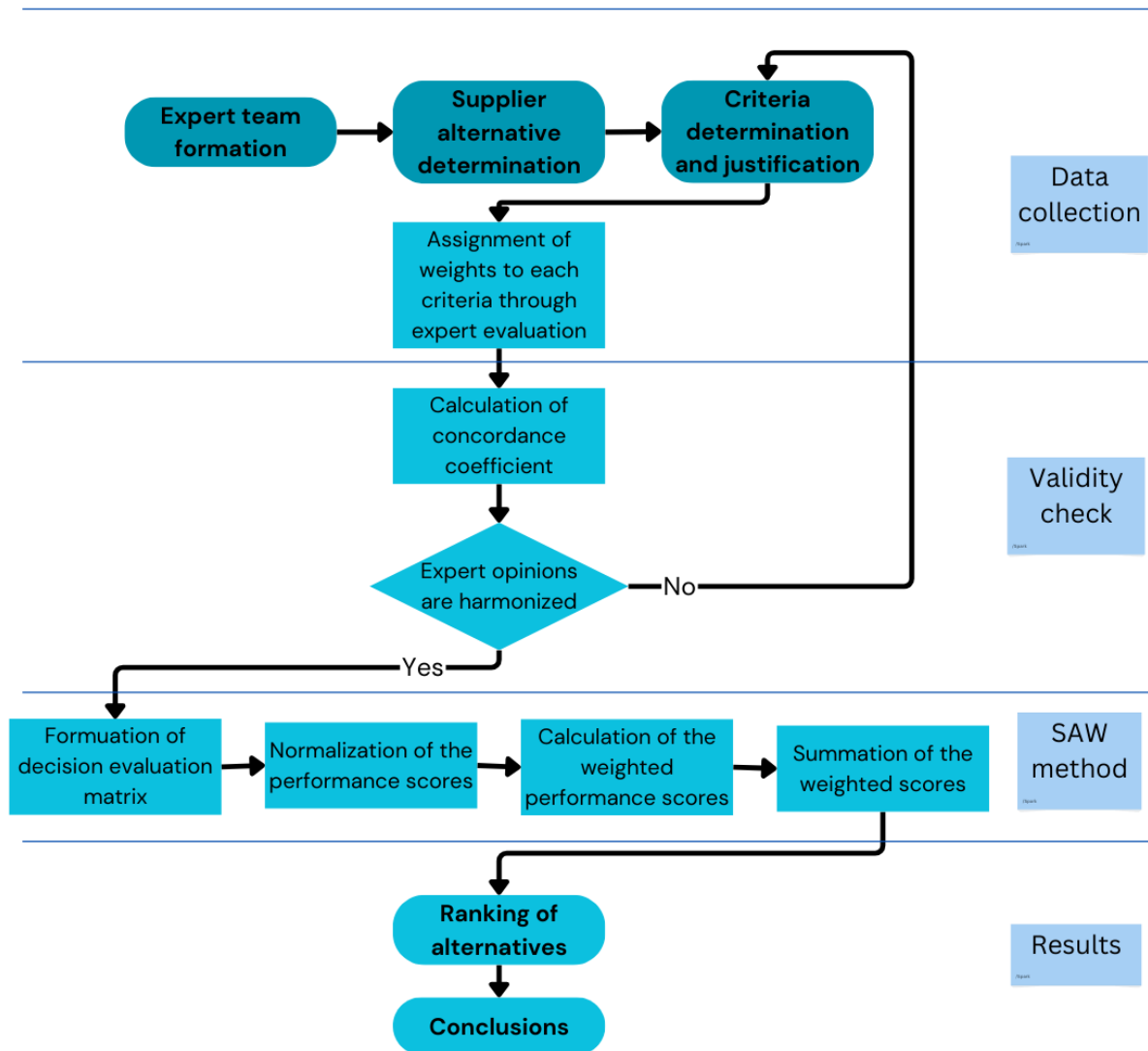


Fig. 3 Supplies leadership evaluation model for EV charger industry companies

Source: designed by author

The Simple Additive Weighting (SAW) method, that is known for enabling the evaluation of indicators across various dimensions (Vafaei et al., 2022). This applied method addresses problems in a specific sequence, and it is a practical choice for this research decision-making implementation, or in this case - the evaluation of leading suppliers in the electric vehicle (EV) charger industry. The standard Simple Additive Weighting method involves 6 main steps (Y. J. Wang, 2019) but the developed method is divided into 4 categories with more actions. These categories are:

1. Data collection.
2. Validity check.
3. SAW method.
4. Results.

The first step included in the process is to identify the criteria relevant to the decision-making process and list the potential alternatives. In the case of evaluating leading suppliers the alternatives would be the different EV charger suppliers being considered. Next, each criterion is assigned to a weight, that relatively reflects its importance. These weights are typically determined through expert criteria evaluation. Thirdly, the calculated and evaluated performance scores are normalized to get the same units. Then, the concordance of the expert evaluation is validated. After that, weighted scores are empirically calculated and are added to get the overall score for each alternative. It is calculated by summing its weighted scores across all criteria. When all scores are clear, the final step is to rank all the alternatives based on their overall scores, the highest score indicating the most preferred alternative.

All in all, the Simple Additive Weighting (SAW) method is an effective and practical tool for evaluating leading EV charger suppliers. Since SAW method focuses on the weighted sum of performance scores, it directly reflects the importance of each criterion as perceived by the decision-maker. This is particularly important in leadership evaluations, where certain qualitative aspects like innovation, quality, or flexibility may have varying degrees of importance. Additionally, saw method is straightforward and easy to implement, the results of the calculations are easier to interpret as they provide a direct score for each supplier based on the weighted sum of their performance across criteria. Its simplicity and transparency facilitate a clear decision-making process, allowing decision-makers to systematically evaluate and rank suppliers based on specific, selected criteria (Shekhovtsov, 2023). By assigning appropriate weights and normalizing performance scores, the SAW method provides a comprehensive evaluation that identifies industry leaders best meeting criteria, that are crucial for leading EV charger suppliers.

Because of mentioned advantages, the SAW method for multicriteria evaluation was recognized as the most suitable method of evaluation of companies when you need to select the most suitable one to prevent the main risks in the context of global challenges. These features, together with ease of application, make adapted SAW method particularly accessible for organizations aiming to efficiently rank leading EV charger suppliers based on multiple criteria. Thereby improving decision-making processes in the context of evaluating leading EV charger suppliers using adapted SAW method was chosen.

2.3 Steps for implementation of designed method

2.3.1 Data collection – research population

To begin with, the first step of data collection part of the method is the formation of expert team. A company providing EV charging services was selected for the evaluation of leading EV charger suppliers. As mentioned earlier, experts' evaluation is implemented to determine the significance of the criteria. The inclusion of evaluations from specific number of experts is critical for ensuring robust and reliable outcomes. Drawing on insights from industry-specific experts is crucial for providing a balance between wide perspectives and manageable data analysis. The number of experts influences reliability of final decision (Drejeris & Samuolaitis, 2021). According to studies data, that is provided in the scheme (Figure 2) eight experts are enough for a reliable decision. This provides approximately 90 percent reliability in the evaluation process.

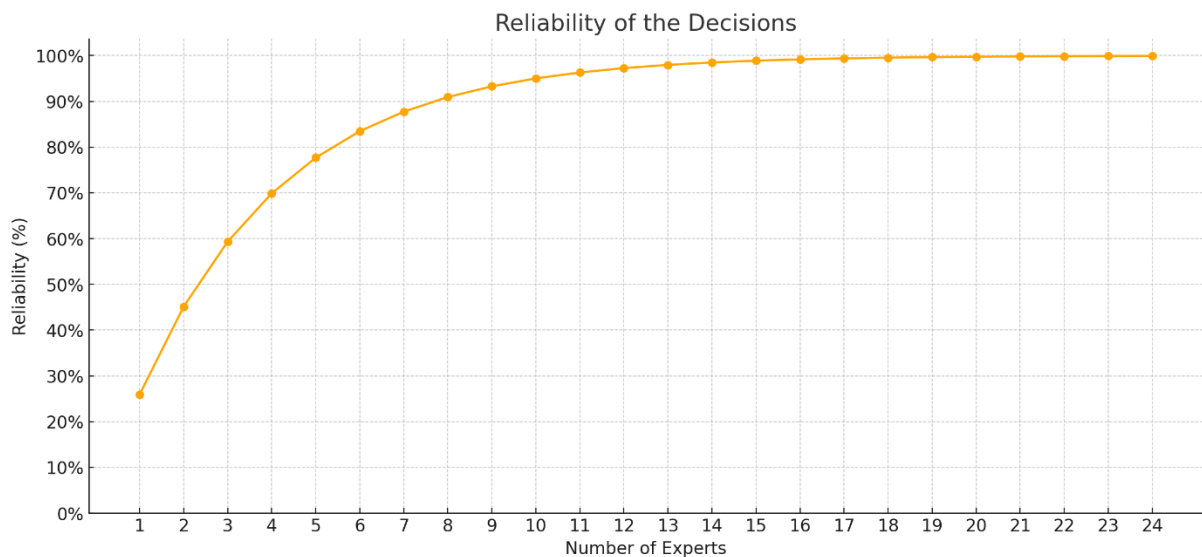


Fig. 4 The decision reliability dependence on number of experts

Source: Wright et al. (2019).

Experts from within the industry possess the necessary knowledge and practical experience to accurately assess the criteria. The carefully chosen experts help evaluate each criterion and alternative, bringing specialized insights that are crucial for an accurate and effective evaluation. These experts from within the company must include personnel, who have been working in a managerial position in the EV charging service department for more than 2 years and have experience in supplier evaluation, selection, tracking, as well as physical implementation of the products. These experts also must have experience in quality control and installation.

An individual expert survey method is used for assessment. The experts are presented with a task of assessing the significance of the criteria for leadership evaluation of EV charger suppliers. After significance determination, all selected alternatives are evaluated as presented earlier. It is important to remember that evaluating a larger pool of suppliers can lead to more accurate and suitable selection decisions, aligning with current conditions and the needs of commercial participants (Drejeris & Samuolaitis, 2021). Considering that, a specific number of leading suppliers by EV charger revenue was chosen – in this case five top suppliers in Europe.

After gathering the team of experts, next crucial step of thorough and strategic approach the process of selecting suppliers for evaluation within a leadership assessment model demand. In the context of the European EV charging station industry, most known and widely spread suppliers need to be chosen. Supplier must also have data that is reachable for the team of experts, as well as the knowledge from the experts point of view (Moges et al., 2023). This process should encompass suppliers that can be assessed by a detailed set of criteria specific to the distinct needs and regulatory framework of the European market. By carefully evaluating potential suppliers against these criteria, the European EV charging station industry can identify and collaborate with leading suppliers capable of driving innovation, ensuring reliability, and supporting the sustainable expansion of the EV charging infrastructure.

Next crucial step is definition of the criteria and alternatives. The design of Simple Additive Weighting (SAW) method, also known as weighted linear combination or scoring method begins with the definition of the criteria and alternatives. The focus is on identifying search objects, their significant features. As mentioned, potential suppliers are diverse economic entities characterized by various factors. Searches can target each of these characteristics individually (Buadit et al., 2023). From a validity standpoint, focusing on the supply object itself is more practical than emphasizing the characteristics of any single economic entity. In EV charger industry, the search typically focuses on all supply items due to the similar needs of EV charging service providers (Moges et al., 2023). This tailored approach ensures that the selected leading suppliers can effectively meet universal requirements of EV charging industry. Evaluating a larger number of suppliers not always increases the likelihood of finding the most suitable and objective selection solutions that align with current conditions. In essence, suppliers that fail to meet the standards of a leading EV charger supplier company, such as those with no modern solutions, limitations in production, delivery, should be eliminated from the initial selection of suppliers. A well-structured pre-selection process helps minimize unproductive costs associated with evaluating suppliers further. No more than 5 leading European suppliers of EV chargers are selected.

Moreover, identifying a comprehensive set of evaluation criteria is regarded as the most critical task in this phase (Singh et al., 2024). Suggestions for these criteria sets vary significantly, ranging from a few to several dozen (A & P, 2023), and include both quantitative and qualitative measures. The 12 main criteria for evaluating the leading EV charger suppliers are described in the first part of the research – literature review. They were effectively justified based on necessity and relevance of these criteria, highlighting the most suitable for the research. Selected and identified criteria are presented in an example table 1. The information provided in the table consist of: individual marking of the specific criteria, listing of that criteria, explanation of the criteria's application, assessment and etc. (Zehir et al., 2016)

Table 4. Criteria for the assessment of leading suppliers.

Marking	Criteria	Explanation
k1	Criteria example 1	Description of how this criterion is used to assess performance or quality in a given context.
k2	Criteria example 2	Explanation of the specific factors or attributes that this criterion measures.
k3	Criteria example 3	Details on the importance of this criterion and how it impacts overall evaluation.
kn	Criteria example n	Information on the application of this criterion in practical scenarios.

Source: Beer and Lemmer (2019)

2.3.2 Data collection - assignment of weights to each criteria.

To assess the criterion's weight on the selection results of leading EV charger suppliers, expert evaluation is considered the most effective approach. Both subjective and objective assessments can be employed to determine the significance of the criteria. According to Baran and Zak (A & P, 2023). Subjective assessment is commonly utilized in practice, where experts in the relevant field determine the criteria's significance, followed by mathematical and statistical methods for calculations. These experts in case of EV charging industry comprise managers and executives from EV charging service providing companies, technical implementation departments, independent specialists in EV industry with extensive experience, and other professionals. Additionally, technical specialists capable of evaluating the reliability of charging equipment, along with quality specialists possessing substantial experience in the field, can contribute to the expert evaluation process. These experts may be sourced from both public institutions and private commercial sectors.

Once the group of experts is formed, the evaluation process takes place. Experts evaluate each factor and alternatives using percentages, scores, or other units. The criteria have different relative weight and estimates. After determining the criteria estimates $\eta_1, \eta_2, \eta_3, \eta_n$,

for each row of the table, the value W_i , showing the total significance estimate is calculated according to the formula:

$$W_i = \sum_{e=1}^m \eta_{ie}, i = 1, m \quad (1)$$

where:

- W_i is the summation of the i-th criterion rating;
- η is the criteria estimates.

$$w_i = \frac{W_i}{\sum_{i=1}^m W_i}, i = 1, m \quad (2)$$

where:

- w_i is the calculated total significance estimate of the criteria.

After calculations the matrix for determining the significance of the criteria is presented in the table number 5.

Table 5. Determination of the significance of the criteria

Experts Criteria	j_1	j_1	j_1	j_j	Overall assessment of significance (W_i)
	J1, expert criterion, Ki, significance estimate (η_1)	J1, expert criterion, Ki, significance estimate (η_2)	J1, expert criterion, Ki, significance estimate (η_3)	J1, expert criterion, Ki, significance estimate (η_4)	
k_1	...	...	...	...	...
k_2	...	...	...	...	...
k_3	...	...	...	...	...
...	...	...	...	...	...
k_n	...	...	...	...	...

Source: designed by author

Once the significance of the criteria has been evaluated, clear assessment of their weights is presented.

2.3.3 Validity check - calculation of concordance coefficient

When ranking or scoring items it is crucial to evaluate the level of agreement among experts who provide rankings on various evaluation measures. Kendall's Concordance Coefficient is employed for evaluation of assignment of weights to each criteria. It is a statistical tool designed to quantify the degree of consensus among multiple raters from different points

of view. A value of coefficient close to 1 indicates strong agreement among experts, whereas a value close to 0 indicates significant divergence in their judgments. Using Kendall's coefficient is essential in contexts of expert evaluation where it is relied upon for decision-making. In evaluating weight of criteria of suppliers leadership within the industry it allows to objectively assess whether experts' opinions are harmonized and enhances the reliability and validity of the study.

To calculate the concordance coefficient, first, values are ranked for each expert according to the percentage (Drejeris & Oželienė, 2019). Then, the total sum of ranks is calculated. For each item the total rank sum is calculated using the formula 3. Each questions rank g_i was linked to each expert's ranking of it r :

$$g_i = \sum_{j=1}^r g_{ij}, \quad (3)$$

where:

- g_{ij} is rank assigned to item i by expert j ;
- r number of ranks.

Next, sum of squared deviations is calculated. This measures how much the rank sums of individual items deviate from average. It shows that some items are consistently ranked much differently, which suggests strong agreement among experts. It is linked to the number of deviations of specific opinions to question g_i from total of $\bar{g}$ of all questions.

$$S = \sum_{i=1}^m (g_i - \bar{g})^2, \quad (4)$$

where,

- g_i total rank sum of item i ;
- $\bar{g}$ mean of the rank sums.

Next, total mean value of the rank sum is calculated. The mean rank sum provides a baseline to compare individual rank sums g_i . Deviations from this mean indicate how far each item's rankings differ from the average.

$$\bar{g} = \frac{\sum_{i=1}^m g_i}{m}, \quad (5)$$

where:

- g_i rank sums for all items;
- m number of items.

Lastly, Kendall's Concordance Coefficient can be calculated. This formula calculates the overall level of agreement among the rankings provided by the experts.

$$W = \frac{12S}{r^2 * m * (m^2 - 1)}, \quad (6)$$

where:

- S Sum of squared deviations of the sum of ranks for each item from the mean rank sum;
- r Number of experts;
- m Number of items being ranked.

After calculating the Kendall's Concordance Coefficient, the total level of agreement among all experts can be evaluated. If the calculated coefficient is close to 1, there is strong agreement and among the experts and opinions are harmonized and if it is close to 0, there is little to no agreement. Low score indicates that the weight assignment is not valid for further evaluation of leading manufacturing companies in the EV charger industry and evaluation needs revision.

2.3.4 SAW method implementation

Once the harmonization of these scores is validated next crucial step of the Simple Additive Weighting (SAW) method is decision matrix construction to systematically organize the data required for evaluation. The matrix is structured in a way, that each row corresponds criterion (In this case Product Quality, Cost/Pricing, Reliability, etc.) used to assess these alternatives and each column corresponds to an alternative leading supplier in EV charger industry. Performance scores, representing the values or ratings that each alternative achieves under each criterion, are then expressed in the matrix. These scores will be derived from expert evaluation process - expert judgments and will include quantitative data as well as empirical measurements. The decision matrix serves as the foundation for following steps of normalization and calculation of weighted scores, facilitating a structured and comparative analysis of all alternatives across multiple criteria. The decision evaluation matrix is presented in table No. 6.

Table 6. Decision evaluation matrix

Parameters			Alternatives					
Criteria for evaluation	Index	Significance	1	2	...	j	...	n
			Evaluation of alternatives					
j_1	1	w_1	v11	v12	...	v1j	...	v1n
j_2	2	w_2	v21	v22	...	v2j	...	v2n
j_3	...	...	...	...	...	...	...	...
j_i	i	w_i	vi1	vi2	...	vij	...	vin
...	...	...	...	...	...	...	...	...
j_n	n	w_m	vm1	vm2	...	vmj	...	vmn
SAW			S_{j1}	S_{j2}	...	S_{jj}	...	S_{jn}

Source: designed by author

Next step of Additive Weighting (SAW) method is to normalize derived performance scores. Depending on the criteria chosen, expert evaluation can derive quantitative and qualitative values. Different measurements for evaluation can be used (percentages, scores, performing units) so they need to be normalized. Depending on the way experts evaluated specific criteria, transformation of these values to normalized expression is necessary.

In order to transform the various scales of performance scores into a comparable scale, SAW method allows classical normalization method. Here, values of the significance are normalised using the following maximizing formula.

$$\bar{r}_{ij} = \frac{r_{ij}}{\max_j r_{ij}}, \quad (7)$$

here,

$$\sum_{j=1}^n r \bar{r}_{ij} = 1, \quad (8)$$

where,

- $\bar{r}_{ij}$ is the performance score of the i-th alternative with respect to the j-th criterion.

When scores are normalized and the harmonization of these scores is validated, next step is to calculate performance scores according to their weight. Each normalized performance

score is multiplied by the corresponding weight of the criterion to obtain the weighted score. For this, following formula is used.

$$V_{ij} = w_j * \bar{r}_{ij}, \quad (9)$$

where:

- V_{ij} is weighted performance score;
- w_j is the weight of the j-th criterion;
- $\bar{r}_{ij}$ is the is the performance score of the i-th alternative with respect to the j-th criterion.

After weight calculation, each derived performance score is specified and will be used for assessment of expert evaluation to calculate weighted scores.

Following weighted performance scores, the overall score for each alternative is calculated. Overall score allows for ranking of each alternative. It is done by summing its weighted scores across all criteria using the following formula.

$$S_j = \sum_{i=1}^m w_i * \bar{r}_{ij}, \quad (10)$$

where,

- S_j - the overall score of the i-th alternative;
- w_i is the weight of the i-th criteria;
- $\bar{r}_{ij}$ is the is the normalized value of the i-th alternative with respect to the j-th criterion.

After performing mathematical calculations using Additive Weighting (SAW) method and the evaluation of the significance of each criterion, the selected alternatives are assessed using formulated decision matrix. This matrix allows to determine and evaluate, which of the suppliers receives the highest score in consideration of a leading supplier in EV charger industry. Proceeding to the selection phase, following matrix presented in table 6 is used. Performing these steps allow to apply the SAW method effectively to evaluate and rank EV charger suppliers, identifying leaders in the industry.

2.3.5 Results of the assessment

After performing calculation, it is possible to rate suppliers. The scores are then presented in table No. 6 and represent their rank compared to other suppliers. Supplier with most points is determined as leading within its competitors and ranks in accordance with the determined scores. After ranks have been carried out, results can be used to suggest recommendations, draw insights on supplier, what attributes are most relevant and important to personnel from within the industry, drawbacks and strength areas of suppliers based on the criteria they have been assessed by and indication of market leaders in the industry. Conclusions and overall assessments of the research methods implementation can be assessed.

The developed tool can now be used in practice for multi-criteria analysis using presented SAW method. This, combined with expert evaluation, quantitative and qualitative data allows to evaluate selected of suppliers in the aspect of leading EV charging company suppliers.

3. APPLICATION OF DERIVED SAW METHODOLOGY FOR EVALUATION OF SUPPLIERS LEADERSHIP IN EV CHARGER INDUSTRY

In this part of the study, derived SAW (Simple Additive Weighting) method for evaluating suppliers leadership in EV charger industry will be applied and tested. Using data derived from description of methodologies for decision making and theoretical background of the study method calculations will be performed.

Firstly, practical implementation will be based on the derived criteria from literature review. Next, expert's evaluations of weighting factors to systematically assess and rank suppliers based on their leadership attributes will be applied. And finally, the methodology is tested on real-world data, ensuring the analysis reflects the complexities of the industry. The results will provide a quantitative foundation for understanding application of designed supplier leadership evaluation model.

3.1 Criteria and alternatives for the assessment of leading suppliers.

To begin with, the very first step as described in the selection and design of research method application is defining criteria that will be used for the assessment of the alternatives. The twelve key aspects of leading EV charger suppliers were identified and analysed in the first part of this study – theoretical background. These criteria together with their explanations will be provided for the team of experts during evaluation stage of the research. Following criteria are presented in the table 7.

Table 7 Criteria for the assessment of leading suppliers.

Marking	Criteria	Explanation
k1	Product Quality	Assessment of the product's durability, performance, and conformance to standards and customer expectations.
k2	Cost/Pricing	Evaluation of the cost competitiveness and value to customer offered by the supplier in relation to market standards.
k3	Reliability	Measurement of the supplier's consistency in delivering products or services on time and according to quality standards.
k4	Financial Performance	Analysis of the supplier's financial stability, profitability, and ability to sustain operations over the long term.
k5	Market Presence	Examination of the supplier's geographical reach in the market by the number of countries where they operate.
k6	Technological Innovation	Evaluation of the supplier's capability to offer technologies or innovative solutions that enhance product value or process efficiency.
k7	Supply Chain Management	Assessment of the supplier's ability to manage logistics, inventory, and supplier partnerships efficiently and effectively.

Table 7 continuation

k8	Regulatory Compliance	Verification of the supplier's adherence to legal, industry, and safety standards relevant to their products and operations.
k9	Flexibility	Evaluation of the supplier's ability to adapt to changing demands, customize offerings, or handle unforeseen disruptions.
k10	Warranty/Guarantee	Examination of the supplier's warranty policies, including the scope, duration, and responsiveness in addressing product issues.
k11	Customer Support Services	Assessment of the quality, availability, and responsiveness of post-sales support provided by the supplier.
k12	Sustainability	Evaluation of the supplier's environmental practices, energy efficiency, and contributions toward sustainable development.

Source: designed by author

After presenting the criteria, alternatives, or as in the case of this research – suppliers are chosen for the application of derived SAW method. As described in the first and second part of the study, top 5 leading suppliers are chosen. For this study, the analysis of most popular EV charger manufacturers in the European market, are chosen (Zeva, 2024). The chosen manufacturing companies are presented as follow.

1. ABB
2. Alpitronic
3. Wallbox
4. Kempower
5. Evbox

These select suppliers (alternatives) are the key component of this evaluation. Selected experts from within the industry must have experience and insights on these leading suppliers to subjectively evaluate them according to stated criteria.

This clarity of alternatives and criteria by which they will be assessed ensures that the evaluation process is transparent, systematic, and replicable. By articulating the criteria clearly, decision-makers can objectively assess each supplier's performance across various dimensions. Also, by selecting applicable suppliers which are known to the experts is crucial for successful evaluation. These key components lay the foundation for successful implementation of constructed suppliers leadership evaluation model in EV charger industry.

3.2 Expert Team Formation and Data Collection Method

As mentioned in the second part, gathering the right expert team for evaluation is crucial to ensure the reliability and validity of the research findings. The expertise, experience, and diverse perspectives of the team members can significantly enhance the quality of the evaluation process. A team of 8 carefully selected experts who possess the necessary qualifications and knowledge in the relevant field were selected. To comply with privacy

policies and maintain confidentiality, each expert involved in the evaluation was assigned a specific pseudonym (j1, j2, etc.) to their position as presented in table below. This approach not only safeguards their identities but also ensures that the focus remains on their professional contributions and insights rather than their personal information.

Table 8 Pseudonyms of experts

Pseudonym	Position
j1	Procurement Manager
j2	Procurement Manager
j3	EV Project manager
j4	EV Project manager
j5	Technology and Innovations Manager
j6	Innovations Manager
j7	EV Infrastructure Engineer
j8	EV Infrastructure Engineer

Source: designed by author

Here, j1 expert is a Procurement Manager working in procurements of EV charging stations in one of leading EV charging service provider companies in Baltic states with more than 2 years of experience in the field. J2 expert is colleague working in the same position, but with over 3 years of experience in the EV industry procurements. J3 and j4 are EV project engineers from different EV charging service provider companies, who have experience of all 5 mentioned manufacturers products. J3 is an expert with 2 years of experience of DC fast charger project implementation and J4 with 4 years of experience both with AC slow charging and DC fast charging station projects. J5 is a technology innovation manager, who pioneered fast chargers in Lithuanian market, with 4 years of experience of selecting EV charging station suppliers. Other innovation manager j6, who worked in the same department for 2 years. Lastly, two EV Infrastructure Engineers j7 and j8 were selected from the same EV charging service provider in Baltic states, who both have worked for 2 years in managing engineering of EV infrastructure and have experience of installations with ABB, Alpitronic, Wallbox and Kempower charging stations.

3.3 Criteria weight assessment

Moving forward with the applied SAW method application, criteria weight assessment is essential part of the process. This is because it reflects the relative importance of each criterion in the decision-making process, ensuring that the evaluation aligns with the strategic priorities and operational imperatives of the organization. For implementation of criteria weight assessment, a team of expert individually evaluated these criteria. Having established the team

of experts that comply with requirements for reliable evaluation of leading EV charging station suppliers, their evaluation data can be collected. For this, table No. 5 will be used. Each expert was presented with the criteria together with their explanation with table No. 7. Their evaluation was filled out in given tables and are presented in following table No. 9. as η_i accordingly.

Table 9. Determination of the significance of the criteria

Experts Criteria	j_1	j_2	j_3	j_4	j_5	j_6	j_7	j_8	Overall significance (W_i)
	J1, experts, Ki weight (η_1)	J2, experts, Ki weight (η_2)	J3, experts, Ki weight (η_3)	J4, experts, Ki weight (η_4)	J5, experts, Ki weight (η_5)	J6, experts, Ki weight (η_6)	J7, experts, Ki weight (η_7)	J8, experts, Ki weight (η_8)	
Product Quality	15	15	15	13	15	16	15	14	0,1475
Cost/Pricing	11	10	11	11	12	9	12	10	0,1075
Reliability	13	12	12	12	11	11	11	12	0,1175
Financial Performance	9	10	10	10	8	10	8	11	0,95
Market Presence	8	8	8	8	9	7	9	8	0,8125
Technological Innovation	10	10	11	10	11	10	11	9	0,1025
Supply Chain Management	8	9	8	9	9	10	9	8	0,875
Regulatory Compliance	7	6	4	6	6	5	6	6	0,575
Flexibility	6	5	7	7	5	6	5	6	0,5875
Warranty/ Guarantee	5	5	6	5	5	6	5	5	0,525
Customer Support Services	4	5	5	5	5	5	5	5	0,4875
Sustainability	4	5	3	4	4	5	4	6	0,4375
Sum:	100%	100%	100%	100%	100%	100%	100%	100%	1

Source: designed by author

The sum of experts' evaluations through all twelve criteria is equal to one hundred percent. After all data is gathered, total overall significance estimate for all criteria is calculated using formulas No. 1 and No. 2 and presented in the last column of the table as W_i . The total sum of computed significance estimates W_i is equal to 1.

From presented results, experts evaluate leading EV charger suppliers prioritizing product quality, reliability, pricing and technological innovation, showing highest estimated relative importance. Least important criteria are sustainability, customer support services and warranty of the manufactured products, gathering close to 5% of relative importance.

3.4 Calculation of concordance coefficient

As given in the description of the computed SAW evaluation model for assessing suppliers leadership, next crucial step of the method is concordance coefficient. It is crucial to calculate if experts opinions are compatible and study data is valid. This step must be done after initial assessment as it shows if it is possible to move on with study.

Using formulas presented in part 2.2.3 - calculation of concordance coefficient is done. First, each expert's evaluation is ranked according to percentage score assigned to each criteria. Next, total rank sum is calculated according to formula No. 3 and followed by the sum of squared deviations using formula No. 4. This amounts to $S = 7786,1$. After calculating mean value of the rank sum, all variables of Kendall's Concordance Coefficient are obtained. Lastly, Kendall's Concordance Coefficient is calculated by formula No. 6 and is equal to $W = 0,85$. In the case of leading EV suppliers evaluation, gathered expert evaluations are harmonized, as W is close to 1. Further implementation of applied SAW method can be continued.

3.5 Formulation of the decision evaluation matrix

Next step for application of derived method, is formulating decision evaluation matrix. For this, each expert was now provided with table No. 6 to evaluate each supplier in accordance with specific criteria. For evaluation, a score from 1 to 10 was used according to suppliers performance in that category by provided explanation of the criteria. Only one criteria – market presence was evaluated by number of countries in which suppliers operate. This is quantitative rather than qualitative value and must be evaluated separately. All expert evaluations were concluded in single table No. 10 and are presented as follows.

Table 10 Decision evaluation matrix with expert evaluation

Parameters			Alternatives				
Criteria for evaluation	Index	Significance	ABB	Alpitronic	Wallbox	Kempower	Evbox
			Evaluation of alternatives				
Product Quality	k1	0,1475	4; 6; 3; 5; 5; 6; 4; 5	10; 9; 9; 9; 8; 9; 10; 9	7; 8; 8; 7; 6; 8; 7; 8	8; 9; 10; 9; 9; 8; 10	6; 7; 7; 6; 7; 6; 8; 7
Cost/Pricing	k2	0,1075	8; 9; 8; 9; 8; 8; 8; 9	6; 5; 5; 4; 6; 5; 5; 5	8; 9; 8; 9; 7; 9; 8; 8	5; 4; 4; 3; 5; 5; 4; 5	6; 8; 8; 6; 7; 7; 7; 8
Reliability	k3	0,1175	6; 8; 7; 6; 8; 7; 6; 7	6; 8; 8; 8; 7; 7; 8; 8	8; 9; 7; 7; 8; 9; 8; 7	5; 4; 5; 4; 4; 5; 5; 6	6; 5; 7; 5; 6; 5; 5; 6

Table 10 continuation

Financial Performance	k4	0,95	8; 9; 9; 7; 8; 9; 8; 9	7; 5; 7; 5; 6; 5; 7; 6	8; 9; 8; 9; 8; 8; 7; 8	5; 6; 6; 6; 5; 5; 6; 5	7; 7; 7; 8; 6; 7; 7; 7
Market Presence	k5	0,8125	80; 80; 80; 81; 80; 80; 80; 80	11; 10; 10; 10; 10; 10; 10; 10	113; 113; 113; 113; 113; 113; 113; 113;	32; 32; 32; 33; 31; 32; 32; 33	70; 70; 70; 70; 70; 70; 70; 70;
Technological Innovation	k6	0,1025	5; 6; 8; 8; 7; 6; 7; 7	4; 5; 4; 3; 4; 5; 5; 4	7; 9; 8; 7; 8; 9; 7; 7	9; 8; 10; 8; 9; 8; 8; 8	4; 5; 4; 5; 4; 4; 4; 4
Supply Chain Management	k7	0,875	7; 9; 8; 9; 7; 8; 8; 8	10; 9; 10; 9; 9; 8; 9; 8	5; 6; 7; 6; 5; 7; 6; 6	4; 5; 4; 5; 4; 4; 5; 6	9; 8; 10; 8; 8; 8; 8; 8
Regulatory Compliance	k8	0,575	5; 6; 7; 6; 5; 6; 6; 7	7; 7; 7; 8; 8; 7; 7; 7	9; 7; 9; 7; 8; 8; 9; 8	4; 4; 5; 4; 6; 5; 4; 4	8; 8; 8; 9; 7; 8; 8; 8
Flexibility	k9	0,5875	5; 7; 6; 8; 5; 7; 6; 7	3; 4; 3; 3; 4; 3; 4; 4	8; 8; 6; 8; 7; 8; 7; 7	6; 5; 6; 6; 5; 6; 5; 5	5; 6; 5; 4; 6; 5; 5; 5
Warranty/ Guarantee	k10	0,525	8; 9; 7; 7; 8; 7; 8; 7	5; 3; 6; 5; 4; 5; 5; 6	9; 8; 8; 9; 8; 8; 7; 9	6; 5; 6; 7; 6; 5; 6; 6	4; 4; 4; 5; 4; 4; 4; 5
Customer Support Services	k11	0,4875	6; 7; 8; 7; 7; 6; 7; 7	7; 8; 9; 9; 8; 8; 7; 9	7; 6; 5; 6; 6; 6; 6; 6	4; 3; 4; 5; 4; 4; 3; 4	4; 5; 5; 4; 5; 4; 4; 5
Sustainability	k12	0,4375	9; 9; 8; 9; 8; 8; 8; 9	3; 2; 4; 2; 3; 2; 4; 2	9; 9; 7; 8; 9; 8; 7; 7	2; 4; 3; 2; 4; 2; 2; 3	5; 5; 5; 4; 5; 5; 4; 5

Source: designed by author

After gathering all study evaluations from experts and presenting them in a table, following step is the summation of these evaluations for each specific alternative in relation to its corresponding criteria. These values are presented in table No. 11 and will be used for further assessment.

Table 11 Decision evaluation matrix with values of expert evaluation

Parameters			Alternatives				
Criteria for evaluation	Index	Significance	ABB	Alpitronic	Wallbox	Kempower	Evbox
Evaluation of alternatives							
Product Quality	k1	14,75	38	73	59	71	54
Cost/Pricing	k2	10,75	67	41	66	35	57
Reliability	k3	11,75	55	60	63	38	45
Financial Performance	k4	9,5	67	48	65	44	56
Market Presence	k5	8,125	642	81	904	257	560
Technological Innovation	k6	10,25	54	34	62	68	34
Supply Chain Management	k7	8,75	64	72	48	37	67
Regulatory Compliance	k8	5,75	48	58	65	36	64

Table 11 continuation

Flexibility	k9	5,875	51	28	59	44	41
Warranty/ Guarantee	k10	5,25	61	39	66	47	34
Customer Support Services	k11	4,875	55	65	48	31	36
Sustainability	k12	4,375	68	22	64	22	38

Source: designed by author

After summing all evaluation scores for all alternatives across following criteria, further calculations can be continued.

3.6 Normalization and calculation of the weighted performance scores

Following step for application of derived SAW methodology for evaluation of suppliers leadership in EV charger industry is normalization of performance scores. As one criteria – market presence was evaluated by number of countries in which suppliers operate, quantitative measure is present. Because of this, score normalization is required. Classic normalization process described in part 2.2.5 is used. For this, all values are divided by the maximum value in the represented category as described in formula No. 8. With these results following normalized table No. 12 is presented.

After normalizing all performance scores provided by a team of 8 experts, weighted performance scores are calculated. These scores represent the total value for ranking the alternatives – suppliers by represented criteria. First, scores are multiplied by weight assigned to each criteria using formula No. 9. Next, the overall scores of the alternatives are calculated. This is done by summing its weighted scores across all criteria using the formula No. 10. Results of performance scores are presented in tables No. 12 last row “SAW”.

Table 12 Decision evaluation matrix with calculations

Parameters			Alternatives				
Criteria for evaluation	Index	Significance	ABB	Alpitronic	Wallbox	Kempower	Evbox
			Evaluation of alternatives				
Product Quality	k1	14,75	0,520548	1	0,808219	0,972603	0,739726
Cost/Pricing	k2	10,75	1	0,61194	0,985075	0,522388	0,850746
Reliability	k3	11,75	0,873016	0,952381	1	0,603175	0,714286
Financial Performance	k4	9,5	1	0,716418	0,970149	0,656716	0,835821

Table 12 continuation

Market Presence	k5	8,125	0,710177	0,089602	1	0,284292	0,619469
Technological Innovation	k6	10,25	0,794118	0,5	0,911765	1	0,5
Supply Chain Management	k7	8,75	0,888889	1	0,666667	0,513889	0,930556
Regulatory Compliance	k8	5,75	0,738462	0,892308	1	0,553846	0,984615
Flexibility	k9	5,875	0,864407	0,474576	1	0,745763	0,694915
Warranty/ Guarantee	k10	5,25	0,924242	0,590909	1	0,712121	0,515152
Customer Support Services	k11	4,875	0,846154	1	0,738462	0,476923	0,553846
Sustainability	k12	4,375	1	0,323529	0,941176	0,323529	0,558824
SAW			10,16001	8,151663	11,02151	7,365245	8,497955

Source: designed by author

After performing mathematical calculations using Additive Weighting (SAW) method and the evaluation of the significance of each criterion, the selected alternatives are assessed using “SAW” results provided in the decision matrix. This matrix allows to determine and evaluate, which of the suppliers receives the highest score in consideration of a suppliers leadership in EV charger industry also highlighting leaders in innovation, market presence or product quality. As presented in tables No. 12 clear leaders in product quality are Alpitronic, Kempower and Wallbox. Also, suppliers who are ranked lower according to pricing such as same alpitronic or Kempower indicates weaknesses of these leading companies. All these measures can be taken into consideration when evaluating and choosing leading suppliers. Overall computed ranks of these suppliers are presented in table No. 13.

Table 13 Suppliers leadership ranking

Rank	Alternative/supplier	Score of SAW
1	Wallbox	$S_{j3} = 11,02$
2	ABB	$S_{j1} = 10,16$
3	Evbox	$S_{j5} = 8,5$
4	Alpitronic	$S_{j2} = 8,15$
5	Kempower	$S_{j4} = 7,37$

Source: designed by author

As data signifies, number 1 leading supplier with representative score of $S_{j3} = 11,02$ coming out as the leading EV charger supplier company in Europe is Wallbox, closely followed by ABB with score of $S_{j1} = 10,16$. Taking third place with significantly lower score is Evbox

$S_{j_5} = 8,5$. Fourth place with similar result is Alpitronic with score of $S_{j_2} = 8,15$. And lastly, falling behind while showing strong scores in quality and technological innovation is Kempower with the score of $S_{j_4} = 7,37$.

CONCLUSIONS

1. After conducting comprehensive literature review, foundation on the concept of leadership within the industry and key aspects on the concept of leadership within the EV charging station suppliers in Europe has successfully been established. It was determined that leadership is multicriteria evaluation, encompassing elements such as market presence, innovation, reliability and quality. Key factors and criteria indicative of leadership in European EV charging station industry include pricing, financial performance, supply chain management, regulatory compliance, flexibility, warranty, customer support and sustainability. These findings provide a robust framework for understanding what criteria influence leadership in the specified industry and can be evaluated in real life context. Mentioned attributes are recommended to be used for all companies having the task of suppliers leadership assessment in the European market of electric vehicle chargers, bringing the value of accurate assessment.
2. Through an in-depth analysis of the electric vehicle charger industry and existing supplier selection methods, specific requirements for an effective evaluation method were identified. These requirements include the need for a comprehensive set of criteria that reflect the unique characteristics of the industry, consideration of multi-criteria factors that fit suppliers' selection requirements. Additionally, the evaluation method must be adaptable to the dynamic nature of the industry and capable of providing objective and quantifiable assessments of supplier's leadership in the industry. A recommendation for companies within the industry is to use these requirements to address the problem of designing easily applicable, systematic method that incorporates qualitative and quantitative assessments.
3. Based on the established theoretical background and identified requirements, a robust model for assessing the leadership of suppliers in the European electric vehicle charger market was developed. The adapted SAW model, which integrates multiple criteria, including factors from the literature review was computed. It employs a multi-criteria decision-making approach to ensure a balanced and comprehensive evaluation. The model's design allows for the inclusion of both qualitative and quantitative data, facilitating a holistic assessment of supplier leadership.
4. The developed methodology was successfully implemented to evaluate the leadership of suppliers in the European electric vehicle charger market. The application of the model demonstrated its effectiveness in distinguishing between varying levels of supplier leadership. The results provided valuable insights into the strengths and weaknesses of different suppliers, highlighting leaders in innovation, market presence, and quality

excellence. The implementation also ranked chosen suppliers, ranking Wallbox as top leading supplier, followed by ABB, then Evbox, Alpitronic and lastly Kempower. This validated the model's practical applicability and its potential to evaluate leading EV charging station supplier and guide strategic decision-making in the industry. Companies within the industry are recommended to implement such assessment in their evaluation processes to bring value of systematically approaching the problem of supplier assessment and solve the issue of lack of standardized model for evaluating.

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